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DISCUSSION PAPER SERIES 22/25

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JUNE 2025

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Linking Empirical Evidence to Theory: A Framework for Understanding Immigration's Labor Market Effects[1]

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Prepared for the *Handbook of Labor Economics*, Volume VI

Abstract

This chapter offers a novel approach to analyzing the effects of immigration on labor markets by structuring the discussion around a conceptual framework that links empirical estimates to fundamental structural parameters. This framework facilitates a clear interpretation and comparison of the parameters estimated by different empirical methods and clarifies the specific questions each method addresses. Section II introduces the canonical labor market model as a foundation for categorizing empirical approaches. Section III details the empirical approaches. Section IV differentiates between immigration's impacts on regions and workers, proposing a framework to connect these perspectives. Recognizing the limitations of the basic canonical model, Section V explores extensions that incorporate critical adjustment mechanisms to immigration shocks, such as endogenous technology adoption, innovation, and product price adjustments. Section VI broadens the analysis by examining monopsonistic labor markets and search frictions, moving beyond the assumption of perfect competition. Finally, Section VII concludes with a discussion of unexplored research questions that are pivotal for advancing the understanding of immigration's labor market effects and shaping future research agendas.

JEL codes: J61, J31, J23
Words: 30,133

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[1] We thank Yifan Wang, Linea Hasager, Zhengang Wang, and Meilin Chen for outstanding research assistance and Ararat Gocmen and Joaquin Urria Yanez for their helpful comments. We are grateful to RFBerlin for funding the Handbook conference.
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I Introduction

In economics, "human migration" refers to the movement of people between geographical regions. International migration, the main focus of this chapter, involves movements across national borders. Economists primarily study two aspects of migration: the experiences of migrants, including their reasons for migration, their labor market assimilation and integration into the host country, and the consequences of migration for both the host and source countries. This chapter will focus on the latter aspect, specifically examining the impact of immigration on labor markets in host countries.

Within economics, the study of migration is a relatively new area. Early contributions emphasized a close link between migration and trade. Much of this research was grounded in the traditional static two-sector, two-factor model that Meade (1955) initially applied in international trade theory. In this model, the economy consists of two perfectly competitive industries, each producing a distinct good with linearly homogeneous production technologies. The two factors of production—typically labor and capital—are assumed to be perfectly mobile between sectors, fully employed, and fixed in supply. The production of these goods is characterized by differing factor intensities across the entire range of production possibilities, with factor reversals excluded.[4] On the demand side, individuals are assumed to have identical and homothetic preferences. This model structure facilitates the application of established international trade theories, notably the Stolper-Samuelson theorem (Stolper and Samuelson, 1941) and the Rybczynski theorem (Rybczynski, 1955). The latter states that factor endowments do not impact factor prices. Therefore, according to this theorem, an immigration shock will not affect native wages and employment; instead, the output mix of the economy will adjust (see Section V.6 for details).

[4] This model is often referred to as the Heckscher-Ohlin model or, since Samuelson plays an important role in its development, the Heckscher-Ohlin-Samuelson model (see Takayama, 1982; Heckscher, 1949; Ohlin, 1933; Samuelson, 1948, 1949).

Extending this simple model, a series of early papers analyzed the consequences of migration for both the host and source countries.[5] These studies demonstrated that the impact of migration depends on several factors, such as whether the goods produced in the economy are traded internationally, whether the flow of capital accompanies the movement of labor, whether migrants send part of their earnings back to the source countries as remittances, and whether the economy can influence world price levels. Extensions of the basic model included incorporating three factors of production—typically skilled and unskilled labor along with capital (e.g., Clark and Thompson, 1990 and Jones and Easton, 1990)—or distinguishing between migrant and native labor as distinct input factors in the host country's labor market (e.g., Ethier, 1985).[6]

Julian Simon's 1990 book, *The Economic Consequences of Migration*, offered a fascinating and intuitive exploration of how immigration can affect the host country's economy and labor market. His "Parable" serves as a captivating introduction, adhering strictly to the principles of neoclassical economics. The book delves into many aspects of immigration’s consequences for the host country, topics that have been further examined in subsequent studies.

Greenwood and McDowell (1986) provided a comprehensive summary of the literature on the economic impact of immigration on native workers, organizing their analysis around a simple neoclassical model with various extensions. However, they found that empirical evidence on the effects of immigration on native workers was limited. Existing studies typically inferred the effects of immigration on native workers by simulating models based on estimated elasticities. One notable study is Grossman (1982), who estimated the

[5] See, for instance, Bhagwati and Rodriguez (1975), Krauss (1976), Bhagwati and Brecher (1980), Rivera-Batiz (1982, 1984), Thompson (1984), Djajić (1986), Ethier (1985, 1986), Gupta (1988), Quibria (1988a, 1988b, 1989), Rivera-Batiz (1989), Quibria (1989), Quibria and Rivera-Batiz (1989), and Rahman and Caples (1991).
[6] Dustmann and Preston (2019) offer a comprehensive summary of some of that literature, focusing on the gains from labor mobility.

elasticities of substitution between capital, native workers, second-generation immigrants, and foreign-born workers using a translog production function to predict the impact of immigration on native wages.[7]

The 1990s saw a shift towards more data-driven research on the impact of immigration on the labor market in the host country's economy, with studies attempting to estimate the impact of immigration on native wages and employment directly. This shift was largely inspired by David Card's (1990) seminal Mariel boatlift study and his joint work with Joseph Altonji (Altonji and Card, 1991). These papers employed reduced-form empirical approaches to analyze microdata and identify the effects of immigration on native wages and employment. The emphasis on causality in these studies aimed to isolate the impact of immigration by using research designs that addressed complex confounding factors. Conceptually, the immigration literature began to diverge from the trade literature. Empirical papers were motivated by the "canonical model"—a one-sector model of the economy where various inputs, such as capital and low- and high-skilled labor, are combined to produce output, and immigration is considered a pure labor supply shock.

Over the years, the study of immigration's effects on the labor market of the host country—particularly on the employment and wages of domestic workers—has expanded to include a broader range of outcomes, such as its influence on technology (e.g., Lewis, 2011), innovation (e.g., Kerr and Lincoln, 2010; Hunt and Gauthier-Loiselle, 2010) and product prices (e.g., Cortes, 2008). Economists have also studied the impact of immigration on the host country's economy more broadly, including the effects of immigration on crime (e.g., Bell, Fasani, and Machin, 2013; Marie and Pinotti, 2024), housing and rental prices (e.g., Saiz, 2003, 2010; Saiz and Wachter, 2011), political outcomes (e.g., Dustmann, Vasiljeva, and

[7] In the late 1970s and early 1980s, a separate empirical literature started to emerge that focused on the experiences of immigrants in the host country and specifically how well they integrated into the labor market. Chiswick (1978), Borjas (1985, 1987), and Dustmann (1993) made important early contributions. Abramitzky, Boustan and Eriksson (2014) and Abramitzky and Boustan (2022) are examples of more recent contributions.

Piil Damm, 2019; Halla, Wagner, and Zweimüller 2017; Tabellini, 2020), and the educational performance of native children (e.g., Figlio, Giuliano, Marchingiglio, Ozek, and Sapienza, 2024).

Over two and a half decades ago, in 1999, a chapter on immigration was published in the *Handbook of Labor Economics*. George Borjas focused his chapter, “The Economic Analysis of Immigration,” on aspects such as the decision to migrate, the characteristics of those who migrate, the integration and assimilation of immigrants in the host country, and the impact of immigration on the host country's labor market. Since then, the number of economic publications in leading economic journals containing terms like “immigration” or “migration” has increased more than fivefold, from less than 25 publications per year in the early 1990s to about 150 papers per year in the 2020s, indicating a significant expansion in research on this topic (see Panel A of Figure 1). In a typical year, about two-thirds of published papers have explored the effects of immigration in various contexts beyond the US (see Panel B of Figure 1).

The most substantial additions to the literature have focused on the consequences of immigration for the host country’s economy and labor markets, as depicted by the lower black bars in Panel A of Figure 1. Both conceptually and empirically, this is where much progress has been made since Borjas’ 1999 chapter, driven by the availability of better survey and administrative data and increasing immigration waves, both in and outside the US. This new data has facilitated novel extensions and provided more profound insights into the subject. Furthermore, this area of research is closely linked to labor economics, with new ideas and concepts from the broader field influencing the study of immigration. Our chapter, therefore, focuses on the economic impact of immigration on the labor market of receiving countries.

In addition to Borjas' (1999) *Handbook* contribution, several other papers have surveyed the literature (e.g., Borjas, 1994; Friedberg and Hunt, 1995; LaLonde and Topel, 1996; and George Borjas' 2014 book *Immigration Economics*). A survey by the National Academy of Sciences (2017) assessed the impact of immigration on the US, providing an exhaustive summary of empirical studies on the subject.

These surveys reveal that, despite extensive research, there is little consensus on immigration's effects on labor markets. This lack of agreement is not surprising, given that immigration is a diverse and multifaceted phenomenon and that the countries and labor markets exposed to it vary greatly. However, there is also wide variation in empirical approaches used to estimate the effects of immigration on the labor market. As emphasized in Dustmann, Schönberg, and Stuhler (2016), these differences in estimated specifications often result in estimates that are not comparable across studies. Moreover, when models are used to predict immigration's effects over more extended periods, assumptions about parameters determined outside the model, such as the elasticity of capital supply, can substantially alter the conclusions. It is, therefore, essential to be clear about the specific research questions addressed by the parameters estimated by these different specifications. Differences in how these questions are framed—often subtle to non-academic readers—can lead to different parameters of interest and sometimes vastly different conclusions.

What sets this chapter apart from previous literature reviews is its aim to go beyond summarizing existing methodological and empirical studies published on the effects of immigration on labor markets over the past decades. We structure our review using a conceptual framework that relates estimates from various empirical approaches to fundamental structural parameters. This allows us to interpret and compare the parameters that different approaches estimate to understand which specific questions they address.

We develop the canonical model that we use to categorize the different empirical approaches in Section II. In Section III, we detail the empirical approaches and review selected empirical studies. In Section IV, we distinguish between the labor market effects of immigration on regions versus workers and outline a simple framework that connects the two. While the basic version of the canonical model overlooks several potentially important adjustment mechanisms on both the worker and firm sides, it can be extended to include additional forms of adjustment, such as endogenous technology adoption, innovation, or product price adjustments. We consider such extensions in Section V. Finally, in Section VI, we move beyond the assumption of perfectly competitive labor markets by considering monopsonistic labor markets and introducing search frictions.

II Wage and Employment Effects of Immigration: The Canonical Model

Before formally introducing the canonical model, we first summarize the primary responses of workers, firms, and markets to an immigration shock. An immigration shock will primarily affect native labor market outcomes through an increase in labor supply—the effect that the existing literature has focused on. Immigrants also consume goods, which could indirectly affect native labor market outcomes—an effect that the existing literature has largely ignored.

II.1 An Overview

Worker Responses to an Immigration Shock. An immigration shock can impact the labor supply decisions of natives in various ways. It may influence their decision to participate in the labor force. If the immigration shock is localized, workers may relocate to areas less affected by immigration. Similarly, they may move from sectors and occupations heavily impacted by immigration to those less affected. Additionally, long-term career choices may be influenced. For example, if the immigration shock primarily involves low-skilled workers, it could encourage school leavers to invest more in education. These responses by native workers will shape the economy's overall, local, sector-specific, occupation-specific, and skill-specific labor supply.

*Firm Responses to an Immigration Shock***.** Firms also react to an immigration shock in multiple ways. They decide whether to enter or exit a market, how many workers of a specific type (e.g., low-skilled or experienced) to employ, whether to hire immigrants or natives, and whether to adjust their capital stocks and output levels accordingly. Over the long term, firms may also modify their production technology. For instance, if the influx of immigrants is predominantly low-skilled, firms may adopt production methods that rely more heavily on low-skilled labor. Immigration can also impact firms' innovation activities; for example, high-skilled immigrants may contribute to knowledge transfer and generate spillover effects, potentially boosting firms' total factor productivity. Immigrants may start new businesses, acting as "job creators." The decisions firms make regarding their capital stock, production technology, and innovation activities will ultimately shape their labor demand for different types of workers. Additionally, firms in different sectors of the economy may respond differently to immigration. For example, sectors heavily reliant on low-skilled workers might expand production in response to a low-skilled immigration shock. In contrast, high-skilled sectors could decrease production, altering the economy's output mix.

Market Responses to an Immigration Shock. Workers and firms interact in markets, and their combined actions determine the equilibrium effects of immigration on wages and employment. Modeling these effects requires assumptions about how the labor market functions (e.g., whether it is monopsonistic or competitive). Furthermore, the effects of immigration on wages and employment are influenced by its impact on the product market. Whether product prices will adapt to immigration depends on factors such as product market competitiveness, whether the economy in question is large or small, and whether it is open or closed. Moreover, in a closed economy, an immigration shock will affect native labor market outcomes not only directly through an increase in labor supply but also indirectly through an increase in consumption.

The Canonical Model. In the next section (Section II.2), we introduce a canonical model of the labor market that serves as the foundation for much of the theoretical and empirical work on the wage and employment effects of immigration in the existing literature. In its simplest version, this framework excludes several adjustment mechanisms discussed above. We treat the immigration shock as a pure labor supply shock, disregarding any indirect, consumption-induced labor market effects of immigration. We abstract from firm entry and exit. We assume a one-sector economy, so the output mix remains unchanged. While we allow firms to adjust their capital stock and total output in response to an immigration shock, they cannot modify their production technology or innovate. We further assume that product prices remain unaffected by the immigration shock, as the product market is perfectly competitive and the economy is small and open. Native workers can adjust their labor supply decisions in response to the immigration shock, but only in a limited manner. Specifically, we permit labor supply to be partially elastic but restrict the elasticity to be uniform across worker types. Finally, we assume that labor markets are perfectly competitive. This basic model forms the core of most empirical analyses in the field.

Within the canonical model, we identify two conceptually distinct wage effects of immigration: total effects that capture the impact of the total immigration shock on aggregate or skill-specific wages; and partial effects that capture the impact of the skill-specific immigration shock on skill-specific wages, holding the total immigration shock constant (Section II.3). While the partial wage effect is informative about the impact of immigration on one skill group relative to another, the total wage effect is informative about both the absolute and relative effects of immigration. We then connect these effects from the model to the effects estimated by empirical approaches in the literature (Sections III.1,III.2, and III.3).

Our analysis refers to the wage and employment effects of immigration on native workers, which may involve both incumbent immigrants and native workers. While incoming (and incumbent) immigrants may have varying skill levels compared to natives, we assume that immigrants and natives are perfect substitutes within the same skill groups. We relax this assumption in Section III.4. We summarize studies that utilize quasi-random immigration shocks to the firm in Section III.5 and discuss empirical challenges, including recent advances in shift-share designs, in Section III.6.

II.2 The Canonical Model: Setup

Production Function. Output Y is produced by combining capital K and labor L according to a Cobb-Douglas production function:

$$Y = \mathrm{A}L^{1-\alpha}K^{\alpha}$$

where A is a productivity shifter capturing total factor productivity. Let labor L be a CES aggregate of "low-skilled" (L_L) and "high-skilled" (L_H) labor:

$$L = [\theta L_L^{\beta} + (1-\theta)L_H^{\beta}]^{1/\beta}$$

The elasticity of substitution between low- and high-skilled workers is given by $1/(1-\beta)$, such that the two labor types are perfect substitutes if $\beta = 1$. It is important to note that this commonly used production function (see, e.g., Card, 2009; Ottaviano and Peri, 2012) assumes skill neutrality of capital and, therefore, does not account for scenarios where capital and high-skilled labor are complements, while capital and low-skilled labor are substitutes.[8]

This production function framework can be extended by allowing for additional nests; for example, low- and high-skilled labor may each be a CES aggregate of experienced and inexperienced labor, each of which, in turn, may be a CES aggregate of native and immigrant labor. We discuss these extensions in Sections III.3 and III.4.

Capital Supply. Capital is supplied to firms according to the following relationship:

$$r = K^{\lambda}$$

where r denotes the price of capital and $1/\lambda$ is the own-price elasticity of capital supply. A common assumption is that, in the long run, capital supply is perfectly elastic (i.e., $\lambda = 0$), whereas it may be perfectly inelastic in the short run (i.e., $\lambda \to \infty$).

Demand for labor. Firms choose capital and labor by maximizing their profits, taking the product price p, the wage rates for low- and high-skilled workers w_L and w_H , and the price of capital r as given:

$$\max_{L_L, L_H, K} \quad pAL^{1-\alpha}K^{\alpha} - (rK + w_L L_L + w_H L_H)$$

[8] An example of a production function that relaxes the assumption of skill neutrality is the one proposed by Lewis (2011), with $Y = A(K^{\beta} + L_L^{\beta})^{\frac{\alpha}{\beta}} L_H^{1-\alpha}$.

In Appendix A.1, we demonstrate that the following relationships emerge between the changes in the skill-specific ($dlogw_g$ for $g = L, H$) and aggregate ($dlogw$) wages and the changes in the skill-specific and aggregate labor demand:

$$(1a) \qquad dlogw_g = \varphi dlogL^D - (1-\beta)\big(dlog\, L_g^D - dlogL^D\big), \qquad g = L, H$$

$$(1b) \qquad dlogw = \varphi dlogL^D$$

Note that superscripts *D* have been added to emphasize that labor quantities pertain to labor *demand*. In Equation (1b), φ represents the inverse labor demand elasticity, which depends on the inverse elasticity of capital supply, λ, and the capital share in output (or total costs), α (see Appendix A.1 for a derivation):

$$(2) \qquad \varphi = -\frac{\alpha\lambda}{1-\alpha+\lambda} < 0$$

In Equation (1a), $(1-\beta)$ denotes the inverse elasticity of substitution between low- and high-skilled labor. The change in aggregate wages, $dlogw$, is a weighted average of the change in skill-specific wages, where the weights s_g are CES aggregators:

$$dlogw = s_L dlogw_L + s_H dlogw_H, \text{ and}$$

$$s_L = \frac{\theta L_L^\beta}{\left[\theta L_L^\beta + (1-\theta)L_H^\beta\right]}, \qquad s_H = \frac{(1-\theta)L_H^\beta}{\left[\theta L_L^\beta + (1-\theta)L_H^\beta\right]}$$

Labor Supply. Consider an exogenous immigration shock dI_g, defined as the net inflow of immigrants of skill type g into the economy divided by native employment of skill type g at baseline (i.e., $dI_g = \frac{\Delta M_g}{L_g^N}$), that shifts the skill-specific labor supply curves and, consequently, the aggregate labor supply curve outward. Native workers may adjust their labor supply decisions in response to the immigration shock along various margins; for example, natives may relocate to areas less affected by immigration, decide to stop working, or acquire more education. To capture the various forms of native employment adjustments, we consider one parameter only: the wage elasticity of labor supply η, assuming that this elasticity is constant across skill groups. We discuss natives' labor supply decisions in response to an immigration shock in more detail in Section V.1. For simplicity, we assume that the labor supply of incoming immigrants is inelastic.

With endogenous native labor supply responses, *total* (i.e., incoming immigrant plus native) skill-specific labor supply shifts out according to:

$$(3a) \quad dlog\, L_g^S = dI_g + dlogL_g^N = dI_g + \eta dlogw_g$$

where $dlogL_g^R$ denotes (endogenous) percent changes in the labor supply of native workers. Shifts in total aggregate labor supply are then a weighted average of the skill-specific shifts, where the weights are once again CES aggregators:

$$(3b) \quad dlog\, L^S = s_L dlog\, L_g^S + s_H dlog\, L_H^S = dI + dlogL^N = dI + \eta dlogw$$

Here, $dI = s_L dI_L + s_H dI_H$ is the total immigration shock in efficiency units of labor.

Equilibrium Wage and Employment Responses. In equilibrium, changes in the supply of labor must equal changes in the demand for labor; hence, $dlog\, L_g^D = dlog\, L_g^S$ and $dlogL^D = dlogL^S$. Substituting Equations (3a) and (3b) into Equations (1a) and (1b) and rearranging yields the following relationships between skill-specific and aggregate wage changes and the skill-specific and total immigration shocks (see Appendix A.2 for details):

$$(4a) \qquad dlogw_g = \frac{\varphi}{1-\varphi\eta} dI - \frac{(1-\beta)}{1+\eta(1-\beta)} \left(dI_g - dI\right)$$

$$(4b) \qquad dlogw = \frac{\varphi}{1-\varphi\eta} dI$$

Expression (4a) highlights that the changes in skill-specific wages depend on both the total (dI) and the skill-specific (dI_g) immigration shock. Expression (4b) illustrates the effect of immigration on aggregate wages.

Both effects are first-order effects, capturing linear expansion effects around a small migration shock. Throughout the chapter, we focus on these first-order effects in the comparative statics analysis; see Appendix B in Dustmann, Frattini, and Preston, 2013, for second-order effects.

II.3 Total versus Partial Effects of Immigration

Based on Equations (4a) and (4b), we can derive two conceptually distinct effects of immigration: *total* and *partial* effects. The total effect of immigration can be further divided into total aggregate and total skill-specific effects. We describe these effects in turn.

II.3.1 Total Aggregate Wage and Employment Effects of Immigration

Consider first the impact of the total immigration shock dI on aggregate wages and aggregate native employment, $\frac{dlogw}{dI}$ and $\frac{dlogL^N}{dI}$, effects we label as the "total aggregate wage effect of immigration"[9] and the "total aggregate employment effect of immigration." The wage effect follows from Equation (4b), while the employment effect follows from the labor supply curve (3b):

$$\text{(5a)} \qquad \frac{dlogw}{dI} = \frac{\varphi}{1-\varphi\eta}$$

$$\text{(5b)} \qquad \frac{dlogL^N}{dI} = \eta\frac{dlogw}{dI} = \frac{\eta\varphi}{1-\varphi\eta}$$

[9] Dustmann, Otten, Schönberg, and Stuhler (2024) refer to this effect as the "pure wage effect of immigration".

The total aggregate wage effect of immigration depends on the inverse labor demand elasticity, φ, and the labor supply elasticity, η. The inverse labor demand elasticity captures the percent decline in aggregate wages in response to an exogenous increase in *total* labor supply by one percent. In other words, the inverse labor demand elasticity is informative about how much aggregate wages would change if native workers cannot adjust their labor supply following the immigration shock (i.e., if native labor supply is perfectly inelastic, such that $\eta = 0$). In the case of a Cobb-Douglas technology in the first layer of the production function, the inverse labor demand elasticity depends on the inverse elasticity of capital supply, λ, and the capital share in output, α (see Equation (2)). Suppose that the supply of capital does not adjust following the immigration shock (i.e., if $\lambda \rightarrow \infty$, a case sometimes referred to as the short run). In this scenario, the inverse labor demand elasticity approaches the capital share in output, $-\alpha$. Thus, when workers and firms cannot adjust their labor supply and capital stock, a one-unit increase in the total immigration shock (equivalent to a one percent increase in total labor supply in efficiency units) will lead to a decline in aggregate wages by $-\alpha$ percent. This case is a "worst-case" scenario. It is worth highlighting that, under a Cobb-Douglas production function, α must lie between 0 and 1, so we would expect the total aggregate wage effect of immigration to be less than -1. Some studies explicitly aim to recover this effect (e.g., Borjas and Edo, 2021; Jaeger, Ruist, and Stuhler, 2018).

If firms adjust their capital stock or native workers alter their labor supply in response to the immigration shock, the adverse impact of immigration on aggregate wages will be smaller and may disappear. Indeed, if the supply of capital is perfectly elastic (i.e., if $\lambda \rightarrow 0$), an immigration shock will leave aggregate wages unchanged even if native labor supply is perfectly inelastic (i.e., if $\lambda \rightarrow 0,\ \varphi \rightarrow 0$). Therefore, the elasticity of capital supply plays a crucial role in determining the impact of immigration on aggregate wages.

The labor supply elasticity η is the second key parameter that affects the impact of immigration on aggregate wages in the economy. The labor supply elasticity determines how much the immigration shock is absorbed through aggregate wage declines instead of aggregate declines in native employment. A higher labor supply elasticity implies a larger native employment response and a smaller wage effect of immigration. If the native labor supply is perfectly elastic (i.e., $\eta \to \infty$), aggregate wages will remain unchanged, and only native employment will adjust.

These considerations highlight the importance of *jointly* studying natives' wage and employment responses to immigration. Wages may hardly respond to an immigration shock because the inverse labor demand elasticity is small or the labor supply elasticity is large. It is straightforward to back out the labor supply elasticity and the inverse labor demand elasticity from the aggregate wage and native employment responses:

$$\eta = \frac{dlogL^N/dI}{dlogw/dI} \tag{6a}$$

$$\varphi = \frac{dlogw/dI}{dlogL^S/dI} = \frac{dlogw/dI}{1+dlogL^N/dI} \tag{6b}$$

Equation (6b) highlights that we can infer the inverse labor demand elasticity by dividing the immigration-induced wage response ($dlogw/dI$) by the immigration-induced percent change in *total* employment ($dlogL^S/dI = 1 + dlogL^N/dI$), thereby accounting for natives' endogenous labor supply responses.

We summarize the effects of immigration on total aggregate native wages in Panel A of Table 1a, where we successively allow for more adjustment mechanisms to the immigration shock and illustrate how these adjustments affect the wage response.

II.3.2 Total Skill-Specific Wage and Employment Effects of Immigration

Next, consider the impact of the total immigration shock dI on skill-specific wages, $\frac{dlogw_g}{dI}$, and native employment, $\frac{dlogL_g^N}{dI}$, effects which we label as the "total skill-specific wage effect of immigration" and the "total skill-specific employment effect of immigration". These effects directly follow from Equation (4a) and the labor supply curve given by Equation (3a):[10]

$$\text{(7a)} \qquad \frac{dlogw_g}{dI} = \frac{\varphi}{1-\varphi\eta} - \frac{(1-\beta)}{1+\eta(1-\beta)}\left(\frac{dI_g}{dI} - 1\right)$$

$$\text{(7b)} \qquad \frac{dlogL_g^N}{dI} = \eta\frac{dlogw_g}{dI}$$

The total skill-specific wage effect consists of two parts. The first part, $\frac{\varphi}{1-\varphi\eta}$, is common to both skill groups and corresponds to the total aggregate wage effect of immigration. This is a consequence of the assumption that capital is skill-neutral. The second part, $-\frac{(1-\beta)}{1+\eta(1-\beta)}\left(\frac{dI_g}{dI} - 1\right)$, differs across the two skill groups. The sub-component $\left(\frac{dI_g}{dI} - 1\right)$ is positive for the skill group that experiences the larger inflow of immigrants and negative for the other skill group. For example, suppose the ratio of low-skilled to high-skilled workers is higher among incoming immigrants than employed natives. In that case, $\left(\frac{dI_g}{dI} - 1\right)$ will be positive for low-skilled and negative for high-skilled workers.[11] Consequently, the wages of the skill group that is more exposed to immigration—and hence more likely to compete with immigrants for jobs—will decline relative to the wages of the skill group less exposed to immigration. If capital supply is perfectly elastic, the more exposed native group experiences an absolute wage decline, while the less exposed group experiences an absolute wage increase. The

[10] See Dustmann, Frattini, and Preston (2013) for the derivation in the case of many skill groups.

[11] To see this, note that $\frac{dI_L}{dI} - 1 > 0$ if $dI_L > dI_H$, as $dI = s_L dI_L + (1 - s_L)dI_H$. Recall that $dI_g = \frac{\Delta M_g}{L_g^N}$. Hence, $dI_L > dI_H$ if $\frac{\Delta M_L}{L_L^N} > \frac{\Delta M_H}{L_H^N}$ or if $\frac{\Delta M_L}{\Delta M_H} > \frac{L_L^N}{L_H^N}$.

relative wage impact is determined by the inverse elasticity of substitution between the two skill groups and disappears if the two skill groups are perfect substitutes. Conversely, if the immigration shock is balanced, meaning that the ratio of low-skilled to high-skilled workers is the same among incoming immigrants and employed natives, the second term disappears, and the wages of low- and high-skilled workers change by the same amount ($\frac{\varphi}{1-\varphi\eta}$).

The labor supply elasticity η once again determines the extent to which the immigration shock leads to adjustments in skill-specific wages versus skill-specific native employment levels. A higher labor supply elasticity mutes the skill-specific wage response but amplifies the skill-specific employment response.

II.3.3 Partial Wage and Employment Effects of Immigration by Skill

A conceptually distinct parameter to the total effects of immigration is the partial wage and employment effect of immigration (by skill) that isolates the impact of the skill-specific immigration shock dI_g and holds the total immigration shock dI constant. These partial effects directly follow from Equation (4a) and the labor supply curve given by Equation (3a):

$$\text{(8a)} \qquad \left.\frac{dlogw_g}{dI_g}\right|_{dI} = \frac{dlogw_g - dlogw_{g'}}{dI_g - dI_{g'}} = -\frac{(1-\beta)}{1+\eta(1-\beta)}$$

$$\text{(8b)} \qquad \left.\frac{dlogL_g^N}{dI_g}\right|_{dI} = \frac{dlogL_g^N - dlogL_{g'}^N}{dI_g - dI_{g'}} = \eta\frac{dlogw_g - dlogw_{g'}}{dI_g - dI_{g'}} = -\eta\frac{(1-\beta)}{1+\eta(1-\beta)}$$

The partial wage and employment effects capture the effects of immigration of one skill group g *relative to* the other skill group g'. They are, therefore, informative only about the distributional but not about the absolute effects of immigration. Partial wage and employment effects are unambiguously negative and depend on two structural parameters: the inverse elasticity of substitution $(1-\beta)$ and the labor supply elasticity η. While a higher inverse elasticity of substitution amplifies both the relative wage and employment responses, a higher labor supply elasticity η reduces the relative wage response but magnifies the relative employment response. In Panel A of Table 1b, we summarize the role of the inverse elasticity of substitution and the labor supply elasticity in determining the partial wage and employment effects of immigration.

In contrast to the partial wage and employment effects of immigration, the total skill-specific wage and employment effects, as outlined in Equations (7a) and (7b), provide insights into both the relative and absolute impacts of immigration. These total effects not only account for the direct impact of immigration on the wages of the exposed group but also for the indirect effects arising from complementarities between different skill groups and between labor and capital. While, according to the basic canonical model, the partial wage and employment effects of immigration are unambiguously negative, the total wage and employment effects can be either negative or positive, depending on the interplay of these indirect influences.

III Empirical Approaches

To empirically estimate the total or partial wage and employment effects of immigration, researchers slice the labor market and leverage variations in immigration shocks across these segments. Most commonly, they examine local labor markets differentially affected by immigration. The "*pure spatial approach*," introduced by Altonji and Card (1991), exploits variations in the total immigration shock across regions. Alternatively, the "*mixture (or spatial-skill) approach*" as implemented, for example, by Card (2001) and Dustmann and Glitz (2012), uses variation in the inflow of immigrants across both skill groups and regions. In contrast, the *"national skill-cell approach"* pioneered by Borjas (2003) eliminates regional variations in immigration shocks. This method segments the national labor market by education and experience groups and uses variation in the education-experience-specific immigration shock at the *national* level for identification.

Each approach addresses important but distinct research questions, and their estimates are not directly comparable. If viewed through the lens of the canonical model, the pure spatial approach identifies the *total* (aggregate or skill-specific) wage and employment effects of immigration, as outlined in Equations (5a), (5b), (7a), and (7b) in Sections II.3.1 and II.3.2. In contrast, the mixture approach estimates the *partial* wage and employment effects of immigration, as described in Equations (8a) and (8b) in Section II.3.3. The national skill-cell approach also identifies partial effects, but one that is distinct from those captured by the mixture approach.

The following sections detail each approach and review selected empirical studies. Table 2 summarizes the different empirical methodologies, their connections to the canonical model, and the research questions they address. Throughout this section, we assume that the immigration shock is exogenous. We discuss identification strategies and instrumentation in Section III.6.1.

III.1 The Pure Spatial Approach

III.1.1 Total Aggregate Effects of Immigration

Empirical Specification and Interpretation. The typical regression estimated in this strand of the literature (e.g., Hunt, 1992; Dustmann, Fabbri, and Preston, 2005) is:

$$(9) \qquad \Delta log w_{rt} = \Delta\pi_t + \theta^{Wpure}\Delta I_{rt} + \Delta u_{rt}$$

where $\Delta log w_{rt}$ denotes the change in average native log wages in region r between a base and end period, $\Delta\pi_t$ denotes time effects that are constant across regions, ΔI_{rt} denotes the total immigration shock to the region, and Δu_{rt} is an error term.[12] Note that, by relating

[12] While the exact definition of the immigration shock varies across studies, our preferred definition is the number of immigrants who enter employment in the region between the base and end periods, divided by the number of employed natives at baseline (as in, e.g., Dustmann, Schönberg, and Stuhler, 2017). Some studies use the change in the immigrant share of local employment (or of the local population) in the area as the right-hand side variable (e.g., Dustmann, Fabbri, and Preston, 2005) This is potentially problematic, as native employment

regional wage *growth* to the regional immigration *shock,* time-invariant unobserved region-specific wage components that may be correlated with the stock of immigrants (a "region fixed effect" in a log wage *level* regression) are differenced out. A causal interpretation of requires orthogonality between the immigration shock (ΔI_{rt}) and the wage growth residual (Δu_{rt}), a condition that we discuss in more detail in Section III.6.1.

The parameter θ^{Wpure} speaks to the following question: "*How does the regional immigration shock affect regional native wages*?" If viewed through the lens of the simple canonical model outlined in Section II.1, it closely corresponds to the total aggregate wage effect of immigration given by Equation (4a) (see also Table 2). It depends on two structural parameters: the inverse labor demand elasticity φ and the labor supply elasticity η.[13] As Dustmann, Otten, Stuhler, and Schönberg (2024) note, this interpretation hinges on the assumption that immigration does not lead to compositional changes in the workforce. Such compositional changes arise if employment responses to the immigration shock differ across worker groups. We discuss this problem and how to deal with it in Section IV.2.

Importantly, since the pure spatial approach leverages variation in the total immigration shock across regions, η should be considered a local labor supply elasticity that captures movements between employment and non-employment and movements across regions.

Selected Studies. In Table 3, we provide examples of estimates of the total aggregate wage effect of immigration obtained from versions of regression Equation (9). While most studies report the impact of a one-percentage-point increase in the immigrant employment (or

and population may adjust to the immigration shock; thus, the immigration shock potentially captures an endogenous outcome.

[13] A discrepancy arises because, in Equation (5a), the CES aggregates s_L and s_H are used to compute the total immigration shock in efficiency units (i.e., $dI = s_L dI_L + s_H dI_H$). In contrast, in empirical studies, the total immigration shock ΔI_{rt} is typically measured in headcounts. Similarly, the aggregate wage change in Equation (5a) corresponds to a weighted average of the skill-specific wage changes with CES aggregates as weights (i.e., $dlogw = s_L dlogw_L + s_H dlogL_H$). While the exact definition of the regional wage change $\Delta logw_{rt}$ differs across empirical studies, it rarely corresponds exactly to its theoretical counterpart.

population) share, some present "reduced-form" estimates. These compare changes in (log) native wages before and after the immigration shock between "treated" and "control" areas (e.g., Card, 1990; Beerli, Ruffner, Siegenthaler, and Peri, 2021). In such cases, we scale the wage estimates reported in the respective studies by the overall immigration shock to ensure comparability with other estimates.

Studies also differ in the time horizon over which Equation (9) is differenced—ranging from one year in Card (1990) to up to six years in Beerli, Ruffner, Siegenthaler, and Peri (2021)—as well as in the aggregation of regional units, such as municipalities (Dustmann, Schönberg, and Stuhler, 2017) versus broad regions (Dustmann, Frattini and Preston, 2013). Both of these factors can influence the wage response. For instance, we generally expect the inverse labor demand elasticity and the total aggregate wage effect to be smaller over longer time horizons as firms have more time to adjust their capital stock. Similarly, we expect the local labor supply elasticity to be smaller and, consequently, the total aggregate wage effect to be larger when the regional unit is more coarsely defined—a point emphasized, for example, by Borjas, Freeman, and Katz (1997) and Borjas (2014, Chapter 4). Columns (3) and (4) of the table record the time horizon and geographical aggregation, respectively. As noted by Dustmann, Otten, Schönberg, and Stuhler (2024) and discussed in Section IV.2, immigration may also lead to compositional changes in the workforce. Studies explicitly addressing compositional changes are highlighted in light green in the table.

The table reveals substantial variation in estimates across studies. Borjas and Edo (2021) and Hunt (1992) report the most negative wage effects, with baseline point estimates suggesting that a one-percentage-point increase in the immigrant labor force share reduces native wages by 0.78% to 0.95%. Dustmann, Schönberg, and Stuhler (2017) and Ortega and Verdugo (2022) also find moderately negative wage effects of -0.13% and -0.24%, respectively.[14] Other studies, such as Tumen (2016) and Card (1990), report point estimates close to zero. In contrast, two studies—Dustmann, Fabbri, and Preston (2005) and Dustmann, Frattini, and Preston (2013)—find positive wage effects on average or at the median, although these estimates are imprecisely measured.

One possible explanation for the small native wage responses observed in some studies is that native labor supply adjusts to the immigration shock, for example, by natives relocating to regions less affected by immigration. Consequently, we might expect a stronger native employment response whenever the wage response to immigration is weaker. However, the data presented in Table 3 offers limited support for this hypothesis. The table displays employment effects alongside the definition of the employment variable in Columns (9) and (10). Although the definition of employment varies across studies, three studies that report a statistically significant aggregate wage decline in response to immigration also document declines in native employment (Dustmann, Schönberg, and Stuhler, 2017; Hunt, 1992; Ortega and Verdugo, 2022). In contrast, other studies examining native employment responses to immigration generally find small (e.g., Beerli, Ruffner, Siegenthaler, and Peri, 2021) or even positive (Tabellini, 2020) employment effects.

One can back out the labor demand (and supply) elasticity from the estimated wage and employment responses to immigration using the structure of the canonical model (Equations (6a) and (6b)). Estimates reported by Dustmann, Schönberg, and Stuhler (2017) indicate a large labor supply elasticity of approximately $\eta = 7$ (0.926/0.134), possibly because the regional unit in their study is highly disaggregated and movements across small regional units are common. Estimates reported by Borjas and Edo (2021) imply inverse labor demand elasticities of $\varphi =$ -0.78 (for men) and -0.95 (for women), while estimates reported by Hunt (1992) and Dustmann, Schönberg, and Stuhler (2017) imply inverse labor demand

[14] Aksu, Erzan, and Kırdar (2022) report negative wage and employment effects in the informal sector but positive effects in the formal sector in response to a large inflow of refugees from Syria to Turkey in the 2010s.

elasticities of -0.98, and -1.8, respectively.[15] According to these estimates, an exogenous increase in total labor supply by 1 percent would lower native wages by between 0.78 and 1.8 percent. The wage and employment effects reported in the other studies in Table 2 suggest very small (or even positive) and imprecisely estimated inverse labor demand elasticities. For comparison, a meta-study by Lichter, Peichl, and Siegloch (2015), based on 151 studies unrelated to immigration, found that the mean labor demand elasticity is -0.551 — corresponding to an inverse labor demand elasticity of approximately -1.8. Fewer than 13% of studies report inverse labor demand elasticities smaller than -1, and hardly any studies record positive labor demand elasticities.

One reason labor demand elasticities inferred from immigration shocks appear larger (and inverse elasticities smaller) than those reported in the meta-study could be that immigration also influences firms' production technologies and innovation activities—mechanisms we explore in Section V (see also Table 1a). Another possible explanation, discussed in Section IV.2, is that immigration may disproportionately reduce employment among low-productivity workers, thereby enhancing overall worker quality.

III.1.2 Total Skill-Specific Effects of Immigration

Empirical Specification and Interpretation. Other Studies (e.g., Dustmann, Schönberg, and Stuhler, 2017; Dustmann, Frattini, and Preston, 2013; Foged and Peri, 2016; Beerli, Ruffner, Siegenthaler, and Peri, 2021) have estimated variants of Equation (9) but use the skill-specific

[15] Assuming that native labor supply adjusts only through unemployment, the native unemployment response in Hunt (1992) suggests an immigration-induced increase in total labor supply of 0.815 percent, implying an inverse labor demand elasticity of -0.8/0.815=0.98. The large native labor supply response in Dustmann, Schönberg and Stuhler (2017) implies an immigration-induced increase in total labor supply of 0.074 (1-0.926) percent and an inverse labor demand elasticity of -1.8 (-0.134/0.074). Borjas and Edo (2021) condition on (log) native labor supply in some of their specifications so that the coefficient on the immigrant share can be interpreted as the inverse labor demand elasticity (see Column (8) in Table 4 in their paper).

(rather than aggregate) wage change of natives in the region ($\Delta logw_{grt}$) as the dependent variable while also controlling for skill-specific time effects ($\Delta\pi_{gt}$):

$$(10) \qquad \Delta logw_{grt} = \Delta\pi_{gt} + \theta_g^{Wpure}\Delta I_{rt} + \Delta u_{grt}$$

This approach thus links the *total* immigration shock to *skill-specific* wage changes. The parameter θ_g^{Wpure} speaks to the following question: "*How does the total regional immigration shock affect regional native skill-specific wages?*"

If viewed through the lens of the canonical model outlined in Section II.2, θ_g^{Wpure} corresponds to the total skill-specific effect of immigration given by Equation (7a) (see also Table 2).[16] It is a combination of several structural parameters: the inverse labor demand elasticity, the labor supply elasticity, the inverse elasticity of substitution between skill groups, and, crucially, whether or not the skill group under consideration is disproportionately exposed to immigration. It captures not only the direct partial effects of immigration on wages of the group under consideration but also the indirect effects stemming from complementarities between the two skill groups and between labor and capital.

Selected Studies. We illustrate the pure spatial approach with multiple skill groups in Figure 2, based on the work of Dustmann, Frattini, and Preston (2013). They focus on the UK, which saw a three-percentage-point increase in the foreign-born population during their study period of 1997 to 2005. Dustmann, Frattini, and Preston (2013) extend the canonical model described in Section II.2 to multiple skill groups and classify immigrants based on their position within the native wage distribution rather than their education. As discussed in

[16] A discrepancy arises because the immigration shock is measured in efficiency units in Equation (7a) but in headcounts in the empirical analysis. The parameter θ_g^{Wpure} thus corresponds to the total skill-specific wage effect of immigration given by equation (7a) up to a factor dI/dI^{HC}, where dI is the total immigration shock in efficiency units and dI^{HC} is the total immigration shock in headcounts.

Section III.6.2, this method may more accurately reflect which types of workers compete for jobs, particularly when highly educated immigrants take on low-skilled positions.

Panel A of Figure 2 shows the distribution of incoming immigrants across the native wage distribution. Immigrants are heavily overrepresented at the bottom (below the 20th percentile), underrepresented in the middle (between the 20th and 90th percentiles), and overrepresented again at the very top (above the 90th percentile).

Panel B (corresponding to Figure 2 in Dustmann, Frattini, and Preston, 2013) displays IV estimates of the total wage effects of immigration along the wage distribution, using past regional settlements as an instrument. This panel mirrors Panel A: the total wage effects of immigration are negative at the lower end of the wage distribution, where immigrants are heavily concentrated. The effects turn positive further up the distribution, where immigrants are underrepresented, and then decline again at the top, where immigrants are once more overrepresented. These findings support a key prediction of the canonical model: native workers more exposed to immigration experience relative wage declines compared to those less exposed.

Panel C (corresponding to Figure 4 in Dustmann, Frattini, and Preston, 2013) further illustrates this point. The panel plots IV estimates of the total wage effects of immigration at every fifth percentile of the native wage distribution (from Panel B) against the relative density of immigrants at those percentiles (from Panel A). This figure visually confirms a robust negative relationship. Viewed through the lens of the canonical model, the slope of the fitted line reflects the inverse elasticity of substitution between skill groups. The estimates in Dustmann, Frattini, and Preston (2013) indicate an inverse elasticity of substitution of 1.69 (an elasticity of substitution of 0.6).[17]

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[17] From equation (7a), the slope of the fitted line in Panel C recovers $\frac{dlogw_g - dlogw_{g'}}{dI_g - dI_{g'}} = -\frac{(1-\beta)}{1+\eta(1-\beta)}$, where $(1-\beta)$ is the inverse of the elasticity of substitution between skill groups and η is the labor supply elasticity. Dustmann, Frattini and Preston (2013) assume that labor supply is inelastic.

We present an overview of additional estimates of the total skill-specific wage effects of immigration, derived from versions of regression Equation (10), in Table 4. Since the sign and magnitude of the wage effect depend on the nature of the immigration shock (e.g., whether it involves low- or high-skilled immigrants), we indicate in Column (5) whether the shock is predominantly low- or high-skilled. Four studies shown in the table (e.g., Altonji and Card, 1991; Dustmann, Frattini, and Preston, 2013; Dustmann, Schönberg, and Stuhler, 2017; and Monras, 2020) support a key prediction of the canonical model: the total wage effect of immigration is negative for the skill group most exposed to the immigration shock.[18] Furthermore, Lalonde and Topel (1991) and Cortes (2008) report small negative effects of a low-skilled immigration shock on the wages of incumbent (low-skilled) immigrants.

In contrast, Foged and Peri (2016) report positive total wage and employment effects for low-skilled natives in Denmark despite the predominantly low-skilled nature of the immigration shock. They attribute this result to native workers upgrading their skills (see also Section V.1). Similarly, Beerli, Ruffner, Siegenthaler, and Peri (2021) find that a predominantly high-skilled immigration shock in Switzerland significantly increased wages and employment for high-skilled natives, both in absolute terms and relative to low-skilled natives. They attribute this positive effect to enhanced innovation following the immigration shock.

[18] It should be noted that Monras (2020) defines the immigration shock as the change in the labor force share of Mexicans among *low-skilled* (as opposed to all) workers in the region. In this context, Mexicans are predominantly low-skilled and hence $dI_H \approx 0$. This approach identifies $\frac{dlogw_{\mathrm{L}}}{dI_L}$ and $\frac{dlogw_{\mathrm{H}}}{dI_L}$, which are somewhat different from (though closely related to) the total wage effect of immigration given by Equation (8a). From Equation (4a) and $dI_H = 0$, $\frac{dlogw_{\mathrm{L}}}{dI_L} = \mathrm{s_L}\frac{\varphi}{1-\varphi\eta} - (1-\mathrm{s_L})\frac{(1-\beta)}{1+\eta(1-\beta)}$ and $\frac{dlogw_{\mathrm{H}}}{dI_L} = \mathrm{s_L}\frac{\varphi}{1-\varphi\eta} + \mathrm{s_L}\frac{(1-\beta)}{1+\eta(1-\beta)}$. Similar arguments apply to Cortes (2008).

III.2 The Mixture Approach

III.2.1 Empirical Sepcification and Interpretation

Like the pure spatial approach, the mixture approach also leverages variation in the immigration shock across regions. However, it links the *skill-specific* immigration shock to skill-specific wage changes while also controlling for region-specific and skill-specific time effects:

$$(11) \qquad \Delta logw_{rgt} = \Delta\pi_{rt} + \Delta\lambda_{gt} + \theta^{Wmix}\Delta I_{rgt} + \Delta u_{grt}$$

The parameter θ^{Wmix} can be thought of as a triple difference estimator where differences are taken over time between skill groups and between regions. For two time periods, two skill groups, and two regions, it simplifies to:

$$\theta^{Wmix} = \frac{(E[\Delta logw_{LA}] - E[\Delta logw_{HA}]) - (E[\Delta logw_{LB}] - E[\Delta logw_{HB}])}{(E[\Delta I_{LA}] - E[\Delta I_{HA}]) - (E[\Delta I_{LB}] - E[\Delta I_{HB}])}$$

Differencing between skill groups within regions cancels out the region-specific time effect $\Delta\pi_{rt}$, while differencing between regions cancels out the skill-specific time effect $\Delta\lambda_{gt}$. This expression emphasizes that the mixture approach identifies a relative wage effect. By incorporating region-specific time effects in regression Equation (11), any immigration effects common to all skill groups (i.e., the direct effects of the total immigration shock) are filtered out. Consequently, estimates from the mixture approach provide insights into the effects of immigration on one skill group relative to another. The parameter θ^{Wmix} addresses the question: "*How does the regional skill-specific immigration shock affect regional native skill-specific wages while holding the total regional immigration shock constant?*"

If viewed through the lens of the canonical model, estimates obtained from the mixture approach correspond to the "partial wage effect of immigration by skill" given by Equation (8a); see also Table 2. This effect depends on two structural parameters: the inverse elasticity of substitution between skill groups $1-\beta$, and the labor supply elasticity η. It is unambiguously negative, especially when the inverse elasticity of substitution between skill groups is larger, and the labor supply elasticity is smaller. Employment effects from the mixture approach are also unambiguously negative, more so when the labor supply is more elastic.

By including region-by-time fixed effects in regression Equation (11), the mixture approach, unlike the pure spatial approach, no longer provides information about the absolute wage and employment effects of immigration. A negative relative wage effect identified using the mixture approach could indicate wage declines for both skill groups due to immigration, with a more considerable decline for one group than the other. Alternatively, it could reflect wage increases for both skill groups, with a larger increase for one group compared to the other. In contrast, the pure spatial approach differentiates between these scenarios, offering a more comprehensive view of the effects of immigration on wages and employment.

While estimates from the mixture approach are less informative than those from the pure spatial approach, the mixture approach addresses a significant identification challenge: immigrants tend to settle in regions experiencing positive economic shocks. The mixture approach accounts for this potential sorting of immigrants into areas with positive overall shocks by controlling for region-specific time effects. However, it assumes that immigrants of a particular skill group do not selectively move to regions experiencing positive shocks specific to that skill group.[19]

III.2.2 Selected Studies

We present several estimates derived from the mixture approach in Table 5. As predicted by the canonical model, partial wage effects are generally negative. However, these estimates

[19] Nevertheless, most empirical studies based on the mixture approach adopt an instrumental variable strategy to isolate quasi-exogenous variation in the region-skill-specific immigration shock ΔI_{grt} in Equation (11).

vary in magnitude and are not always statistically significant. The variation across studies can be partly attributed to different definitions of skill groups and the time lag between observations. For instance, Monras (2020) reports the most negative effect, focusing on two skill groups and short-term impacts (one year after the unexpected arrival of Mexican immigrants following the Peso crisis). Similarly, Card (2009) finds negative relative wage effects when distinguishing between high school and college graduates. In contrast, Card and Lewis (2007) find little evidence that the wages of high school graduates relative to high school dropouts are affected by relative labor supply changes over a 10-year horizon, suggesting that these two groups are close to perfect substitutes.[20]

Using the estimates of the partial wage (and employment) effects of immigration, we can deduce the elasticity of substitution between skill groups by leveraging the structure of the canonical model (see Equations (8a) and (8b)). Among the studies in Table 4, only one (Monras, 2020) implies an elasticity below 2, while six of the nine studies suggest elasticities above 4. The elasticity of substitution between skill groups can also be inferred from the total wage effects of immigration by skill level obtained using the pure spatial approach. For example, estimates by Dustmann, Frattini, and Preston (2013), who define skill groups based on wage percentiles, imply an elasticity of substitution of 0.6 (see Panel C of Figure 1).

For comparison, seminal studies on the evolution of returns to education by Katz and Murphy (1992) and Card and Lemieux (2001) report an elasticity of substitution between high school and college labor in the US of about 1.41 (for both men and women) and between 2 and 2.5 (for men), respectively. One reason the elasticities of substitution inferred from immigration shocks tend to be higher than those estimated in the education literature could be that skill-specific immigration shocks trigger additional adjustment mechanisms not

[20] In a meta-analysis, Foged, Hasager, and Yasenov (2022) conclude that differences in labor market institutions account for some of the variation in the estimates of the partial wage and employment effects of immigration across studies.

accounted for in the baseline canonical model, such as endogenous technology adoption or changes in industry structure. We explore these adjustment channels in Sections V.3 and V.6.

Another explanation for the large implied elasticities of substitution between skill groups inferred from immigration shocks is downgrading—when highly educated immigrants work in low-skilled jobs, thus competing with low-skilled rather than high-skilled natives. The smaller elasticities of substitution reported by Monras (2020) (which studies an unexpected inflow of Mexican immigrants, who predominantly have low formal education and hence downgrade less) and by Dustmann, Frattini, and Preston (2013) (who define skill groups based on workers' positions in the wage distribution, mitigating the issue of downgrading) support this explanation. We discuss the phenomenon of downgrading in more detail in Section III.6.2.

III.3 The National Skill-Cell Approach

Borjas (1994) has criticized empirical approaches that rely on regional variation in immigration shocks, arguing that the effects may diffuse across the entire economy if native employment is highly elastic at the geographical margin. This critique suggests that, within the canonical model outlined in Section II.2, the local labor supply elasticity η is large, leading to small wage effects but considerable native employment responses. Supporting this hypothesis, Borjas (2014, Chapter 4) shows that in the pure spatial approach, the total aggregate wage effects of immigration become more negative as the size of the regional units increases.

To address this issue, Borjas (2003) proposes an alternative method for estimating the labor market effects of immigration, which eliminates regional variation in immigration shocks. This method segments the national labor market by education and experience groups and uses variation in the education-experience-specific immigration shock at the *national* level for identification. We describe the empirical specification of this "national skill-cell approach" in the following section. Subsequently, we interpret the wage and employment estimates obtained from this approach through the lens of an extension of the canonical model and present findings from selected studies that utilize the national skill-cell approach.

III.3.1 Empirical Specification

The national skill-cell approach links the education-age-specific immigration shock at the national level to education-age (or experience)-specific wage changes while also controlling for education and age-specific time effects:

$$(12) \qquad \Delta logw_{gat} = \Delta\pi_{at} + \Delta\lambda_{gt} + \theta^{NSC}\Delta I_{gat} + \Delta u_{gat}$$

where the subscripts g and a denote education and experience.[21] Borjas (2003) distinguishes between five education and eight experience groups. The parameter θ^{NSC} can be thought of as a triple difference estimator where differences are taken over time between education groups and between experience groups. As argued by Dustmann, Schönberg, and Stuhler (2016), for two time periods, two education groups (**L**ow and **H**igh) and two experience groups (**I**nexperienced and **E**xperienced), it simplifies to:

$$\theta^{NSC} = \frac{(E[\Delta logw_{LI}] - E[\Delta logw_{LE}]) - (E[\Delta logw_{HI}] - E[\Delta logw_{HE}])}{(E[\Delta I_{LI}] - E[\Delta I_{HE}]) - (E[\Delta I_{LI}] - E[\Delta I_{HE}])}$$

Differencing between experience groups within education groups eliminates the education-specific time effects $\Delta\lambda_{gt}$, while differencing between education groups removes the experience-specific time effects $\Delta\pi_{at}$. This expression illustrates that the national skill-cell approach identifies a relative wage effect that differs from that identified by the mixture

[21] Borjas (2003) estimates (log) wage regressions in levels rather than in first differences (as in Equation (12) above) and includes age group-by-time fixed effects, education group-by-time fixed effects, and age-by-education group fixed effects in the level regression. The resulting estimates should be similar to the first difference regression (12).

approach. By including education-specific time effects in Equation (12), the national skill-cell approach eliminates any effects of immigration that are common to all education-experience groups (i.e., the direct effects of the total immigration shock) as well as those common to all experience groups within the same education category (i.e., the direct effects of the education-specific immigration shock). As a result, estimates from the national skill-cell approach provide insights into the wage effects of immigration for one experience group relative to another experience group within the same education group. They address the question: "*How does the national education-experience-specific immigration shock impact national native education-experience-specific wages while holding constant the total and education-specific national immigration shock?*"

III.3.2 Interpretation: Extending the Canonical Model

The national skill-cell approach addresses an important question regardless of researchers' assumptions about the "true" underlying model influencing wage and employment responses to immigration. However, by extending the canonical model outlined in Section II.2, we can interpret the wage and employment effects of immigration obtained from this approach within the framework of the extended model.

Suppose that labor in each education group g is a CES aggregate of inexperienced (indexed by the sub-index $a = I$) and experienced (indexed by the sub-index $a = E$) workers (as discussed in Section VII in Borjas, 2003):[22]

$$L_g = [\tilde{\theta} L_{gI}^{\gamma} + (1 - \tilde{\theta}) L_{gE}^{\gamma}]^{1/\gamma}$$

where $-\frac{1}{1-\gamma}$ is the elasticity of substitution between inexperienced and experienced workers within education group g. It is then straightforward to show that Equation (4a) becomes (see Appendix A.3 for details):

[22] This production function is similar to that in Card and Lemieux (2001).

$$(13) \qquad dlogw_{ga} = \frac{\varphi}{1-\varphi\eta} d\tilde{I} - \frac{(1-\beta)}{1+\eta(1-\beta)} \left(d\tilde{I}_g - d\tilde{I}\right) - \frac{(1-\gamma)}{1+\eta(1-\gamma)} \left(dI_{ga} - d\tilde{I}_g\right)$$

where $dI_{ga} = \frac{\Delta M_{ga}}{L^R_{ga}}$ is the education-experience-specific immigration shock (i.e., the inflow of immigrants in a particular education-experience group divided by native employment in that skill-experience group at baseline), $d\tilde{I}_g = s_{gI} dI_{gI} + (1 - s_{gI}) dI_{gE}$ is the education-specific immigration shock in efficiency units,[23] and $d\tilde{I} = s_L d\tilde{I}_L + s_H d\tilde{I}_H$ is the total immigration shock in efficiency units. This expression highlights that the wage response to immigration for education group g and experience group a depends not only on the total and education-specific immigration shocks, $d\tilde{I}$ and $d\tilde{I}_g$, but also on the education-experience-specific immigration shock dI_{ga}. Natives who are, in terms of their education and experience, most similar to the incoming immigrants (e.g., low-skilled, inexperienced natives if $d\tilde{I}_{\mathrm{L}} > d\tilde{I}$ and $dI_{gI} > d\tilde{I}_g$) suffer the largest wage losses, while wages of natives who are most dissimilar to incoming immigrants may increase.

Recall that the typical estimation regression adopted in the national skill-cell approach includes year-by-education fixed effects (see Equation (12)). In consequence, this approach implicitly holds both the total ($d\tilde{I}$) and the education-specific immigration shock ($d\tilde{I}_g$) constant. If viewed through the lens of the canonical model, we can think of the wage effect of immigration obtained from the national skill cell approach as a "partial wage (employment) effect of immigration by education and experience":

$$(14a) \qquad \left.\frac{dlogw_{ga}}{dI_{ga}}\right|_{d\tilde{I}, d\tilde{I}_g} = \frac{dlogw_{gI} - dlogw_{gE}}{dI_{gI} - dI_{gE}} = -\frac{(1-\gamma)}{1+\eta(1-\gamma)} \leq 0$$

$$(14b) \qquad \left.\frac{dlogL^N_{ga}}{dI_{ga}}\right|_{d\tilde{I}, d\tilde{I}_g} = \frac{dlogL^N_{gI} - dlogL^N_{gE}}{dI_{gI} - dI_{gE}} = \eta \frac{dlogw_{gI} - dlogw_{gE}}{dI_{gI} - dI_{gE}} = -\eta \frac{(1-\gamma)}{1+\eta(1-\gamma)} \leq 0$$

[23] s_{gI} and s_{gE} are CES aggregators of the second nest, with $s_{gI} = \frac{\tilde{\theta} L^\gamma_{gI}}{\tilde{\theta} L^\gamma_{gI} + (1-\tilde{\theta}) L^\gamma_{gE}}$ and $s_{gE} = \frac{(1-\tilde{\theta}) L^\gamma_{gE}}{\tilde{\theta} L^\gamma_{gI} + (1-\tilde{\theta}) L^\gamma_{gE}}$.

These partial effects are unambiguously negative. Within an educational group, the experience group more exposed to the immigration shock will suffer a wage decline relative to the other experience group. A larger inverse elasticity of substitution $(1-\gamma)$ will amplify both the relative wage and employment responses. Conversely, a higher labor supply elasticity will reduce the relative wage response but magnify the relative employment response. The labor supply elasticity in the national skill-cell approach differs conceptually from the pure spatial and mixture approaches. In the national skill-cell approach, the elasticity captures only workers' movements into and out of employment. In contrast, in the pure spatial and mixture approaches, it also accounts for worker movements across regions.

III.3.3 Selected Studies

We present estimates of the partial wage and employment effects of immigration obtained from the national skill-cell approach in Table 6. In his original study, Borjas (2003) reports statistically significant negative effects on wages and employment. He finds that a one-percentage-point increase in the employment share of immigrants within an education-experience group reduces weekly earnings of male natives in that group by 0.57 percent and their fraction of time worked by 0.52 percent (see Table 1 in Borjas, 2003). Subsequent studies that have adopted this approach generally confirm a negative wage response, as predicted by the canonical model (see, for example, Bratsberg, Raaum, Røed, and Schøne, 2014; Llull, 2018b; Prantl and Spitz-Oener, 2020).[24]

Comparing the estimates of partial wage effects across Tables 5 and 6, the wage effects derived from the national skill-cell approach tend to be more negative than those from the mixture approach. One possible explanation is that the labor supply elasticity is higher at the

[24] Revisiting Borjas's (2003) original study, Card and Peri (2016) report smaller and statistically insignificant wage estimates compared to those reported by Borjas (2003). Card and Peri (2016) estimate the difference-in-difference model in first differences rather than levels (which is how Borjas, 2003, estimates it) and scale the inflow of immigrants by baseline employment (whereas Borjas uses the employment share of immigrants in the education-experience group as the regressor of interest).

regional level than at the national level, causing the effects of a local immigration shock to partially diffuse across the entire economy (as suggested by Borjas, 2003). Alternatively, additional adjustment channels, such as endogenous technology adoption and changes in industry structure, may play a more significant role for skill-specific immigration shocks (captured by the mixture approach) than for experience-specific immigration shocks within education groups (captured by the national skill-cell approach).

A related approach that disregards variation in the immigration shock across regions slices the national labor market into occupations or industries but does not distinguish between experience groups. This approach uncovers the wage effect of immigration in one occupation (or industry) relative to other occupations. Friedberg (2001) and Hoen (2020) are examples of this approach. Both studies report negative relative wage effects (see Panel C of Table 6). Similarly, Bratsberg and Raaum (2012) document wage declines in industries more exposed to immigration relative to less exposed industries in the construction sector after accounting for compositional changes in workforce quality (see Panel D of Table 6).

III.4 Structural Approaches to Estimating the Effects of Immigration

The three empirical approaches described so far—the pure spatial approach, the mixture approach, and the national skill-cell approach—each address distinct questions about how immigration affects native wages and employment. These questions are relevant regardless of researchers' assumptions about the "true" underlying model driving the wage and employment responses to immigration. As illustrated above, the canonical model helps us interpret each approach's estimated wage and employment effects by linking them to underlying structural parameters. An alternative approach directly estimates the structural parameters of the canonical model. This method leverages the model's structure and makes assumptions about some parameters determined outside the model to calculate the total wage effects of immigration for different groups of workers. In an early empirical contribution, Grossman (1982) adopted this approach by considering native workers and first- and second-generation immigrants to be distinct input factors in production, along with capital. She then estimated the elasticities of substitution between input factors to predict the impact of immigration on native wages based on a translog production function.

Closer to the canonical model outlined in Section II.2, Borjas, Freeman, and Katz (1992) assume that output is produced according to a CES production function combining low- and high-skilled labor. This production function implies a close link between skill-specific relative labor supplies and skill-specific relative wages (i.e., $dlog\frac{w_L}{w_H} =- (1 - \beta) dlog\frac{L_L}{L_H}$, obtained from rearranging Equation (1a)). Using this relationship, they estimate the elasticity of substitution between skill groups. Based on observed changes in the relative labor supply of skill groups induced by immigration throughout the 1980s, they then quantify the decline in the relative wages of native high school dropouts attributable to immigration.

Extending this approach, Borjas (2003) assumes a nested CES production function very similar to the one used in Section II.2 and its extension in Section III.3.[25] Capital and labor are combined to produce output in the first nest; educational groups make up the second nest, while age groups within each education group comprise the third nest. He uses the relationships $dlog\frac{w_{gI}}{w_{gE}} =- (1 - \gamma) dlog\frac{L_{gI}}{L_{gE}}$ (rearrange Equation (A.1) in Appendix A.3) and $dlog\frac{w_L}{w_H} =- (1 - \beta) dlog\frac{L_L}{L_H}$ (rearrange Equation (1a)) to estimate the inverse elasticity of substitution between inexperienced and experienced workers within education groups, $1 - \gamma$, and the inverse elasticity of substitution between low- and high-skilled workers, $1 - \beta$. We report estimates in Panel A of Table 7. Equipped with these estimates, Borjas (2003) then uses the structure of the model to compute the total effects of immigration by education and

[25] Borjas's (2003) production function is more general than that assumed in Sections II.2 and III.3, in that he allows for more than two education and experience groups.

experience for observed immigration shocks for the US economy between 1980 and 2000. He does so assuming that capital is fixed (i.e., $\lambda \rightarrow \infty$) and that labor supply is perfectly inelastic (i.e., $\eta \rightarrow 0$). Borjas (2003) concludes that over this period, native wages fell by 3.2% due to immigration. High school dropouts with 16-20 years of experience in the labor market, the group with the highest representation of immigrants, experienced the largest wage decline of -13.6%. In contrast, natives with some college education and 36-40 years of experience, a group where immigrants are less represented, saw a slight wage increase of +0.8% from immigration.

Ottaviano and Peri (2012) and Manacorda, Manning, and Wadsworth (2012) build on Borjas (2003) but additionally allow immigrants and natives to be imperfect substitutes within each education-experience group.[26] Specifically, they introduce a third nest into the production technology: $L_{ga} = [\widehat{\theta} L_{ga}^{N\delta} + (1-\widehat{\theta}) L_{ga}^{M\delta}]^{1/\delta}$, where (1- δ) is the inverse elasticity of substitution between natives (indexed by the subscript *N*) and immigrant workers (indexed by the subscript *M)* within an education-experience group. Imperfect substitutability implies a negative relationship between the relative wages and the relative employment of immigrants and natives within education-experience groups (see Appendix A.4):

$$(15) \qquad dlogw_{ga}^{M} - dlogw_{ga}^{N} =-(1-\delta)\left(dlogL_{ga}^{M} - dlogL_{ga}^{N}\right)$$

Ottaviano and Peri (2012) and Manacorda, Manning, and Wadsworth (2012) use this relationship to estimate the inverse elasticity of substitution between immigrants and natives within education-experience groups, $(1-\delta)$. As in Borjas (2003), they then move up the nests of the production function, estimating the inverse elasticity of substitution between inexperienced and experienced workers within education groups, $(1-\gamma)$, and the inverse

[26] The assumption here is that immigrants and natives, equivalent in their experience and education from a production point of view, are imperfect substitutes *within* an education-experience cell. This is different from, for example, Grossman (1982), who assumed that immigrants and natives are generally imperfect substitutes, possibly because of their different skills.

elasticity of substitution between low- and high-skilled workers, $(1-\beta)$. Equipped with estimates for these elasticities and assuming that capital supply is perfectly elastic (i.e., $\lambda \to 0$) and labor supply is perfectly inelastic (i.e., $\eta \to 0$), they then compute the total wage effects of immigration for specific worker groups for observed immigration shocks in the US (Ottaviano and Peri, 2012) and the UK (Manacorda, Manning and Wadsworth, 2012).

We present baseline estimates for various elasticities of substitution and the simulated total wage effects of immigration in Table 7. Ottaviano and Peri (2012) analyze the impact of immigration in the US between 1990 and 2006, reporting cumulative wage effects for different worker groups. They conclude that incumbent immigrants bore the brunt of the immigration shock, with their wages declining by 6.8% over the study period due to the imperfect substitutability between immigrants and natives. While Borjas (2003) found that immigration between 1980 and 2000 led to a 3.2% decline in native wages, Ottaviano and Peri (2012) report small wage gains for natives over the 1990-2005 period. This discrepancy is primarily due to differences in two key assumptions: Borjas assumed perfect substitutability between immigrants and natives within education-experience groups and a fixed capital supply; Ottaviano and Peri assumed imperfect substitutability and a fully flexible capital supply.

Manacorda, Manning, and Wadsworth (2012) studied the wage effects of immigration in the UK between 1975 and 2005, reporting annual wage changes. Similar to the US findings, they find that incumbent immigrants in the UK experienced significantly larger wage losses due to immigration than natives. Unlike in the US, however, wage losses for university graduates were similar to average wage losses for incumbent immigrants and natives. This difference can be attributed to two factors. First, the immigration shock in the UK was less education-biased compared to the US (in terms of formal education, as discussed in Section

III.6.2); and second, the elasticity of substitution by education appears to be larger in the UK than in the US.[27]

Like the pure spatial approach, these structural approaches potentially provide information on the absolute and relative wage effects of immigration. However, unlike the estimation methods discussed earlier, structural approaches rely on the model's framework, assuming that the underlying model accurately represents the data-generating process.[28] An important limitation of these structural approaches is their reliance on the accurate assignment of immigrants to education-experience cells where they compete with native workers. Downgrading, where immigrants take jobs below their observed education and experience levels upon arrival, can undermine the validity of this method, as demonstrated by Dustmann and Preston (2012) and discussed further in Section III.6.2. Additionally, some structural parameters, such as the elasticity of capital supply, are challenging to estimate directly from the data, forcing researchers to make ad hoc assumptions. Differences in these assumptions can lead to varying assessments of immigration's effects, as seen in the contrasting conclusions of Borjas (2003) and Ottaviano and Peri (2012).

III.5 Firm-Level Immigration Shocks

More recently, several studies have leveraged variations in immigration shocks across firms to examine the effects of immigration on firm outcomes. Research focusing on the US H1B

[27] Both Ottaviano and Peri (2012) and Manacorda, Manning and Wadsworth (2012) focus on labor demand and do not model workers' labor supply decisions; rather, they simulate the total wage effects of immigration under the assumption of perfectly inelastic labor supply. Llull (2018a) and Piyapromdee (2021) are two examples of the structural approach to immigration that carefully model workers' labor supply decisions. Llull (2018a) abstracts from regional mobility and focuses on workers' education decisions, whether or not to work, and in which occupation to work (see also Section V.1). In contrast, Piyapromdee (2021) abstracts from workers' labor force participation decisions and occupational choices and instead focuses on regional mobility. She then explores how regional mobility mitigates the labor market effects of immigration and uses the structure of the model to estimate various elasticities of substitution, evaluating the wage effects of a policy that would increase the share of high-skilled from 17 to 25% for various cities and worker groups. We report the simulated wage effects from her study for some groups in Table 7.

[28] While estimates from the pure spatial, mixture, and national skill-cell approach address meaningful questions irrespective of the underlying model, the interpretation of the effects when viewed through the lens of a theoretical model and the link to structural parameters also hinges on the assumption that the underlying model is correct.

visa program—a firm-sponsored visa program for high-skilled immigrants in science and engineering—provides examples. For example, Kerr, Kerr, and Lincoln (2015) find that firms expand the total employment of skilled workers in response to an increase in the employment share of young skilled migrants, the target group of the H1B visa program. Mahajan, Morales, Shih, Chen, and Brinatti (2024) compare firms that win or lose the H1B lottery and show that a lottery win has little impact on native employment. In contrast, using a similar design, Doran, Gelber, and Isen (2022) document significant declines in firms' native employment following a lottery win. Other studies, such as Clemens and Lewis (2022) and Amuedo-Dorantes, Arenas-Arroyo, Mahajan, and Schmidpeter (2024), focus on the H2B visa program, which allows firms to sponsor low-skilled immigrants. They find that increased hiring of low-skilled immigrants boosts firms' output with minimal impact on native employment. These studies exploit clean and arguably exogenous variations in immigration shocks across firms, providing new insights into firm responses to immigration—an area often overlooked by regional studies.

However, studies utilizing firm-level immigration shocks estimate conceptually different parameters from those using market-level immigration shocks across regions. Consequently, native employment and wage effects derived from the two approaches are not directly comparable. For instance, in a competitive labor market, a firm-level immigration shock would not affect firm wages, as wages are determined at the market level. Additionally, total employment gains in firms that win the lottery might come at the expense of employment losses in nearby firms. Thus, minor changes in native employment at the firm level following a firm-specific immigration shock could be consistent with more significant declines in native employment at the regional level following a regional immigration shock. Moreover, firm-level studies primarily focus on responses within firms and often overlook broader market-level adjustments, such as firm entry and worker reallocation across firms. The canonical model outlined in Section II.2 addresses the wage and employment effects of a market-level immigration shock and, without modification, is not suitable for modeling the impact of firm-level immigration shocks on firm-specific outcomes.

III.6 Empirical Challenges

III.6.1 Creating Quasi-Random Variation in Immigration Shocks

A key challenge in empirical studies is the non-random nature of immigration shocks. For example, we would expect immigrants to move into booming areas where wages are rising and jobs are plentiful. Such sorting patterns can lead to an upward bias in the pure spatial approach, meaning that the true causal effect of immigration on aggregate and skill-specific wages and employment might be more negative than the estimates suggest. Similarly, in the mixture approach, non-random sorting of immigrants can result in upward-biased estimates if immigrants of a particular skill group choose to work in regions where wages for that skill group are increasing (i.e., they sort based on region-skill-specific shocks). The more negative IV estimates compared to OLS estimates reported in Llull (2018b) suggest that estimates from the national skill-cell approach may also be upward biased, as immigrants might be more likely to enter the host economy when their education-age group experiences a positive wage shock. This section focuses on the pure spatial approach and discusses the main empirical strategies for isolating quasi-random variation in total immigration shocks across regions. With appropriate adjustments, these considerations can also be applied to the mixture approach.

An immigration episode that closely approximates a quasi-random regional immigration shock is the 1980 Mariel boatlift, studied by Card (1990) and revisited by Borjas (2017) and Peri and Yasenov (2019). The Mariel boatlift brought thousands of mostly low-skilled Cuban immigrants to Miami, resulting in a sudden increase of about 7% in Miami's labor force. Importantly, these Cuban immigrants did not settle in Miami because of favorable local economic conditions; rather, the immigration shock was triggered by events in Cuba outside Miami's control. Furthermore, the immigrants largely remained in Miami due to the established Cuban community in the city. Card (1990) constructed a control group based on other "immigration hubs" in the US, such as Los Angeles. His paper is often considered one of the first to adopt a "difference-in-differences" approach. The causal interpretation of his estimates primarily relies on the assumption of a "common time trend" between the treatment and control groups.[29]

Several studies have utilized similar "natural experiments" involving sudden and sharp immigration episodes triggered by arguably exogenous pull factors in the host country or push factors in the home country. Examples include the repatriation of 900,000 people to France following Algeria's independence (Hunt, 1992), commuting policies (Dustmann, Schönberg, and Stuhler, 2017; Beerli, Ruffner, Siegenthaler, and Peri, 2021), the Mexican Peso crisis (Monras, 2020), and the 2005-2009 economic boom in Norway (Dodini, Loken, and Willen, 2024). However, pull or push factors that trigger immigration waves at the *national* level are not sufficient for identification in the pure spatial approach, which assumes that new immigrants are quasi-randomly allocated across *regions*. Studies such as Dustmann, Schönberg, and Stuhler (2017), Beerli, Ruffner, Siegenthaler, and Peri (2021), and Dodini, Loken, and Willen (2024) have highlighted that immigrants frequently choose to settle in regions bordering their home countries, indicating that proximity to their home country could introduce potentially exogenous variation in *regional* immigration shocks.

However, the most common method for achieving quasi-random allocation of immigrants across regions is an instrumental variable strategy based on the "past settlement" instrument. Altonji and Card (1991) pioneered this approach by using the fraction of immigrants in a city in 1970 to predict changes in the fraction of immigrants over the

[29] See Angrist and Krueger (1999) on this assumption, who investigate a Mariel boatlift "that did not happen."

following decade, following Bartel's (1989) observation that immigrants tend to settle in areas where previous immigrants have settled. Card (2001, 2009) refined this instrument by distinguishing between immigrants from different countries. This strategy is often called a "Bartik" or "shift-share" instrument.

Two recent papers, Goldsmith-Pinkham, Sorkin, and Swift (2020) and Borusyak, Hull, and Jaravel (2022), clarify the assumptions necessary for the validity of shift-share designs. In the following section, we outline how these insights apply to the context of immigration studies. To fix ideas, suppose researchers are interested in the effect of the total immigration shock between periods t_1 and t_2 to region r (ΔI_r) on regional wage growth $\Delta logw_r$ (as in Equation (9)):

$$\Delta logw_r = \Delta\pi + \theta^{Wpure}\Delta I_r + \Delta u_r$$

Here, the immigration shock $\Delta I_r = \frac{\Delta M_r}{L^N_{rt_1}}$ is specified as the number of immigrants who enter employment in region *r* between periods t_1 and t_2 (ΔM_r), scaled by native employment in period t_1 ($L^N_{rt_1}$). Now consider a slightly modified version of the instrument for ΔI_r proposed by Card (2009):[30]

$$(16) \qquad Z_r = \frac{1}{L^N_{rt_0}}\sum_c \frac{M_{crt_0}}{M_{ct_0}}\Delta M_c = \sum_c \underbrace{\frac{M_{crt_0}}{L^N_{rt_0}}}_{\text{share } s_{rc}} \underbrace{\frac{\Delta M_c}{M_{ct_0}}}_{\text{shift } g_c}$$

Here, $\frac{M_{crt_0}}{M_{ct_0}}$ denotes the share of immigrants from country *c* who work in region *r* in period t_0 (a period that precedes the immigration shock), ΔM_c denotes the number of immigrants from the origin country *c* who enter employment in the host country between periods t_1 and t_2, and $L^N_{rt_0}$ denotes native employment in the region in t_0. The instrument effectively allocates the

[30] Card (2009) scales by regional employment in period t_1 instead of period t_0; that is, $Z_r^{\text{Card}} = \frac{1}{L^N_{rt_1}}\sum_c \frac{M_{crt_0}}{M_{ct_0}}\Delta M_c$. This scaling ensures a first stage of 1 if immigrants who enter employment in the country between t_1 and t_2 make the same location choices as incumbent immigrants in t_0. We have modified Card's instrument to separate it into a "share" and a "shift" so that the recent insights by Goldsmith-Pinkam, Sorkin, and Swift (2020) and Borusyak, Hull, and Jaravel (2022) on shift-share designs can be applied.

total number of incoming immigrants from a specific country of origin (ΔM_c) to regions according to immigrants' settlements in period t_0 ($\frac{M_{crt_0}}{M_{ct_0}}$). We can rewrite this instrument to separate it into a "share" (i.e., the employment share of immigrant group c in region r in period t_0, $\frac{M_{crt_0}}{L^N_{rt_0}}$) and a "shift" (i.e., the number of immigrants from country of origin c who enter employment in the host economy between periods t_1 and t_2, scaled by the total number of immigrants of that group in t_0, $\frac{\Delta M_c}{M_{ct_0}}$). It should be noted that the shares $\frac{M_{crt_0}}{L^N_{rt_0}}$ do not add up to 1 but to the overall immigrant share in the region. Borusyak, Hull, and Jaravel (2022) refer to this case as that of "incomplete shares."

Goldsmith-Pinkam, Sorkin, and Swift (2020) and Borusyak, Hull, and Jaravel (2022) provide alternative conditions under which "shift-share" or "Bartik" instruments yield consistent estimates of the parameter of interest (θ^{Wpure}). Goldsmith-Pinkam, Sorkin, and Swift (2020) clarify that the 2SLS estimator for θ^{Wpure} using Z_r as an instrument for ΔI_r in Equation (9) will yield consistent estimates provided that, for every country of origin, immigrants' employment shares in the region in t_0, $\frac{M_{crt_0}}{L^N_{rt_0}}$, are uncorrelated with the residual Δu_r of the wage *growth* equation (referring to periods t_1 and t_2); that is, $\mathrm{E}[\frac{M_{crt_0}}{L^N_{rt_0}}\Delta u_r] = 0$ ("exogenous shares").

Variation in $\frac{M_{crt_0}}{L^N_{rt_0}}$ stems from two sources. First, from variation in the overall immigration share across regions (i.e., $\frac{M_{rt_0}}{L^N_{rt_0}}$); and second, from variation in the composition of immigrants, conditional on the overall immigrant share in the region. Importantly, the orthogonality condition $\mathrm{E}[\frac{M_{crt_0}}{L^N_{rt_0}}\Delta u_r] = 0$ is more likely to hold if the lag between the periods of interest (t_2 and t_1) and the period to which the shares refer (t_0) is "longer."[31] To see this, suppose that the shares refer to period t_1 instead of period t_0. Regions with higher immigrant shares in period t_1 are likely to be regions that experienced positive shocks in that same period. Hence, $\frac{M_{crt_1}}{L^N_{rt_1}}$ is likely to be correlated with u_{r1}, and so also with $\Delta u_r = u_{r2} - u_{r1}$. Using shares further back in time deals with this problem provided that shocks are not too persistent.[32,33]

Borusyak, Hull, and Jaravel (2022) point out that the Bartik instrument may be valid even if the shares are not exogenous and provide alternative conditions for identification, relying on "exogenous shocks" instead of "exogenous shares." To ensure that identification solely comes from "exogenous shocks" and not from "exogenous shares," the overall immigrant share in the region in t_0 needs to be included as a regressor in the IV regression. The intuition behind their result is as follows. If shares are not exogenous, the orthogonality condition $\mathrm{E}[\frac{M_{crt_0}}{L^N_{rt_0}}\Delta u_r] = 0$ will be violated for at least some countries of origin *c*. However, if there are many small countries of origin, and if the country-specific immigration shocks $\frac{\Delta M_c}{M_{ct_0}}$ are uncorrelated with each other, then the overall bias will average out to zero. More

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[31] Computing the instrument based on lagged shares (in t_0) is less essential if researchers condition on the overall immigrant share $\frac{M_{rt_0}}{L^N_{rt_0}}$ in regression Equation (9), since such a specification solely leverages variation in the composition of immigrants across regions, holding the overall immigrant share constant. Note that the "exogenous shock" assumption invoked in Borusyak, Hull, and Jaravel (2022) requires conditioning on the overall immigrant share.

[32] Dustmann, Frattini, and Preston (2013) point out that the shift-share instruments are valid under the assumption that economic shocks are not too persistent. They propose to test for persistence using tests for first- and second-order autocorrelation in the residuals, as suggested by Arellano and Bond (1991).

[33] Goldsmith-Pinkam, Sorkin, and Swift (2020) propose several tests for the validity of the exogenous shares assumption. One important test involves first determining which countries' variation in the data drives the overall Bartik instrument. Building on Rotemberg (1983), they decompose the Bartik estimator into a weighted sum of the just-identified instrumental variable estimators that each use one country-of-origin's share ($\frac{M_{crt_0}}{L^N_{rt_0}}$) as a separate instrument, where the weights (typically referred to as "Rotemberg weights") can be computed from the data. They then propose to probe the plausibility of the "exogenous shares" assumption by correlating the country-of-origin shares $\frac{M_{crt_0}}{L^N_{rt_0}}$ with observed regional characteristics that may predict changes in the outcome variable, focusing on groups with the highest Rotemberg weight.

formally, Borusyak, Hull, and Jaravel (2022) note the following identity (adopted from Equation (5) in their paper):

$$\mathrm{E}\left[\sum\nolimits_{\mathrm{r}} Z_r \Delta u_r\right] = \mathrm{E}\left[\sum\nolimits_{\mathrm{r}}\sum\nolimits_{c} \underbrace{\omega_r \frac{M_{rt_0}}{L_{rt_0}^N}}_{s_{rc}} \underbrace{\frac{\Delta M_c}{M_{ct_0}}}_{g_c} \Delta u_r\right] = \mathrm{E}\left[\sum\nolimits_{c} s_c\, g_c \overline{\Delta u}_c\right]$$

where $s_c = \sum_r \omega_r \frac{M_{rt_0}}{L_{rt_0}^N}$, $\overline{\Delta u}_c = \frac{\sum_r \omega_r \frac{M_{rt_0}}{L_{rt_0}^N} \Delta u_r}{\sum_r \omega_r \frac{M_{rt_0}}{L_{rt_0}^N}}$, ω_r is a regional weight (capturing, e.g., regional employment as a share of nation-wide employment in the base period, $\frac{L_{rt_0}^N}{L_{t_0}^N}$), and $g_c = \frac{\Delta M_c}{M_{ct_0}}$. This expression represents the orthogonality between a shift-share instrument and an unobserved residual ($\mathrm{E}[\sum_{\mathrm{r}} Z_r \Delta u_r] = 0$) as the orthogonality between the underlying shocks g_c and a shock-level unobservable $\overline{\Delta u}_c$ ($\mathrm{E}[\sum_c s_c\, g_c \overline{\Delta u}_c] = 0$). It highlights that the Bartik estimator will have a causal interpretation if, weighted by s_c (i.e., the employment share of immigrant group c in the host economy), country-of-origin-specific immigrant inflow rates $g_c = \frac{\Delta M_c}{M_{ct_0}}$ are orthogonal to country-of-origin-specific wage growth residuals $\overline{\Delta u}_c$. As Borusyak, Hull, and Jaravel (2022) show, sufficient conditions for this to hold are as follows: first, immigration shocks are as good as randomly assigned; and second, there are many uncorrelated immigration shocks such that a shock-level law of large numbers applies.

In practice, these conditions are unlikely to be met in the context of immigration if a few dominant immigrant groups (such as Mexicans in the US) drive the overall inflow of immigrants into the country.

III.6.2 Classification of Immigrants into Skill Groups and Immigrant Downgrading

Upon arrival, immigrants often accept jobs that require fewer skills than their formal education and experience would suggest. This phenomenon occurs when qualifications obtained in the home country are not immediately recognized in the host country or when skills acquired abroad are not fully transferable. Dustmann, Frattini, and Preston (2013) refer to this as “downgrading” and demonstrate that it is substantial in the UK, particularly for recent arrivals. Dustmann, Schönberg, and Stuhler (2016) provide additional evidence of downgrading in Germany and the US.

Figure 3 (Figure 1 in Dustmann, Frattini, and Preston, 2013) illustrates immigrant downgrading in the UK. The figure first shows the predicted position of recent immigrants in the native wage distribution, assuming that the returns to education and experience are the same for both immigrants and natives. It then contrasts this with their actual position. The figure indicates that, based on their observed education and experience levels, recent immigrants should be underrepresented at the lower end (below the 60th percentile) of the native wage distribution. However, they are overrepresented in this segment, likely due to downgrading to lower-paying jobs.

Downgrading has important implications for empirical approaches that examine the relative wage and employment effects of immigration. For example, in the mixture approach, workers are typically categorized into skill groups based on their formal education, as recorded in the data. Immigrants with formal education from their home country are thus labeled as “high-skilled.” However, upon arrival in the host country, they may downgrade and work “low-skilled” jobs. As a result, despite being classified as “high-skilled,” these immigrants predominantly compete with low-skilled natives who lack formal education. The mixture approach may then reveal a small, or even positive, partial wage and employment effect of immigration. However, in this scenario, the small partial effects arise because of the incorrect classification of immigrants into skill groups that do not accurately reflect job competition. Consequently, if skills are defined based on formal education and downgrading is common, the mixture approach may provide a misleading picture of the distributional effects of immigration. Similar concerns apply to the national skill-cell approach. Alternative skill classifications that better capture competition for jobs, such as classifications based on occupations, as in Card (2001) and Glitz (2012), alleviate this problem.

Downgrading also poses an important challenge for estimating the elasticity of substitution between immigrants and natives within skill cells (e.g., Manacorda, Manning, and Wadsworth, 2012; Ottaviano and Peri, 2012). Dustmann and Preston (2012) show that, in the presence of downgrading, immigrants and natives may appear as imperfect substitutes within skill cells even if they are perfectly substitutable when correctly classified into skill cells. Existing estimates may thus understate the degree of substitutability between immigrants and natives.

IV Worker Mobility and the Components of Regional Employment and Wage Effects

Most empirical studies on the labor market effects of immigration, regardless of the specific empirical approach employed, rely on repeated cross-sectional data.[34] In the pure spatial approach, studies utilizing repeated cross-sectional data—such as those by Altonji and Card (1991), Hunt (1992), and nearly all studies summarized in Tables 3 and 4—examine the impact of regional immigration shocks on regional wages and employment.

A recent paper by Dustmann, Otten, Schönberg, and Stuhler (2024) demonstrates that these regional effects of immigration are composites of effects that address important questions in the immigration debate but remain unidentified when using repeated cross-sectional data alone. They show that these effects can be disentangled and accurately

[34] More recently, several papers use longitudinal data, including Bratsberg and Rauum (2012), Foged and Peri (2016), Dustmann, Schönberg, and Stuhler (2017), Kuosmanen and Meriläinen (2023), Illing (2023), Delgado-Prieto (2023), Dodini, Loken, and Willen (2024), and Orefice and Peri (2024).

estimated using longitudinal data that tracks workers over time and across regions. They also illustrate that the regional effects of immigration typically estimated can differ significantly from the effects on individual workers. Dustmann, Otten, Schönberg, and Stuhler (2024) provide a comprehensive framework that systematically connects the regional impacts of immigration to worker-level effects, clarifies the conditions under which these effects align, and quantifies the components that differentiate them. The following section summarizes their approach, focusing on the aggregate wage and employment effects of immigration identified through the pure spatial approach.

III.1 Decomposing the Regional Employment Effect of Immigration

Consider the pure spatial approach that regresses the percent change in regional native employment on the total immigration shock in the region (as in Equation (9), using $\frac{L_{rt}^N - L_{rt-1}^N}{L_{rt-1}^N} \approx \Delta log L_{rt}^N$ as the dependent variable). The estimated coefficient is informative about the impact of a regional immigration shock on regional native employment. It addresses the following question: *What is the impact of a local immigration shock on the local employment of natives?* When interpreted through the lens of the canonical model, this estimated effect corresponds to the total aggregate employment impact of immigration, as described by Equation (4b). Dustmann, Otten, Schönberg, and Stuhler (2024) decompose the change in regional native employment into three components:

$$\underbrace{\frac{L_{r2}^N - L_{r1}^N}{L_{r1}^N}}_{\substack{\text{change in regional} \\ \text{employment}}} = - \underbrace{\frac{L_{r,non}^N}{L_{r1}^N}}_{\substack{\text{outflows:} \\ \text{displacement}}} - \underbrace{\frac{L_{r,\bar{r}}^N}{L_{r1}^N}}_{\substack{\text{outflows:} \\ \text{relocation}}} + \underbrace{\frac{L_{\{\bar{r},non\},r}^N}{L_{r1}^N}}_{\substack{\text{inflows:} \\ \text{crowding out}}}$$

where L_{rt}^N denotes native employment in region r in period t ($t = 1, 2$). The first term on the right-hand side, $\frac{L_{r,non}^N}{L_{r1}^N}$, is the share of natives employed in r in period 1 and who are no longer employed (indexed by the subscript *non*) in period 2. By regressing this variable on the regional immigration shock, the estimated coefficient provides evidence on whether immigration leads to job losses among employed natives—an effect termed 'displacement' by Dustmann, Otten, Schönberg, and Stuhler (2024). It answers the following question: *What is the impact of a local immigration shock on the employment prospects of natives employed in the area at the time of the shock?* This displacement effect is central to the policy debate surrounding immigration but is seldom directly identified in the existing literature and is sometimes confused with the regional employment effect of immigration.

The second term, $\frac{L^N_{r,\bar{r}}}{L^N_{r1}}$, is the share of natives employed in region r in period 1 who have moved in period 2 to employment in another region $\bar{r}$. Regressing this variable on the immigration shock provides an estimate of the extent to which employed workers relocate to other regions in response to an immigration shock—an effect referred to as the 'relocation effect' of immigration.

The third term, $\frac{L^N_{\{\bar{r},non\},r}}{L^N_{r1}}$, is the share of natives working in period 2 in region r but not in that region in the base period. This term represents the 'inflow' into employment within a region, which can originate from either non-employment (*non*) or employment in other regions ($\bar{r}$). By regressing this term on the immigration shock, the estimated coefficient reveals how much immigration reduces local hiring—a phenomenon Dustmann, Otten, Schönberg, and Stuhler (2024) describe as the 'crowding out' effect of immigration. The estimates for 'displacement,' 'relocation,' and 'crowding out' collectively account for the overall regional employment impact of immigration, as captured using the left-hand side variable as the dependent variable.

Drawing on a natural experiment of an influx of immigrants into the German-Czech border region following the fall of the Iron Curtain in 1989, Dustmann, Otten, Schönberg, and Stuhler (2024) show that the regional employment effect of immigration commonly estimated in the literature and the displacement effect of immigration can be strikingly different. This is demonstrated in Panel A of Figure 4 (corresponding to Figure 1 in Dustmann, Otten, Schönberg, and Stuhler, 2024). In their study, an increase in the immigrant employment share by one percentage point resulted in a reduction of native employment in the local area by 0.87% after three years and 0.73% after five years (represented by the black squares in the figure). However, the displacement effects of immigration (depicted by the blue triangles in the figure) were small and, except for 1993, not statistically significant. This indicates that, in this context, immigration did not lead to substantial job losses for employed natives.

Estimates on the decompositions allow Dustmann, Otten, Schönberg, and Stuhler (2024) to explain why the two effects are so different. They demonstrate that regional native employment primarily adjusts through a reduction in inflows ('crowding out')—that is, workers who would have started employment in the region had the immigration shock not occurred are no longer entering employment in that region after the shock. In contrast, the effect of immigration on relocation is small.[35]

III.2 Decomposing the Regional Wage Effect of Immigration

Consider the pure spatial approach, which involves regressing the change in native log wages in a region on the total immigration shock, as shown in Equation (9). The estimated coefficient captures the regional wage effect of immigration and addresses the following question: *What is the impact of a local immigration shock on local native wages*? In the existing literature, this effect is typically attributed to a downward movement along the labor demand curve due to an immigration-induced outward shift in the labor supply curve (see the 'total aggregate wage effect of immigration' in Equation (4a)). However, as Dustmann, Otten,

[35] The analysis by Dustmann, Otten, Schönberg and Stuhler (2024) refers to small regional units. Estimated effects could differ when larger regional units are considered instead.

Schönberg, and Stuhler (2024) emphasize, this interpretation relies on the critical assumption that immigration does not change the composition of the regional workforce.

To understand why immigration might induce changes in workforce composition, consider a scenario where immigration reduces regional employment more for low-productivity natives than high-productivity ones due to their higher local labor supply elasticity. In this case, immigration would improve the overall quality of the workforce, thereby dampening the regional wage effect of immigration.

Several studies have acknowledged this issue. Card (2001) provides bounds for this 'selectivity bias'; Llull (2018a) models workers' labor supply decisions and accounts for selectivity bias using the model's structure; Borjas and Edo (2021) employ Heckman selection models to isolate the total aggregate wage effect of immigration; and Bratsberg and Raaum (2012), Fallah, Krafft, and Wahba (2019), and Ortega and Verdugo (2022) estimate Equation (9) at the individual level, incorporating worker fixed effects into their regressions.

Dustmann, Otten, Schönberg, and Stuhler (2024) conduct a systematic analysis of selectivity bias by extending the canonical model from Section II.2 to allow labor supply elasticities to vary across different worker types. In their model, worker types differ in 'productive efficiency' (which corresponds to a worker-fixed effect in a wage regression) but are still perfect substitutes in production. They demonstrate that the difference between the aggregate *population-weighted* labor supply elasticity and the aggregate *efficiency-weighted* labor supply elasticity determines the composition bias. Suppose high-efficiency (i.e., high-productivity) workers have lower labor supply elasticities than low-efficiency workers. In that case, the aggregate efficiency-weighted labor supply elasticity will be smaller than the aggregate population-weighted elasticity. As a result, workforce quality improves following an exogenous immigration shock, potentially leading to a near-zero regional wage effect of immigration, even though the total aggregate wage effect is negative.

The change in native log wages in the region can be decomposed into three components: (1) the change in wages of workers employed in the region both before and after the immigration shock, (2) the wage changes resulting from changes in workforce composition due to outflows, and (3) the wage changes due to inflows. The first component reveals the total aggregate wage effect of immigration, as it restricts the sample to workers continuously employed in the region, thereby holding workforce composition constant and eliminating the selectivity bias.[36]

Using the same immigration shock as in the previous subsection, they illustrate that the regional and total aggregate wage effects of immigration can differ significantly. We present their findings in Panel B of Figure 4, which shows that native regional wages barely changed following the immigration shock (represented by the black squares). In contrast, the total aggregate wage effects of immigration (depicted by the blue triangles) are negative, with wages declining by 0.188% after three years and 0.24% after five years. This discrepancy arises because the quality of the workforce improved in response to the immigration shock, leading to a muted regional wage effect.

Overall, Dustmann, Otten, Schönberg and Sthuler's (2024) findings indicate that the selectivity bias in the regional wage effect of immigration, as estimated using the pure spatial approach, can be substantial. Studies by Bratsberg and Raaum (2012), Fallah, Krafft, and Wahba (2019), and Ortega and Verdugo (2022) show that the wage effects of immigration become more negative when worker-fixed effects are included in the regression, suggesting that selectivity bias is also important in their contexts.

Although our discussion has focused on the pure spatial approach, selectivity bias may also exist in the mixture and national skill-cell approaches. Suppose labor supply

[36] This approach will eliminate the selectivity bias arising from time-constant wage components that affect workers' mobility decisions. Dustmann, Otten, Schönberg, and Stuhler (2024) provide upper and lower bounds for the selectivity bias due to time-changing wage components and find them to be tight (after controlling for age in the wage growth regression).

elasticities and worker productivity vary within skill groups (mixture approach) or education-experience groups (national skill-cell approach), and these variations are correlated. In that case, an exogenous immigration shock can induce changes in workforce quality within these groups. The method proposed by Dustmann, Otten, Schönberg, and Stuhler (2024) provides an intuitive and theoretically grounded framework for addressing selectivity bias, which can be applied not only to the pure spatial approach but also to the mixture and national skill-cell approaches.

V Alternative Adjustment Channels to Immigration

The canonical model outlined in Section II.2 limits the adjustment channels available to workers and firms in response to immigration. This section extends the model to incorporate additional mechanisms, such as endogenous technology adoption and innovation. By doing so, we illustrate how these more complex models change the interpretation of wage and employment effects typically estimated in the existing literature (refer to Tables 1a and 1b for an overview) and discuss their empirical implications.

V.1 Worker Responses: Task and Education Upgrading

We begin by considering additional worker responses to immigration. Our discussion of the simple canonical model emphasized that a higher labor supply elasticity η leads, all else equal, to a larger (total and partial) employment response and a smaller (total and partial) wage response to immigration. The interpretation of the labor supply elasticity varies across empirical approaches. In the pure spatial and mixture approaches, it should be understood as a local labor supply elasticity, capturing movements in and out of employment and across regions. In contrast, in the national skill-cell approach, it represents a national labor supply elasticity, capturing only movements into and out of employment. Tables 3 to 6 provide an overview of the various estimates of the total and partial employment effects of immigration derived from the pure spatial, mixture, and national skill-cell approaches.

Instead of focusing on worker movements into and out of employment or across regions, Peri and Sparber (2009) examine workers' incentives to switch tasks in response to an immigration shock. Consider a scenario with two types of jobs, one characterized by repetitive and regular tasks ('Routine') and the other by cognitive and irregular tasks ('Abstract'). Suppose incoming immigrants predominantly occupy routine jobs due to lacking formal qualifications or language skills. In the canonical model outlined in Section II.2, replacing skills L and H with tasks *Routine* and *Abstract*, such an immigration shock would increase the total labor supply for routine relative to abstract jobs, leading to a decline in wages compared to abstract jobs. This wage disparity may incentivize some native workers to 'upgrade' from routine to abstract tasks. As native workers shift away from routine tasks towards abstract jobs, the relative native labor supply for routine jobs decreases, thereby mitigating the partial wage effect of immigration. Furthermore, since abstract jobs typically offer higher wages than routine jobs, an immigration shock biased towards routine tasks could result in higher wages for native workers due to task upgrading. For example, native plumbers might transition to higher-paying roles such as certification or office work following the arrival of immigrant plumbers.[37]

Peri and Sparber (2009) provide empirical support for this hypothesis by demonstrating that the share of native workers employed in abstract tasks increases in local areas following an immigration shock. However, as Dustmann, Otten, Schönberg, and Stuhler (2024) highlight, this native abstract employment share may not accurately reflect task upgrading, as it can rise even if the total number of natives in abstract jobs declines after the immigration

[37] Gyetvay and Keita (2024) analyze an alternative form of native "upgrading". They show that immigration induced natives to relocate from low- to high-wage firms, which in turn muted the total wage effect of immigration.

shock. This increase would occur if the decline in native employment in routine tasks outpaces the decline in abstract tasks.

Dustmann, Otten, Schönberg, and Stuhler (2024) argue that a more direct test of the upgrading hypothesis would involve examining whether natives who were employed in routine tasks before the immigration shock transition to abstract tasks in response to the shock—an analysis that requires longitudinal data. They find no evidence that natives switch from routine to abstract jobs in response to immigration, even though the native abstract employment share (the key variable in Peri and Sparber, 2009) increases. In contrast, studies by Foged and Peri (2016) and Hoen (2020) provide empirical support for the individual task upgrading hypothesis.

Young natives, particularly new labor market entrants, may have additional options for responding to an immigration shock that are less accessible to older natives. For instance, when confronted with a predominantly low-skilled immigration shock that potentially depresses wages for low-skilled workers, recent school leavers might choose to invest more in education. The existing evidence generally supports this mechanism, suggesting that young natives may increase their educational attainment to avoid direct competition with low-skilled immigrant workers (e.g., McHenry, 2015; Hunt, 2017; Llull, 2018a; Dustmann, Otten, Schönberg, and Stuhler, 2024).[38]

V.2 Firm Responses: Capital and Output

While the existing immigration literature has primarily focused on the effects of immigration on wages and employment, the canonical model outlined in Section II.2 also predicts the impact of immigration on output, capital, and the rental rate of capital. These possible

[38] Cascio and Narayan (2022) make a similar argument and show that an increase in the relative demand for high school dropouts due to fracking increased high school dropout rates.

adjustments are not only interesting in their own right but also help us better understand the total wage and employment responses to an immigration shock.[39]

Specifically, as Equations (5a) and (7a) highlight, the total wage effects of immigration crucially depend on the inverse labor demand elasticity, which, in turn, depends on the (inverse) elasticity of capital supply (see Equation (2)). When the supply of capital is more elastic, the wage decrease is less pronounced. In the extreme case of perfectly elastic capital supply, an immigration shock would not lead to a reduction in aggregate wages (i.e., $\frac{dlogw}{d\tilde{I}} = 0$ if $\lambda \to 0$). Surprisingly, little evidence exists that assesses the magnitude of the capital response to an immigration shock, leading to often arbitrary assumptions about the elasticity of capital supply when assessing the effects of immigration on wages.[40]

In Appendix B, we show that an immigration-induced labor supply shock will generally lead to an increase in capital K, output Y, and the rental rate of capital r:

$$\frac{dlogK}{dI} = \frac{1-\alpha}{1-\alpha+\lambda(1+\alpha\eta)} \geq 0$$

$$\frac{dlogr}{dI} = \frac{(1-\alpha)\lambda}{1-\alpha+\lambda(1+\alpha\eta)} \geq 0$$

$$\frac{dlogY}{dI} = \frac{(1-\alpha)(1+\lambda)}{1-\alpha+\lambda(1+\alpha\eta)} \geq 0$$

where α is the capital share, λ is the inverse capital supply elasticity, and η is the labor supply elasticity. It should be noted that the inverse capital supply elasticity λ determines to what extent the immigration shock is absorbed through an increase in capital as opposed to an increase in the rental rate, just as the labor supply elasticity η determines to what extent

[39] For the particular production function adopted in Section II.2, capital and output responses to immigration will not affect the partial wage and employment effects of immigration; see Equations (8a), (8b), (14a) and (14b).

[40] For instance, as we discussed in Section III.4, when computing the total aggregate and skill-specific wage effects of immigration, Borjas (2003) assumes that the capital supply is perfectly inelastic, whereas Ottaviano and Peri (2012) assume that it is perfectly elastic.

wages versus employment respond to the immigration shock. If capital supply is perfectly inelastic (i.e., $\lambda \to \infty$), the capital stock will not adjust to immigration $(\mathrm{i.e.,}\ \frac{dlogK}{dI} = 0)$ while the rental rate of capital will increase. In contrast, if capital supply is perfectly elastic (i.e., $\lambda \to 0$), the capital stock will increase, and the rental rate will remain unchanged ($\mathrm{i.e.,}\ \frac{dlogr}{dI} = 0$). Moreover, expansions in output will be larger if capital supply is more elastic.

Empirical evidence on how output, capital, and rental prices respond to regional immigration is limited. Existing studies generally align with the predictions of the canonical model. For instance, in line with adjustments of the capital stock, Mitaritonna, Orefice, and Peri (2017) and Aksu, Erzan, and Kirdar (2022) observe that firms invest more following an immigration shock. Yet, we are unaware of empirical studies that aim to estimate the local capital supply elasticity directly, even though it plays a key role in determining the total wage and employment effects of immigration.

V.3 Firm Responses: Endogenous Technology Adoption

So far, we have assumed that the production technology is fixed. However, firms have some control over how to produce their output. If labor is abundant and wage costs are low, they are incentivized to choose a technology that is more labor-intensive and less capital-intensive. Similarly, firms may rely on less skill-intensive technologies if low-skilled labor is abundant and high-skilled labor is scarce. In this section, we build on the task framework proposed by Acemoglu and Restrepo (2018) and extend the canonical model to allow for endogenous technology adoption. We focus here on the key insights and intuitions and defer technical details to the appendix (Appendix C).

V.3.1 The Total Aggregate Wage Effect of Immigration

Consider first the firm's decision whether to adopt a more labor-intensive or capital-intensive production technology. Assume that the production process of the final good Y is comprised of a unit measure of tasks, $y(x)$, with an elasticity of substitution $\rho \in (0, \infty)$:

$$Y = A\left(\int_0^1 y(x)^{\frac{\rho-1}{\rho}} dx\right)^{\frac{\rho}{\rho-1}}$$

Further, assume that the production function within each task is given by $y(x) = k(x) + \psi(x)l(x)$, where x denotes the task's complexity, $l(x)$ and $k(x)$ denote labor and capital used in the production of the task and $\psi(x)$ is the relative productivity of labor in the task. Assuming that $\psi(x)$ is strictly increasing in the task's complexity x, labor has a comparative advantage in more complex tasks. There is, therefore, a unique cut-off θ such that tasks in [0, θ] are produced by capital, whereas tasks in (θ, 1] are produced by labor.

In Appendix C.1.1, we show that, for the specific case where the elasticity of substitution across tasks is equal to $\rho = 1$, the production function of the representative firm approaches a Cobb-Douglas production function, as we have assumed in the canonical model. However, the capital share of output α is no longer fixed but a choice variable of the firm. In Appendix C.1.2, we then show that firms switch to a less capital-intensive production technology (i.e., more tasks are performed by labor) in response to a positive immigration shock: $\frac{d\alpha}{dI} < 0$.

The intuition behind this result is that immigration makes labor more abundant and cheaper relative to capital, thus increasing the share of tasks allocated to labor. Switching to a more labor-intensive production technology, in turn, mutes the total aggregate wage effect of immigration (see Appendix C.1.3):

$$\frac{dlogw}{dI} = \underbrace{\frac{\varphi}{1-\varphi\eta}}_{\substack{\text{canonical} \\ \text{model} \\ (<0)}} \left(\underbrace{1 + \frac{1}{\alpha(1-\alpha)} \frac{d\alpha}{dI}}_{\substack{\text{endogenous technology} \\ \text{adoption } (<1)}} \right)$$

Endogenous technology adoption thereby provides one explanation for small total aggregate wage effects of immigration identified from the pure spatial approach, even if native labor supply is inelastic and the inverse labor demand elasticity φ is large.

V.3.2 The Partial Wage Effect of Immigration by Skill

We can also adopt the task framework to study firms' choices regarding the skill intensity of the production function. For simplicity, we ignore firms' choice of capital and focus on the partial wage effect of immigration by skill.[41] Assume that labor L comprises a continuum of tasks where the elasticity of substitution across tasks is equal to $1/(1-\beta)$. Each task can be produced using low- and high-skilled labor, and the two inputs are perfect substitutes in the production of each task. High-skilled labor has a comparative advantage in more complex tasks; therefore, there is a unique cut-off θ such that tasks in $[0, \theta]$ are produced by low-skilled labor, whereas tasks in $(\theta, 1]$ are produced by high-skilled labor. In Appendix C.2, we show that firms lower the skill intensity of the production technology (such that more tasks are performed by low-skilled labor) in response to an immigration shock that is relatively low-skilled ($dI_L - dI_H > 0$): $\frac{d\theta}{dI_L - dI_H} > 0$.

The intuition for this result is that a low-skilled immigration shock makes low-skilled labor more abundant, inducing firms to use this factor more intensively in production. This, in turn, mutes the partial (or relative) wage effect of immigration by skill:

[41] Note that, for the production function assumed in Section II.2 where capital and labor are combined to produce output in the first nest, and where labor is a composite of low- and high-skilled labor in the second nest, this assumption is without loss of generality since firms' capital choices have no impact on the *relative* wages of low- and high-skilled workers. For our arguments here, it is therefore irrelevant whether capital supply is fixed or infinitely elastic.

$$\left.\frac{dlogw_g}{dI_g}\right|_{dI} = \frac{dlogw_L - dlogw_H}{dI_L - dI_H} = \underbrace{-\frac{(1-\beta)}{1+\eta(1-\beta)}}_{\substack{\text{canonical model} \\ (<0)}} \underbrace{\left(1 - \left(\frac{1}{\theta} + \frac{\psi(\theta)^{\frac{\beta}{\beta-1}}}{\int_{\theta}^{1} \psi(x)^{\frac{\beta}{\beta-1}} dx}\right) \frac{d\theta}{dI_L - dI_H}\right)}_{\text{endogenous technology adoption } (<1)}.$$

Endogenous technology adoption, therefore, provides one explanation for small partial wage effects of immigration by skill identified from the mixture approach, even if native labor supply is inelastic and the inverse elasticity of substitution between low- and high-skilled labor $(1-\beta)$ is large.

V.3.3 Empirical Evidence

The empirical evidence largely supports the hypothesis that firms change their production technology in response to an immigration shock. In an early contribution, Lewis (2011) shows that, in the US, plants in areas more exposed to immigration adopt less machinery per unit output. Hornbeck and Naidu (2014) provide evidence that black out-migration following the Great Mississippi Flood of 1927 increased the capital intensity of the agricultural sector. More recently, Coluccia and Spadavecchia (2021) report that tighter immigration restrictions in the US in the 1920s reduced emigration from Italy to the US (thus making labor more abundant in Italy), which in turn lowered the likelihood that Italian firms implemented labor-saving technologies. Similarly, Andersson, Karadja, and Prawitz (2022) document that emigration from Sweden to the US (which made labor scarcer) increased the capital intensity in Swedish agriculture and industry. Focusing on rural-urban migration in China, Imbert, Seror, Zhang, and Zylberberg.(2022) find that manufacturing production becomes more labor-intensive following an immigration shock. Clemens, Lewis, and Postel (2018) argue that a switch to a more capital-intensive production technology helps to explain why the exclusion of nearly half a million Mexican “Bracero” farm workers in the US in the 1960s failed to improve labor market conditions of native farm workers. San (2023) provides direct support for this mechanism by showing that US firms in the agricultural sector directed their innovation activities towards labor-saving technologies after labor became scarcer following the termination of the Bracero agreements between the US and Mexico.

Empirical evidence on firms changing the skill intensity of production following a skill-biased immigration shock is limited. In line with this hypothesis, Dustmann and Glitz (2015) show that a low-skilled immigration shock in Germany in the 1990s barely affected relative wages but strongly increased the employment share of low-skilled workers within firms in tradable industries, suggesting that firms use low-skilled workers more intensively after the immigration shock (see also Section V.6).

V.4 TFP and Innovation

Immigration, particularly high-skilled immigration, may affect not only firms' technological choices but also their innovation activities. There are at least three reasons for this. The first reason is selection. The US has been historically very successful at attracting top talent (even though, on average, immigration to the US tends to be low-skilled). For example, immigrants are overrepresented among US-based Nobel Prize winners (e.g., Peri, 2007) and patent applicants (Hunt and Gauthier-Loiselle, 2010). Immigrants may, therefore, be more likely to be innovators than natives. Second, immigrants who are more skilled than natives may increase the innovative activity of natives because of knowledge transfer (see, e.g., Moretti, 2004 for evidence on positive external effects of education, as well as Jarosch, Oberfield, and Rossi-Hansberg, 2021 and Herkenhoff, Lise, Menzio, and Phillips, 2024 for an investigation of learning from co-workers). Third, immigration may boost innovation even if immigrants are as educated and skilled as natives since immigrants, due to their different cultural backgrounds, increase ethnic diversity in research teams. This may produce a broader pool of ideas (see, e.g., Heath, Seegert, and Yang, 2023 and Hong and Page, 2004 for evidence on the effect of diversity on team productivity, as well as Parrotta, Pozzoli, and Pytlikova, 2014a, 2014b for evidence on the link between labor diversity and innovation in firms).

Conversely, the innovative activities of immigrants could also crowd out the innovative activities of natives and thus cause negative spillovers if, for example, immigration discourages natives from majoring in innovation-intensive STEM-related fields. Moreover, more diverse research teams could reduce innovative activity due to increased coordination costs.

In the canonical model outlined in Section II.2, increased innovation due to immigration should increase total factor productivity A. Innovation allows firms to produce more output using the same amount of inputs. This, in turn, may lead to positive total aggregate wage effects of immigration (see also Table 1a). For the specific production function adopted in Section II.2, an increase in total factor productivity affects both skill groups equally and thus has no impact on the partial wage effect of immigration by skill (see also Table 1b).[42]

Several pieces of evidence support the view that high-skilled immigration positively affects innovation (e.g., Kerr and Lincoln, 2010; Hunt and Gauthier-Loiselle, 2010; Moser, Voena, and Waldinger, 2014; Moser and San, 2020; Beerli, Ruffner, Siegenthaler, and Peri, 2021; Terry, Burchardi, Tarquinio, and Hassan, 2024). However, there is also evidence to the contrary. In a firm setting, when comparing lottery winners and losers of H1B visas, Doran, Gelber, and Isen (2022) find little evidence that a higher share of skilled migrants in the firm boosts the firm's innovative activities. Borjas and Doran (2012) find that the influx of Russian mathematicians into the US following the collapse of the Soviet Union increased the mobility rate of American mathematicians to lower-ranked institutions and out of academia, reducing their number of publications, particularly in high-quality journals. It should be noted that universities and academic journals are likely to operate differently from private sector

[42] In more general production functions, increased innovation may differentially affect the marginal productivity of low- and high-skilled workers; see, for example, Lewis (2011).

firms. They may find it challenging to expand (i.e., to create more faculty positions, publish more papers per journal, or establish new journals), making it more probable that immigrants displace the research activities of natives according to these measures.

Direct empirical evidence on the effects of immigration on total factor productivity is limited. Hornung (2014) finds substantial long-term effects of Huguenot settlement on the productivity of textile manufactories in Prussia in the early 19th century, likely driven by knowledge transfer. In a modern setting, Peri (2012) reports positive effects of immigration shocks across US states on state-level TFP. At the firm level, Dodini, Loken, Willen (2024) report a decline in value added per worker in Swedish firms and an increase in Norwegian firms following an economic boom in Norway that led to increased labor mobility from Sweden to Norway.

Agglomeration economies offer an alternative explanation for immigration-induced increases in total factor productivity. The argument is that immigration boosts economic density, and denser and thicker markets may facilitate knowledge transfer or enhance the matching of workers to firms (e.g., Marshall, 1890, Lucas, 1988, and Ciccone and Hall, 1996). Ciccone and Nimczik (2022) present evidence consistent with this perspective. They show that German municipalities that, due to exogenous factors, received a higher influx of refugees after World War II exhibit higher population density, productivity, and wages 70 years later. They attribute this effect to agglomeration economies.

V.5 Changes in Product Prices: A Closed Economy

So far, we have assumed that the economy is small and open. All output is, therefore, traded in world markets, and any immigration-induced change in output in the economy has a negligible impact on world output and, hence, aggregate product prices. In this section, we first outline a model of a closed one-sector economy and investigate the effect of immigration on product prices.[43] In a closed economy, an immigration shock will shift not only the labor supply curve but also the labor demand curve—as immigrants consume and thus increase product demand. The model below allows for both labor supply-induced and consumption-induced effects of immigration. We then review the empirical evidence on product price adjustments and consumption-induced labor market effects of immigration.

V.5.1 The Canonical Model in a Closed Economy

To keep the model as simple as possible, we focus on the total aggregate wage effect and consider only one type of labor. This is without loss of generality since product prices do not impact firms' relative demand for low- and high-skilled labor in the nested production function assumed throughout this chapter. We maintain the assumption that product markets are perfectly competitive.[44] The market-level product demand curve is downward sloping:

$$Y = \mu p^{-\tau}$$

where μ is a product demand shifter and $-\tau$ is the market-level product demand elasticity. Further, assume that native workers base their labor supply decisions on the real rather than the nominal wage and define the labor supply elasticity as $\eta = \frac{dlogL^{\mathrm{N}}}{dlog(w/p)}$.

We consider two effects of immigration. First, as before, immigrants supply labor and, accounting for the endogenous labor supply response of natives, shift the labor supply curve out by $dlogL^{\mathrm{S}} = dI + dlogL^{\mathrm{N}} = dI + \eta dlog\left(\frac{w}{p}\right)$. Second, immigrants also consume. Here, we model this effect as an outward shift of the firm's product demand curve, with $dlog\mu/$

[43] Berbee, Brücker, Garloff, and Sommerfeld (2022) develop a multi-sector model of the consumption-driven labor market effects of immigration, where immigrants increase product demand and, therefore, labor demand only in the non-tradable sector.

[44] Immigration will lead to product price adjustments also in a small, open economy if product markets are imperfectly competitive. However, immigration-induced consumption effects are absent in this economy.

$dI > 0$. In Appendix D, we show that in a closed economy, immigration affects real wages, native employment, and product prices as follows:[45]

$$\frac{dlogp}{dI} = -\underbrace{\frac{(1-\alpha)(1+\lambda)}{\alpha\eta\lambda\tau + \alpha\eta + \tau(1-\alpha) + \alpha + \lambda\tau}}_{\text{labor supply shock }(-)} + \underbrace{\frac{\lambda + (1-\alpha) + \alpha\eta\lambda}{\alpha\eta\lambda\tau + \alpha\eta + \tau(1-\alpha) + \alpha + \lambda\tau}\frac{dlog\mu}{dI}}_{\text{consumption shock }(+)}$$

$$\frac{dlog\frac{w}{p}}{dI} = -\underbrace{\frac{\alpha\lambda\tau + \alpha}{\alpha\eta\lambda\tau + \alpha\eta + \tau(1-\alpha) + \alpha + \lambda\tau}}_{\text{labor supply shock }(-)} + \underbrace{\frac{\alpha}{\alpha\eta\lambda\tau + \alpha\eta + \tau(1-\alpha) + \alpha + \lambda\tau}\frac{dlog\mu}{dI}}_{\text{consumption shock }(+)}$$

$$\frac{dlogL^N}{dI} = \eta\frac{dlog\frac{w}{p}}{dI}$$

Consider first the labor supply effect of immigration and assume that immigrants do not consume (i.e., $dlog\mu/dI = 0$). In this case, immigration must lead to a decline in product prices as output increases (see also Section V.2), and firms face a downward-sloping product demand curve. Consumers, therefore, benefit from immigration through lower prices. The decline in product prices will be more pronounced if product demand is less elastic (i.e., if τ is small). Despite the decline in product prices, an immigration-induced labor supply shock continues to affect real wages negatively.[46]

Next, consider the case where immigration affects demand for the output good, $dlog\mu/dI > 0$. This will push up product prices. Moreover, the increase in product demand will increase labor demand, pushing up wages. This consumption effect of immigration works in the opposite direction as the labor supply effect. It is, therefore, possible that immigration

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[45] Here, α is capital's output share in the Cobb-Douglas production function, λ is the inverse elasticity of capital supply, τ is the product demand elasticity, η is the labor supply elasticity, and μ is a demand shifter.

[46] Note that if immigration-induced consumption effects are absent and the product demand elasticity approaches infinity (i.e., $\tau \to \infty$)—which we have implicitly assumed so far (i.e., firms can sell as much output as they want at given prices)—an immigration-induced labor supply shock will have no impact on product prices. The labor supply-driven effect of immigration on real wages becomes $\frac{dlog\frac{w}{p}}{dI} = \frac{-\alpha\lambda}{\alpha\eta\lambda+\lambda+(1-\alpha)}$, which is equivalent to Equation (5a) using $\varphi = -\frac{\alpha\lambda}{1-\alpha+\lambda}$.

positively affects real wages, native employment, and product prices, depending on whether the labor supply or consumption effect of immigration dominates.

V.5.2 Empirical Evidence

Product Prices. Empirical evidence on the impact of immigration on product prices is scarce. Leveraging variation in immigration shocks across cities in the US, Cortes (2008) shows that immigration leads to price declines, specifically in immigrant-intensive non-tradable service industries such as babysitting, housekeeping, gardening, and dry-cleaning. Bratsberg and Raaum (2012) report substantial price declines for construction activities in Norway following an inflow of immigrants in the construction sector. Lach (2007) emphasizes an effect of immigration on product prices not captured in the model outlined above: immigrants search more extensively for goods and are, therefore, more price-sensitive than natives. In monopolistic product markets, retailers are incentivized to lower their markups to attract these new high-elasticity consumers. In line with this argument, Lach (2007) finds that product prices (including those for tradable goods) declined more in Israeli cities that experienced a larger influx of Jews from the former Soviet Union in the early 1990s. These papers, therefore, support the view that consumers benefit from increased migration as immigrants reduce inflationary pressures. However, Aksu, Erzan, and Kirdar (2022) reach a different conclusion. Leveraging variation in the influx of Syrian refugees across local labor markets in Turkey, they find that consumer prices increased more in regions more exposed to immigration, suggesting that, in their context, the consumption effect of immigration dominated the labor supply effect.

*Consumption-induced Labor Market Effects of Immigration***.** Most existing empirical and theoretical literature views immigration as a pure labor supply shock and ignores that immigration may shift firms' product demand curve and, hence, their labor demand curve.

Two recent papers aim to isolate the demand effect of immigration and find it to be important. Both papers leverage quasi-exogenous variation in the influx of refugees and asylum seekers across local labor markets in Germany. Since asylum seekers are, in the short run, largely excluded from the labor market, they primarily affect labor market outcomes through the consumption channel rather than the labor supply channel. Auer and Götz (2024) find that increased refugee migration reduced the local unemployment rate and created jobs in the local economy, primarily in services, public administration, and social work. Berbée, Brücker, Garloff, and Sommerfeld (2022) reach similar conclusions.

V.6 Changes in the Industry Structure: A Two-Sector Heckscher-Ohlin Model

So far, we have assumed that the economy comprises only one sector. Next, we present an extended model with two sectors, as in the Heckscher-Ohlin model. Here, we examine the case where the two sectors differ in their skill intensity, focusing on the partial wage effect of immigration by skill (as in Equation (8a)). In a modified version, one sector is more capital-intensive than the other, and we analyze the total aggregate wage effect of immigration (as in Equation (5a)). In such multi-sector economies, there exists an additional margin through which the economy can absorb an immigration shock: a shift in the industry structure. As a result, immigration may not influence the partial wage effect of immigration by skill or the total aggregate wage effect, even if low- and high-skilled workers are imperfect substitutes in production and capital and labor supply are perfectly inelastic.

V.6.1 The Heckscher-Ohlin Model

To fix ideas, consider a small and open two-sector economy in which output in each sector $j = 1,2$ is produced according to a constant return-to-scale CES production function combining low- and high-skilled labor (L_{jL}, L_{jH}), as in the second nest of the canonical model:

$$Y_j = A_j[\theta_j L_{jL}^{\beta} + (1-\theta_j)L_{jH}^{\beta}]^{1/\beta}, \quad j = 1,2$$

We ignore firms' choice of capital for simplicity. Assume that sector 2 is more skill-intensive than sector 1 (i.e., $\theta_1 > \theta_2$). Further, suppose that the economy is endowed with a fixed labor supply $\bar{L}_L$ and $\bar{L}_H$. In a one-sector economy, the partial wage effect of immigration by skill would thus be equal to $-(1-\beta)$, the inverse elasticity of substitution between low- and high-skilled labor. Also, assume that both types of labor are freely mobile across the two sectors; consequently, wage rates must equalize across the two sectors. Let p_1 and p_2 denote the prices of the products produced in the two sectors. We assume that labor and product markets are perfectly competitive and that the economy is small and open.

Equilibrium Conditions. In such an economy, a benevolent social planner will maximize GDP subject to the constraint that low- and high-skilled labor is fully utilized:

$$\max_{Y_1,Y_2} \qquad p_1Y_1 + p_2Y_2$$

$$\text{s.t. } L_{L1} + L_{L2} = \bar{L}_L \ \text{ and } L_{H1} + L_{H2} = \bar{L}_H$$

The following conditions hold in equilibrium. First, the slope of the production possibility frontier, which shows the maximum possible output combinations of the two goods that the economy can achieve when low- and high-skilled labor are fully and efficiently employed, must be equal to the price ratio, $\frac{dY_2}{dY_1} = \frac{p_1}{p_2}$. Figure 5 illustrates this condition graphically. The solid curve (PPF) in the figure depicts the production possibility frontier, while the slope of the dashed line (PP) is equal to the price ratio $\frac{p_1}{p_2}$. In the original equilibrium E_0, the dashed line is tangent to the production possibility frontier.

Second, firms in both sectors must use low- and high-skilled labor efficiently, and the ratio between the wage rates for the two types of labor w_L and w_H (the slope of the isocost line) must be equal to the marginal rate of technical substitution (the slope of the isoquant) in the two sectors (see Appendix E.1 for details). This condition pins down firms' optimal low- and high-skilled labor choices (l_{Lj}^* and l_{Hj}^*) in each sector per unit of output, at given wage rates w_L and w_H.

Third, firms must earn zero profits in equilibrium. Since the production function exhibits constant returns to scale, firms' cost functions will be linear in output. For profits to be zero in each sector, the cost of producing one extra unit of output must thus be equal to the product price, $w_L l_{Lj}^* + w_H l_{Hj}^* = p_j, j = 1,2$. These zero-profit conditions, in combination with the conditions for efficient utilization of input factors, pin down the two wage rates of the economy as a function of product prices p_1 and p_2 only. Consequently, product prices uniquely determine the wage rates for low- and high-skilled workers in the economy (provided that both goods are produced in positive quantities); in contrast, the economy's labor stocks do not impact wage and rental rates (see Appendix E.2 for details).

Fourth, the full employment conditions pin down the amount of output Y_1 and Y_2 produced in each sector (see Appendix E.3 for details).

The Impact of a Skill-Biased Immigration Shock. Next, consider an exogenous immigration shock to the economy that increases the stock of low-skilled labor more than the stock of high-skilled labor $(\text{i.e.}, dlog\bar{\mathrm{L}}_{\mathrm{L}} - dlog\bar{\mathrm{L}}_{\mathrm{H}} := dI_L - dI_H > 0)$. Since the economy is small and open, a skill-biased immigration shock will not affect product prices p_1 and p_2. Consequently, wage rates w_L and w_H also remain unchanged — as product prices uniquely determine factor prices. The partial wage effect of immigration by skill, $\left.\frac{dlogw_g}{dI_g}\right|_{dI} = \frac{dlogw_L - dlogw_H}{dI_L - dI_H}$, is therefore equal to zero. This result is typically referred to as *factor price equalization* (Samuelson, 1948) or *factor price insensitivity* (Leamer and Levinsohn, 1995). It implies that free trade of goods is sufficient to ensure that wage rates equalize across economies, even if labor is immobile. Factor price equalization further implies that immigration does not affect skill intensities $(\frac{l_{Lj}^*}{l_{Hj}^*})$ within sectors.

Instead of factor prices (and within-sector factor intensities) responding to the immigration shock, immigration will lead to a shift in the output mix of the economy. The *Rybczynski Theorem* (Rybczynsky, 1955) states that the output of the good that uses low-skilled labor more intensively will expand more than proportionally in response to an immigration shock that is biased toward low-skilled workers (i.e., $\frac{dlogY_1}{dI_L - dI_H} > 1)$. The output of the good that uses high-skilled labor intensively, in contrast, will contract (i.e., $\frac{dlogY_2}{dI_L - dI_H} < 0)$. We summarize these predictions in Panel B of Table 1b.

Figure 5 visually represents the Rybczynski Theorem. An immigration shock that is biased towards low-skilled workers will shift the production possibility frontier outward for both goods but less so for the skill-intensive good, as shown by the shift of the production possibility frontier from PPF to PPF' in the figure. In the new equilibrium E_1, the price line has shifted out (from PP to P'P') while its slope remains unchanged (since product prices are determined in world markets). The price line is once again tangent to the production possibility frontier. Production of the more skill-intensive good Y_2 has decreased, while production of the less skill-intensive good Y_1 has increased (see also Appendix E.4).

Assuming homothetic and uniform preferences for immigrants and natives, consumption in the old equilibrium will take place at E_0 (where the preference curve is assumed to be tangent to the PPF, so that all produced goods are also consumed). In the post-migration equilibrium, the economy produces at E_1 but consumes at C. Thus, it will produce more low-skill-intensive goods and less high-skill-intensive goods than it consumes. The difference in the production and demand for the two goods will be traded, and the economy will import the high-skill-intensive good and export the low-skill-intensive good.

While we have illustrated the Rybczynski Theorem in the case of two sectors that differ in their skill intensity, similar arguments will apply if output is produced using capital and labor, and the two sectors differ concerning their labor and capital intensities. According to the Rybczynski Theorem, an immigration shock will have no impact on total aggregate wages (i.e., $\frac{dlogw}{dI} = 0$) even if capital and labor supply are perfectly inelastic. Moreover, immigration will have no impact on rental rates, native employment, and capital intensities within each sector. Instead, output in the labor-intensive sector will expand, while output in the capital-intensive sector will decline. We summarize these implications in Panel B of Table 1a.

The Rybczynski Theorem can be generalized to multiple input factors (instead of only two input factors as analyzed here). The assumptions under which it will hold include: there are at least as many traded goods as there are factors of production; each good is produced in positive quantities in each country; the production function exhibits constant returns to scale; input factors are freely mobile across sectors; and product prices are fixed.[47]

V.6.2 Empirical Evidence

Empirical evidence on whether an immigration shock indeed alters the economy's industry structure is limited. The scarce existing research does not strongly support the predictions of the Rybczynski Theorem. For example, Card and Lewis (2007) and Gonzalez and Ortega

[47] See Dustmann and Preston (2019) for extensions to multiple goods, and situations where not all goods are traded.

(2011) focus on differences in skill intensities across sectors and the effects of a skill-biased immigration shock on the industry structure.[48] Their starting point is a decomposition of the percentage change in total (i.e., immigrant plus native) employment for a particular skill group *g* into a between-industry and within-industry component:[49]

$$\frac{L_{g2}-L_{g1}}{L_{g1}}=\sum_{j=1}^{J}\frac{L_{gj1}}{L_{g1}}\frac{L_{jg2}-L_{jg1}}{L_{jg1}}=\underbrace{\sum_{j=1}^{J}\frac{L_{gj1}}{L_{g1}}\frac{L_{j2}-L_{j1}}{L_{j1}}}_{\substack{\text{between−industry}\\ \text{employment changes:}\\ \text{Rybczynski effects}}}+\underbrace{\sum_{j=1}^{J}\frac{L_{gj1}}{L_{g1}}\frac{\frac{L_{gj2}}{L_{j2}}-\frac{L_{gj1}}{L_{j1}}}{\frac{L_{gj1}}{L_{j1}}}}_{\substack{\text{within−industry}\\ \text{employment changes:}\\ \text{relative wage changes}\\ \text{and endogenous technology}\\ \text{adoption}}}+\underbrace{R}_{\text{residual}}$$

where $\frac{L_{gj1}}{L_{g1}}$ is the share of workers of skill group *g* who are employed in industry *j* in period 1 (the base period); $\frac{L_{j2}-L_{j1}}{L_{j1}}$ is the percentage change in total employment in industry *j* between periods 1 and 2, and $\frac{\frac{L_{gj2}}{L_{j2}}-\frac{L_{gj1}}{L_{j1}}}{\frac{L_{gj1}}{L_{j1}}}$ is the percentage change in the share of workers of skill group *g* within industry *j*. According to the Rybczynski Theorem*,* a skill-biased immigration shock should be fully absorbed through changes in the industry composition (the between-industry effect), while skill intensities within industries (the within-industry effect) should not adjust. The within-industry adjustment could reflect changes in relative wages, as discussed in Section III.2, or endogenous technology adoption, as discussed in Section V.4.

Leveraging variation in skill-specific immigration shocks across regions, as in the mixture approach, Card and Lewis (2007) and Gonzalez and Ortega (2011) then regress the

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48 Hanson and Slaughter (2002) propose an extended decomposition of changes in education-specific employment at the state level, distinguishing between output mix changes in the traded sector; national changes in industry production techniques; and state-specific changes in production techniques. While there is some evidence that state-level education-specific employment changes are partially absorbed through changes in the output mix of the traded sector, changes in production techniques dominate.

49 R is an interaction effect equal to $\sum_{j=1}^{J}\frac{L_{gj1}}{L_{g1}}\frac{L_{j2}-L_{j1}}{L_{j1}}\frac{\frac{L_{gj2}}{L_{j2}}-\frac{L_{gj1}}{L_{j1}}}{\frac{L_{gj1}}{L_{j1}}}$.

percentage change in skill-specific regional employment ($\frac{L_{rg2}-L_{rg1}}{L_{rg1}}$), as well as the between- and within-industry components, on the region-skill-specific immigration shock. In both studies, the instrumental variable estimates suggest that skill-specific regional employment adjusts primarily within industries and not between industries. These studies, therefore, contradict the predictions of the Rybczynski Theorem.

Dustmann and Glitz (2015) conduct an employment decomposition analysis at the firm level rather than the industry level, focusing on a low-skilled immigration shock in Germany during the 1990s. They highlight that when firms within an industry produce heterogeneous products, changes in industry-level factor intensities resulting from output reallocations between firms within the same industry may be misattributed to within-industry adjustments. This misattribution can understate the Rybczynski effect. Their findings indicate that the immigration shock had a minimal impact on between-industry adjustments. However, as they reduce the level of aggregation from two-digit industries to three-digit industries and ultimately to firms, changes in the output mix gain significance, consistent with the predictions of the Rybczynski theorem. They further demonstrate that the role of new and exiting firms in absorbing labor supply shocks is significant and comparable in magnitude to the estimated contribution of output mix adjustments. Nevertheless, their overall conclusion is that immigration predominantly led to declining skill intensities within firms, which they attribute to endogenous technology adoption (see Section V.2).[50]

[50] In line with the Rybczynski Theorem, Lafortune, Tessada, and González-Velosa (2015) found evidence consistent with an immigration-induced change in the output mix within the agricultural sector in the context of a low-skilled immigration shock to the US between 1910 and 1940. This response is only visible in diversified regions, but not in regions with high initial specialization in specific crops.

VI The Labor Market Effects of Immigration When Labor Markets Are Not Perfectly Competitive

So far, we have assumed that labor markets are perfectly competitive. Next, we explore the labor market effects of immigration when the labor market is monopsonistic (e.g., Card, Cardoso, Heining, and Kline, 2018) or when there are search frictions (e.g., Mortensen and Pissarides, 1994). We first assume that the labor supply elasticity to the firm is the same for immigrants and natives and show that in this case, the wage and employment effects are similar in models of monopsonistic and perfect competition (Section VI.1). We then allow the labor supply elasticity to be different for natives and immigrants (Section VI.2). In this case, the impact of immigration on native wages and employment could be smaller or larger under monopsony (or search frictions) than under perfect competition, depending on the assumptions that researchers make about the wage determination process and firm entry.

V.1 Monopsonistic Labor Markets with Homogenous Labor Supply Elasticities

Consider the case where the firm's labor supply elasticity is the same for immigrants and natives. Hence, firms have similar monopsony power over the two groups.

Production Function. We consider a simplified production function compared to Section II.2, where capital is fixed, and there is only one worker type. We further assume that immigrants and natives are perfect substitutes. The production function for firm j exhibits decreasing returns to scale ($0 < \alpha < 1$):

$$Y_j = A\overline{K}l_j^{1-\alpha}$$

where, as before, A denotes total factor productivity, and $\overline{K}$ represents the firm's fixed capital stock. Firms choose how many workers l_j to employ and face a fixed cost of production, *C*. For simplicity, we assume that firms are homogeneous (i.e., A, $\overline{K}$ and *C* do not vary across firms).

Competitive Output Market. We further assume that the output market is perfectly competitive. Firms are thus price takers. Moreover, the economy is small and open, so the product price is unaffected by immigration. We normalize the product price to 1.

Monopsonistic Labor Markets. The local labor market is monopsonistic. More specifically, we follow Card, Cardoso, Heining, and Kline (2018) and assume that workers derive utility not only from wages but also from the work environment that the firm provides. Worker *i*'s indirect utility in firm *j* is equal to

$$U_{ij} = \beta logw_j + \varepsilon_{ij}$$

Here $logw_j$ is the wage that firm *j* pays to all its workers, and ε_{ij} denotes the worker's idiosyncratic preferences for working at the firm, capturing, for example, commuting time, how well she gets along with her co-workers or boss, or her preferences for the firm's working schedule.

Workers may also decide not to work in the local labor market. This "outside option" could involve not working at all or working in a different local labor market. Their indirect utility from choosing this option equals:

$$U_{ib} = logb + \varepsilon_{ib}$$

We assume that ϵ_{ij} and ϵ_{ib} are independent draws from a type I extreme value distribution. Workers choose to work for the firm that provides the highest utility (or the outside option, if this option maximizes utility). Hence, by standard arguments (McFadden, 1977), the probability that a worker chooses to work for firm *j* equals:

$$P(\arg\max_{k\in J}\{U_{ik},U_{ib}\}=j) \ = \frac{exp\{\beta logw_j\}}{exp\{logb\}+\sum_{k\in J}exp\{\beta logw_k\}}$$

where J denotes the number of firms in the market. As is customary in the literature, we assume that there are many firms and that each firm is too small to influence other firms' wage offers (i.e., there are no strategic interactions).

*Labor Supply to the Firm and the Market***.** This setup implies that firms face an upward-sloping labor supply curve where $\beta = dlogl_j/dlogw_j|_{logw_{k\neq j}}$ is the labor supply elasticity to the firm and $\bar{L}$ denotes the total number of workers who could potentially work in the local economy:[51]

$$logl_j^S = log\bar{L} + \beta logw_j - log[exp\{logb\}+\textstyle\sum_{k\in J}exp\{\beta logw_k\}]$$

Aggregate labor supply to the local economy equals

$$logL^S = log\bar{L} + log(\textstyle\sum_{k\in J}exp\{\beta logw_k\}) - log[exp\{logb\}+\textstyle\sum_{k\in J}exp\{\beta logw_k\}]$$

Firms' Optimization Problem. Firms choose labor to maximize profits:

$$\max_{l_j} \quad A\bar{K}l_j^{1-\alpha} - w_jl_j - C$$

It should be noted that since all firms are identical, they offer the same wage and employ the same number of workers.

*Labor Market Equilibrium***.** In labor market equilibrium, the following conditions must hold.

[51] Since each firm is small, $dlog(exp\{logb\}+\sum_{k\in J}exp\{\beta logw_k\})/dlogw_j = 0$.

i. Firms maximize profits. From the firm's first-order condition:

$$log(1-\alpha) + logA\bar{K} - \alpha logl = log(\frac{\beta+1}{\beta}) + logw$$

ii. The labor market clears:

$$\underbrace{log(J \cdot l)}_{\text{market-level labor demand}} = \underbrace{log\bar{L} + log(J \cdot w^{\beta}) - log(b + J \cdot w^{\beta})}_{\text{market-level labor supply}}$$

iii. Firms make zero profits (in the long run): $A\bar{K}l^{1-\alpha} - wl - C = 0$

The zero-profit condition (iii) pins down the number of firms in the economy, as firms will enter the market if profits are positive. These three equations determine the three equilibrium outcomes: the wage w offered by each firm, the number of workers l employed by each firm, and the number of firms *J* operating in the market.

The Impact of Immigration on Employment and Wages: Short run. Consider an immigration-induced shift in the pool of workers who supply labor to the market, $\bar{L}$. Adopting our earlier notation, define $dlog\bar{L} := dI$. Suppose the number of firms in the economy is fixed in the short run. In Appendix F.1, we show that, in this case, the effects of immigration on wages *w* and native employment L^N mirror those in the canonical model under perfect competition if the capital stock is fixed:

$$\frac{dlogw}{dI} = -\frac{\alpha}{1+\alpha\eta}$$

$$\frac{dlogL^N}{dI} = -\frac{\alpha\eta}{1+\alpha\eta}$$

where η is the labor supply elasticity to the market, with $\eta = \frac{b\beta}{b+Jw^{\beta}}$. These effects are exactly the same as the total aggregate effects in the canonical model under perfect competition if the capital supply is perfectly inelastic (i.e., if $\lambda \rightarrow 0$, then $\varphi \rightarrow -\alpha$; see Equations (5a), (5b), and (2)). Further note that an immigration shock increases firms' profits in the short run, mirroring the result that the price of capital increases if capital supply is inelastic (see Section V.2):

$$\frac{dlog\Pi_j}{dI} > 0$$

The Impact of Immigration on Employment and Wages: Long run. In the long run, positive profits will induce firms to enter the market, driving up wages (just as an increase in the price for capital will lead to capital inflows into the economy in the canonical model). In the new long-run equilibrium, firms' profits must again be zero. In Appendix F.2, we show that, due to firm entry, immigration has no impact on wages, firm employment, and market-level native employment:

$$\frac{dlogw}{dI} = \frac{dlogl}{dI} = \frac{dlogL^N}{dI} = 0$$

Therefore, in the long run, the immigration shock is fully absorbed by the entry of new firms. This result once again mirrors the result from the canonical model that immigration leaves wages and native employment unchanged if the capital supply is perfectly elastic (i.e. if $\lambda \rightarrow \infty$ and $\varphi \rightarrow 0$).

To summarize, if the labor supply elasticity to the firm—and, hence, the firm's monopsony power—is the same for immigrants and natives, a simple model of monopsonistic labor markets delivers the same implications as the canonical model with perfectly competitive labor markets. In the short run, immigration leads to declining wages and increased firm profits (the price of capital in the canonical model). In the long run, immigration does not impact wages and firm profits but increases firm entry (the capital stock in the canonical model).

VI.2 Different Labor Supply Elasticities or Reservation Wages for Natives and Immigrants

Some recent papers have investigated the labor market impacts of immigration when labor supply elasticities differ between natives and immigrants. While Amior and Manning (2024), Gyetvay and Keita (2023), and Borjas and Edo (2023) consider the labor market effects of immigration within a monopsonistic labor market similar to that described in Section VI.1, Chassamboulli and Palivos (2013, 2014), Chassamboulli and Peri (2015), Albert (2021), and Amior and Stuhler (2023) instead investigate the labor market effects of immigration within a search model. A key assumption in these models is that the labor supply elasticity to the firm, or the reservation wage, is lower for immigrants than for natives. This assumption implies that migrants provide "cheap" labor to firms. The different models reach starkly different conclusions regarding the magnitude and sign of the total wage and employment effects of immigration, depending on the assumptions they make about the wage-setting process and the entry of firms into the labor market. Here, we briefly summarize the key ideas behind these papers.

VI.2.1 Monopsonistic Labor Markets

Suppose that the labor supply elasticity to the firm is larger for natives than for immigrants, so firms have more monopsony power over immigrants than natives (i.e., $\beta^N > \beta^M$). There are several reasons why this might be the case. Immigration restrictions often tie visas to a particular job, making it difficult for immigrants to switch jobs (e.g., Naidu, Nyarko, and Wang, 2016). Even in the absence of migration restrictions, immigrants might be less efficient at job search than natives because they are less informed about job opportunities or because they face language barriers. Firms may enjoy particularly strong market power over undocumented migrants, as switching jobs could increase the risk of deportation (e.g., Borjas and Edo, 2023; Albert, 2021).

Amior and Manning (2024) consider the impacts of immigration in a monopsony model similar to that described in Section VI.1. They first argue that if firms can perfectly wage discriminate and pay immigrants and natives different wages for the same work within the same firm, immigrants and natives do not directly compete for jobs. Immigration will still affect native wages, but only through its impact on workers' marginal product of labor, just as in the canonical model under perfect competition outlined in Section II.2 and in the monopsony model outlined in Section VI.1.

However, firms might find it challenging to pay immigrants and natives different wages for identical work. If firms are forced to pay the two groups the same wage, firms' markdowns will be higher if the immigrant employment share is higher.[52] An immigration shock will, therefore, decrease native wages (in the short run) because of a decline in the marginal product of labor (as in the canonical model) and an increase in the markdowns that firms enjoy. In consequence, the impact of immigration on wages will be more negative under monopsony than under perfect competition. Since markdowns increase, immigration will increase firms' profits. This finding helps to explain why firms often actively lobby for immigration.

Moreover, suppose firms have more monopsony power over undocumented than documented immigrants. In that case, an undocumented immigration shock should lead to larger wage declines and increases in firm profits than a documented immigration shock (see

[52] If firms can perfectly discriminate, the markdowns from workers' marginal product of labor will be higher for immigrants than natives, as immigrants' labor supply to the firm is less elastic. If firms cannot discriminate, the optimal wage will lie between what a discriminating firm would pay immigrants and natives. As the immigrant share increases, this wage will be closer to the wage a discriminating firm would pay to immigrants. An immigration shock will, therefore, increase firms' markdowns; see Section 2.2 and Appendix A in Amior and Manning (2024) for more details.

also Borjas and Edo, 2023, who study the labor market effects of a large-scale amnesty program in France).[53]

Neither Amior and Manning (2024) nor Borjas and Edo (2023) consider that higher firm profits should, in the long run, encourage firm entry, which, in turn, should lower firm profits and push up native wages, as outlined in Section VI.1.

V.2.2 Search frictions

Chassamboulli and Palivos (2013, 2014), Chassamboulli and Peri (2015), Albert (2021), and Amior and Stuhler (2023) investigate the labor market effects of immigration within a search model. These papers assume that immigrants and natives are perfect substitutes. They further assume that immigrants have lower reservation wages than natives because, for example, their flow utility from unemployment is lower or because they face higher search costs. Similar to immigrants' lower labor supply elasticity in the monopsony model, this assumption reflects that immigrants provide "cheap" labor to firms.

Amior and Stuhler (2023) assume that wages are determined through wage posting. They further assume that firms can post only one wage, mirroring the assumption of no wage discrimination in Amior and Manning (2024). When deciding which wage to post, firms face a similar trade-off as in the monopsony model: a higher wage reduces profits once a vacancy is filled but increases the probability of filling the vacancy. Amior and Stuhler (2023) first show that, in such a model, some firms will post a low wage (and attract immigrants only) while some otherwise identical firms will post a high wage (and attract both immigrants and natives). They then show that, in this setup, immigration could potentially lead to substantial declines in native employment that exceed -1. The intuition for this finding is that more firms

[53] Unlike Amior and Manning (2024), Borjas and Edo (2023) assume perfect wage discrimination. In their model, the "spillover" effect from larger markdowns for (undocumented) immigrants to natives arises because immigrants and natives are imperfect substitutes.

will adopt the low-wage strategy in response to an influx of immigrants. This, in turn, reduces native employment *over and above* the reduction implied by the canonical model.

In contrast, Chassamboulli and Palivos (2013, 2014) and Chassamboulli and Peri (2015) reach a very different conclusion. They assume that wages are determined through Nash bargaining. This assumption implies that firms can wage discriminate and pay immigrants lower wages than natives for identical work. It further implies that immigrants and natives do not directly compete for jobs, so the negative consequences of an immigration influx on native employment and wages highlighted in Amior and Stuhler (2023) (and Amior and Manning, 2024) are absent. Chassamboulli and Palivos (2013, 2014) and Chassamboulli and Peri (2015) then focus on the job creation channel ignored in Amior and Stuhler (2023): access to cheaper labor due to immigration induces firms to create more jobs. This, in turn, improves the outside options of natives and might lead to higher native wages and employment, even though immigrants and natives are perfect substitutes in production. Thus, in this model, search frictions might lead to *positive* total wage and employment effects of immigration, contrary to the conclusions reached by Amior and Stuhler (2023).[54]

To summarize, the total wage and employment effects of immigration could be *more negative* in monopsonistic or frictional labor markets than in perfectly competitive labor markets. However, they could also potentially turn *positive*, depending on researchers' assumptions about firm and job creation and the wage-setting process (i.e., whether firms have more monopsony power over immigrants than natives and whether they can pay them different wages for identical work). It is unclear which assumptions are more realistic. While a set of recent papers has studied the sorting of migrants across firms and wage setting for immigrants and natives within firms (e.g., Arellano-Bover and San, 2023; Dostie, Li, Card

[54] Albert (2021) sets up a search model with wage bargaining where immigrants and natives directly compete for jobs as firms may receive more than one application per vacancy. In his model, therefore, both the competition effect of immigration emphasized by Amior and Stuhler (2023) and the job creation effect of immigration emphasized by Chassamboulli and Palivos (2013, 2014) and Chassamboulli and Peri (2015) are present.

and Parent, 2023), empirical evidence on the impact of immigration on firm creation is scarce.[55]

Our summary here has assumed that firms are identical. The monopsonistic or search models of immigration developed by Amior and Stuhler (2023) and Gyetvay and Keita (2023) accommodate firm heterogeneity, yielding additional testable implications. Amior and Stuhler (2023) argue that immigration should lead to larger wage and employment declines in low-productivity firms where immigrants are overrepresented. Gyetvay and Keita (2023) emphasize that immigration induces native workers to move from low- to high-productivity firms. Both papers find empirical support for these predictions in the context of two large immigration waves to Germany in the early 1990s (triggered by the fall of the Iron Curtain) and the 2010s (triggered by the EU enlargement and Great Recession).

VII Discussion and Conclusion

We have structured this chapter around the canonical labor market model, which serves as a foundation for analyzing the impacts of immigration. Within this framework, we conceptually distinguish between total and partial wage and employment effects of immigration. We then interpret the key empirical approaches used in the literature through the lens of the model, representing their estimates as combinations of the underlying structural parameters (see

[55] Dustmann and Glitz (2015) present evidence consistent with the hypothesis that immigration leads to firm entry (see e.g. Column (3) in Table 3 of their paper). Anelli, Basso, Ippedico, and Peri (2020) show that increased emigration reduces firm creation, an effect that they primarily attribute to selection of young and highly entrepreneurial individuals into emigration. In line with this argument, Azoulay, Jones, Kim, and Miranda (2022) document that immigrants are more likely than natives to found new businesses. While these papers are thus consistent with a positive link between immigration and firm entry, the mechanism highlighted in these two papers differs from the mechanism implied by the theoretical model (selection of migrants vs. the effect of immigration on firm creation by native workers). Imbert and Ulyssea (2024) provide empirical evidence in favor of the mechanism emphasized here (firm creation by non-migrant workers) in in the context of rural-urban migration in Brazil. Mahajan (2024) shows that, in the US context, immigration inflows increase exits of low-productivity firms.

Tables 1a and 1b). This approach allows us to clarify the specific questions each method addresses (see Table 2).

Despite its simplicity, the canonical model is highly effective in illustrating how immigration influences the labor market. While most studies focus on wages and employment, the model also predicts impacts on capital investment, output, and interest rates. Furthermore, the model can be extended to incorporate additional margins of adjustment, such as changes in industry structure, shifts in production technology, or increased innovation (see Section V). These mechanisms are intrinsically interesting and shape how wages and employment of native workers respond to immigration shocks (see Tables 1a and 1b).

The canonical model assumes that labor markets are perfectly competitive. While this provides a useful benchmark, it overlooks important aspects of labor markets that are critical for understanding the full range of immigration's effects on natives' labor market outcomes. For example, it does not consider involuntary job losses among native workers, immigration-induced firm entry and exit, or changes in firms' profits. Furthermore, the canonical model is not suited to analyze the impacts of firm-level immigration shocks, such as when firms are allocated additional permits through a lottery system. It also fails to address whether immigration can alleviate labor market shortages, a key issue in current public debates.

Recent research has begun to examine wage and employment effects under alternative market structures, such as monopsonistic labor markets and those with search frictions. These studies have reached contrasting conclusions due to differing model assumptions, as summarized in Section VI. This divergence highlights the need for further exploration, which we view as a promising direction for future research. Over the next decade, we anticipate significant developments in understanding immigration's effects beyond the perfect competition framework.

Several additional gaps in the literature remain that warrant further attention. One major gap concerns how firms respond to immigration shocks at the market level. Key questions remain unanswered, such as whether firms tend to increase investments and expand their capital stock, boost output and productivity, or enhance profits following an immigration shock. Similarly, little is known about whether immigration fosters the creation of new businesses and what types of businesses are most likely to emerge. As highlighted in the canonical model or a model featuring monopsonistic competition, immigration can exert downward pressure on native wages unless accompanied by an increase in capital accumulation or firm creation. Understanding how firms react to market-level immigration shocks is therefore crucial for comprehending the broader impacts on native wages and employment.

Another critical area is the dynamic effects of immigration. Most existing studies rely on (instrumented) difference-in-differences designs that typically capture a mixture of short- and long-term effects. However, the temporal dynamics of immigration's impact are crucial. For instance, immigrants often experience initial downgrading followed by upgrading, which creates skill-specific labor supply shocks that evolve. Additionally, as documented by Dustmann and Görlach (2016) and Adda, Dustmann, and Görlach (2022), significant return migration results in subsequent negative labor supply shocks. Capturing these dynamics requires high-quality longitudinal data and structural dynamic models capable of addressing such complexities.

Finally, an important unresolved issue is the wide variation in estimates of immigration's effects on employment and wages across studies. One reason for this variation, as highlighted in our chapter, is that different empirical approaches identify distinct effects that are not directly comparable. However, even among studies using similar methodologies, estimates vary widely. Understanding and reconciling these variations is essential for advancing the field.

While the canonical model provides a strong foundation for analyzing immigration, it is clear that the field must move toward more nuanced frameworks to address these research gaps. Expanding our understanding of firm responses, dynamic impacts, and cross-study variation will enhance our ability to design effective policy interventions and provide a more comprehensive picture of immigration’s role in labor markets.

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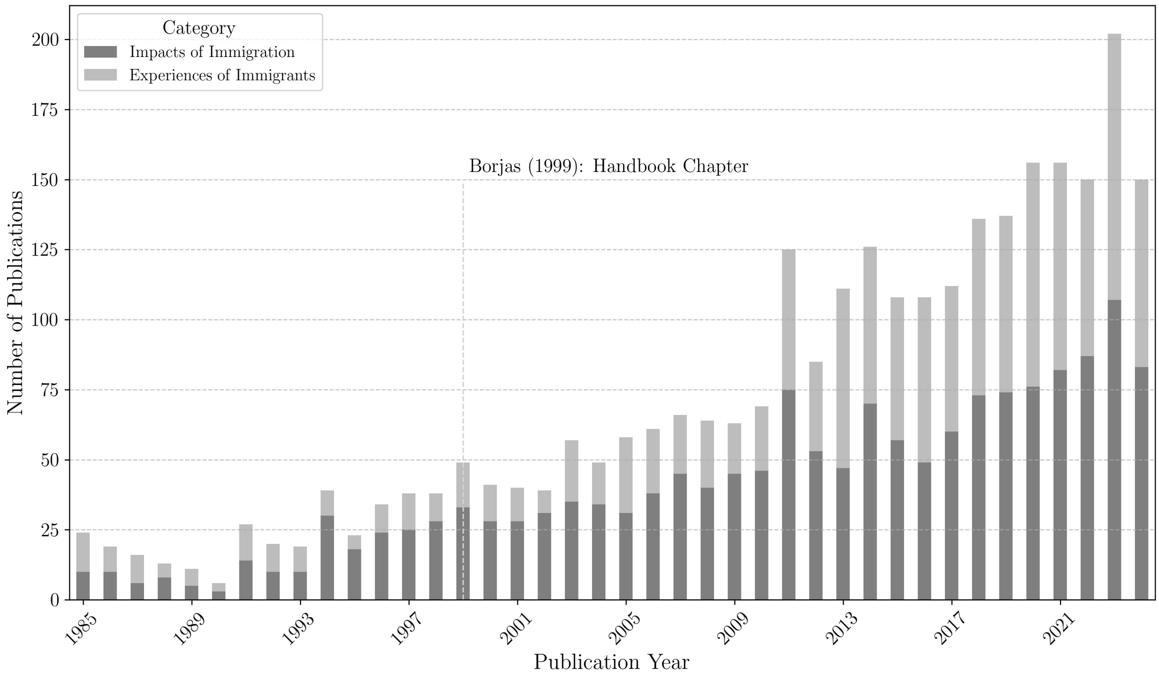
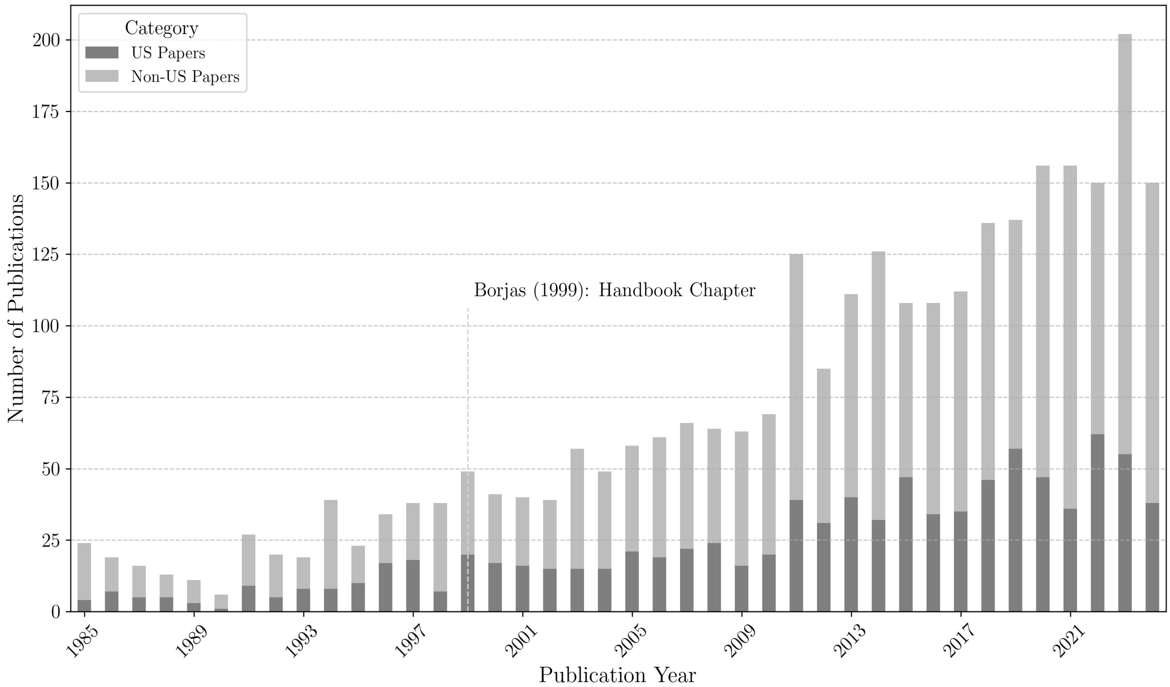
Figure 1: Publications related to 'Immigration' in Leading Economic Journals over Time

Panel A: By Research Topic



Panel B: By Country



Notes: The figures show the annual number of publications in the field "Economics of Immigration", broken down by topic (Panel A, the impacts of immigration on the host economy vs. the experiences of immigrants, including their decisions to move and assimilation in the host economy) and country (Panel B). The publication data is sourced using the advanced search option in the Web of Science, where we searched for the terms "immigra*" and "migra*" in the title, abstract, keywords and keywords plus (auto-generated by Web of Science) in the following journals: AER, QJE, RESTUD, JPE, Econometrica, AER: Insights, RESTAT, JEEA, AEJ: Applied, AEJ: Policy, JOLE, JHR, JPopE, JDE, JIE, ILR Review, Labour Economics, EJ, JPubE, EER, Demography.

Table 1a: Total Aggregate Wage Effects of Immigration in the Canonical Model : The Role of Various Adjustment Mechanisms

Interpretation of Total Aggregate Wage Effect	Additional Empirical Implications
Panel A: Simple Canonical Model (Section II.3.1):	
i) resident labor supply and capital is fixed	
$\frac{dlogw}{dI} = -\alpha$	No change in resident employment, no change in the capital stock
ii) resident labor supply is fixed, capital supply is partially elastic	
$\frac{dlogw}{dI} = \varphi = -\frac{\alpha\lambda}{1-\alpha+\lambda}$	No change in resident employment, increase in the capital stock
iii) resident labor supply and capital supply are partially elastic	
$\frac{dlogw}{dI} = \frac{\varphi}{1-\varphi\eta}$	Decline in resident employment, increase in the capital stock
Panel B: Additional Adjustment Channels (Section IV)	
i) endogenous teachnology adoption (Section IV.3.1)	
$\frac{dlogw}{dI} = \frac{\varphi}{1-\varphi\eta}(1+\frac{1}{\alpha(1-\alpha)}\frac{d\alpha}{dI})$	Increase in the labor intensity of the production technology (within industries)
ii) nnovation and TFP (Section IV.4)	
$\frac{dlogw}{dI} = \frac{\varphi}{1-\varphi\eta} + \frac{dA}{dI}$	Changes in TFP, innovation activity
iii) closed economy (Section IV.5)	
$\frac{dlog\frac{w}{p}}{dI} = \frac{-\alpha\lambda\tau-\alpha}{\alpha\eta\lambda\tau+\alpha\eta+\tau(1-\alpha)+\alpha+\lambda\tau} + \frac{\alpha}{\alpha\eta\lambda\tau+\alpha\eta+\tau(1-\alpha)+\alpha+\lambda\tau}\frac{dlog\mu}{dI}$	Changes in product prices; changes in resident consumption
iv) industrial structure (Section IV.6)	
$\frac{dlog\,w}{dI} = 0$	Expansion of labor-intensive sectors; contraction of capital-intensive sectors

Note: The table summarizes the total aggregate wage effect of immigration according to the canonical model, successively allowing for additional adjustment channels.

Legend:

- dI: total immigration shock (in efficiency units)
- α: capital share in output and total costs
- φ: labor demand elasticity
- λ: inverse capital supply elasticity
- η: labor supply elasticity
- A: total factor productivity
- $-\tau$: product demand elasticity
- μ: product demand shifter

Table 1b: Partial Wage Effects of Immigration by Skill in the Canonical Model : The Role of Various Adjustment Mechanisms (Low-Skilled Immigration Shock)

Interpretation of Total Aggregate Wage Effect	Additional Empirical Implications
Panel A: Simple Canonical Model (Section II.3.2):	
i) resident labor supply is fixed	
$\left.\frac{dlogw_g}{dI_g}\right\|_{dI} = -(1-\beta)$	No change in the relative employment of low- vs high-skilled residents
ii) resident labor supply is partially elastic, same labor supply elasticity for low- and high-skilled	
$\left.\frac{dlogw_g}{dI_g}\right\|_{dI} = -\frac{(1-\beta)}{1+\eta(1-\beta)}$	Change in the relative employment of low- vs high-skilled residents
Panel B: Additional Adjustment Channels (Section IV)	
i) endogenous technology adoption (Section IV.3.2)	
$\left.\frac{dlogw_g}{dI_g}\right\|_{dI} = -\frac{(1-\beta)}{1+\eta(1-\beta)}(1-(\frac{1}{\theta}+\frac{\psi(\theta)^{\frac{\beta}{\beta-1}}}{\int_\theta^1 \psi(x)^{\frac{\beta}{\beta-1}}dx})\frac{d\theta}{dI_L-dI_H}$	Increase in the skill intensity of the production technology (within industries)
ii) industry structure	
$\left.\frac{dlogw_g}{dI_g}\right\|_{dI} = 0$	Expansion of sectors that use low-skilled labor intensively; contraction of sectors that use high-skilled labor intensively

Note: The table summarizes the partial wage effects of immigration by skill according to the canonical model, successively allowing for additional adjustment channels. For the nested production function assumed throughout the chapter where capital and labor are combined to produce output in the first nest, and where labor is an aggregate of low- and high-skilled labor in the second nest, changes in product prices and total factor productivity do not impact the partial wage effect of immigration by skill.

Legend:

- dI: total immigration shock (in efficiency units)
- dI_g: skill -specific immigration shock $(dI_L > dI_H)$
- $1-\beta$: inverse elasticity of substitution between skill groups
- η: labor supply elasticity
- θ: share parameter in the CES production function allocated to low-skilled labor
- $\psi(\theta)$: productivity enhancement due to endogenous technology adoption

Table 2: Wage Effects of Immigration: Empirical Approaches, Interpretation, and Link to the Canonical Model

Empirical Approach	Variation in Immigration Shock	Typical Dependent Variable	Question Addressed	Link to Canonical Model	Examples of Studies
Main Approaches:					
Pure Spatial Approach $\theta^{W pure}$	Regions (Total immigration shock in the region) Equation (9)	aggregate (log) wage of natives in the region	"How does the total regional immigration shock affect regional wages of natives?" informative about the absolute wage effects of immigration	in the absence of compositional changes (discussed in Section III.2): total aggregate wage effect of immigration Equation (5a), Table 1a (extensions)	Table 3 Section II.4.1
Pure Spatial Approach $\theta_g^{W pure}$	Regions (Total immigration shock in the region) Equation (10)	skill-specific (log) wage of natives in the region	"How does the total regional immigration shock affect regional skill-specific wages of natives?" informative about both relative (by skill) and absolute wage effects of immigration	total wage effect of immigration by skill Equation (7a)	Figure 2, Table 4 Section II.4.1
Mixture Approach $\theta^{W mix}$	Regions and Skills (Skill-specific immigration shock in the region) Equation (11)	skill-specific (log) wage of natives in the region (inclusion of region fixed effects in regression)	"How does the skill-specific regional immigration shock affect regional skill-specific wages of natives, holding the total regional immigration shock constant?" informative about the relative effects of immigration by skill	partial wage effect of immigration by skill Equation (8a), Table 1b (extensions)	Table 5 Section II.4.2
National Skill-Cell Approach θ^{NSC}	Education and experience (Education-experience specific immigration shock at the national level) Equation (12)	education-experience specific (log) wage of natives at the national level	"How does the national education-experience-specific immigration shock affect national education-experience specific wages of natives, holding the national total and education-specific immigration shock constant?" informative about the relative effects of immigration by experience within education groups	partial wage effect of immigration by education and experience Equation (14a) labor supply elasticity refers to the national labor supply elasticity	Table 6, Panel A Section II.5.3
Additional approaches:					
Occupational Approach	Occupations (Occupation-specific immigration shock at the national level)	occupation-specific (log) wage of natives at the national level	"How does the occupation-specific immigration shock affect occupational wages of natives?" informative about the relative effects of immigration by occupation	related to the partial wage effect of immigration by skill Elasticity of substitution between skill groups refers to many occupations; labor supply elasticity refers to the national occupational labor supply elasticity	Table 6, Panel B Section II.5.3
Firm-Level Approach	Firm (Firm-specifc immigration shock)	firm-specific (native) employment, wages, innovation activities...	"How does the firm-speciific mmigraion shock affect firm outcomes?"	Canonical model based on perfectly competitive labor markets not applicable to interpret findings	Section II.7

Note: The table summarizes the empirical approaches utilized in the literature to estimate various wage effects of immigration. The table states the questions that each empirical approach addresses and highlights the links to the canonical model.

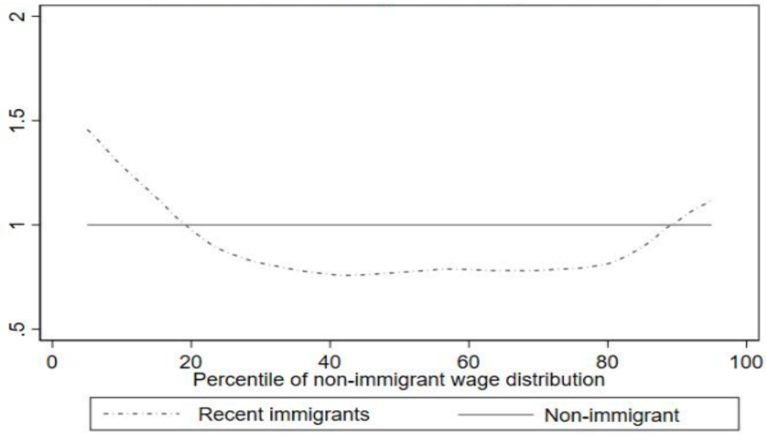
Table 3: Total Aggregate Wage and Employment Effects of Immigration: Pure Spatial Approach (Selected Studies)

(1) Study	(2) Country	(3) Main Data and Time Period	(4) Regional Unit	(5) Identification Strategy	(6) Specification of Immigration Shock	(7) Specification of the wage variable	(8) Estimated Wage Effect	(9) Specification of the employent variable	(10) Estimated Employment Effect
Card, 1990	US	CPS, 1979-1985 (1981 vs 1979)	cities (Miami vs Atlanta, LA, Houston, Tampa- St. P.)	DiD , Reduced Form (Miami vs 4 comparison cities, before and after Marial boatlift)	Miami * post1980 ("reduced form")	log real hourly earnings in city, white natives	0.02 scaled by total imm. shock: 0.286	unemployment rate in city, white natives	-0.011 scaled by total imm. shock: -0.157
Hunt, 1992	France	Census, 1962 and 1968 (1968 vs 1962)	88 regions	first diferences, IV (past settlement, temperature; repatriation following Algeria's independence)	repatriates in 1968 divided by labor force in 1962 in region	change in log wage in region, non-repatriates	-0.80 (0.330)	change in unemployment rate in region, non-repatriates	0.195 (0.062)
Dustmann, Fabbri and Preston, 2005	UK	Labor Force Survey, 1992-2000	17 regions	first differences, IV (past settlement)	change in immigrant-to-native population ratio in region	change in log wage in region, natives	0.909 (0.583)	change in native employment rate in region	-0.035 (0.088)
Boustan, Fishback and Kantor, 2010	US	Census, 1940	69 metropolitan areas	cross-section, IV (New Deal, weather, distance)	net inflow of immigrants in region between 1935 and 1940, divided by population in 1935	(log) hourly wage in region, non-migrants	-0.521 (0.730)	(log) weeks worked in region, non-migrants	-0.954 (0.354)
Dustmann, Frattini and Preston, 2013	UK	Labor Force Survey, 1997-2005 (annual changes)	17 regions	first differences, IV (past settlement)	change in immigrant-to-native population ratio in region	change in median log wage in region, natives	0.444 (0.093)	not studied	not studied
Tumen, 2016	Turkey	Labor Force Survey, 2010-2013 (2012/13 vs 2010/11)	26 regions	DiD, Reduced Form (treatment and control regions, before and after inflow of Syrian refugees)	treatment vs control ("reduced form")	change in log wage in region, natives	0.0081 (0.006) scaled by total imm. shock: 0.001	change in labor force participation rate in region, natives	-0.0103 (0.006) scaled by total imm. shock: -0.147
Dustmann, Schönberg and Stuhler, 2017	Germany	IAB Social Security Records, 1986-1996 (3 years after immigration shock)	municipality	first differences, IV (distance to border, before and after border opening)	inflow of Czech workers between 1990-1992 divided by total employment in 1990 in municipality	change in log daily wage in municipality, natives	-0.134 (0.047)	change in log employment in municipality, natives	-0.926 (0.251)
Tabellini, 2020	US	Census, 1910-1930	180 US cities	continuous DiD, IV (past settlements plus World War I and 1920s Immigration Acts)	immigrant-to-population ratio in city	(log) occupational score, native men	0.097 (0.036)	employment-to-population ratio in city, native men	0.299 (0.064)
Beerli, Ruffner, Siegenthaler, and Peri, 2021	Switzerland	Swiss Earnings Structure Survey, 1994-2012 (average effect over 6 years after full border opening)	county	DiD, Reduced Form (border vs inland, before and after border opening)	distance indicator ("reduced form")	change in average log hourly wages in county, natives	-0.002 (0.021) Scaled by total imm. shock: -0.036	change in log employment in county, natives	0.04 (0.045) Scaled by total imm. shock: 0.714
Borjas and Edo, 2021	France	annual LFS, 1982-2016, Censuses	22 regions	continuous DiD, IV (past settlements)	(log) of 1+number of migrants divided by number of natives in the labor force in the region	(log) monthly wage, native men (log) monthly wage, native women	-0.780 (0.180) -0.950 (0.30)	no estimates reported	no estimates reported
Aksu, Erzan & Kirdar, 2022	Turkey	Turkish Household Labor Force Survey, 2004-2015	26 regions	DID, IV (distance to Syrian provinces plus refugee wave)	ratio of migrants to natives in the region	(log) wage in informal sector, native men (log) wage in formal sector, native men	-0.595 (0.178) 0.351 (0.151)	employment indicator, informal sector, native men employment indicator, informal sector, native men	-0.62 (0.261) 0.663 (0.207)
Ortega and Verdugo, 2022	France	Matched employer-employee administrative panel DADS, 1976-2007	286 commuting zones	first differences, IV (past settlement)	change in immigrant employees divided by the initial number of employees in the commuting zone	(log) daily wage, native men	-0.238 (0.121)	native outflow, men (adjusted probability to work in a different commuting zone)	0.790 (0.332)

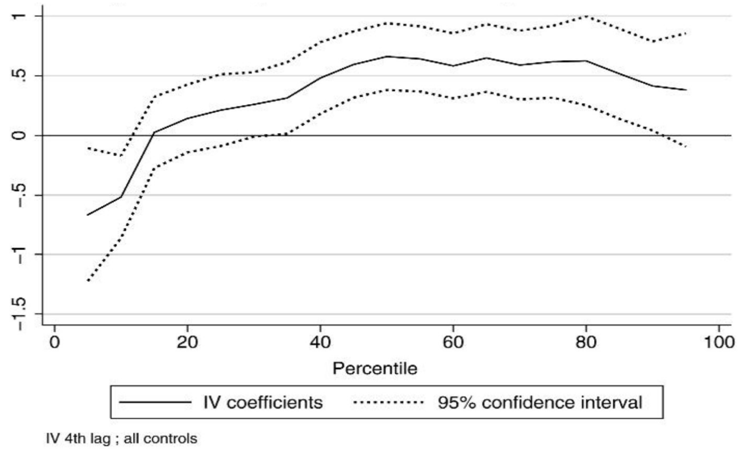
Note: The table summarizes findings from selected studies that utilize the pure spatial approach to estimate total aggregate wage effects of immigration. Studies highlighted in grey attempt to account for a potential "selectivity bias" described in detail in Section III.2. Borjas and Edo (2021) control for the (log) of the native labor force in the wage regression so that their wage estimates can be interpreted as the inverse labor demand elasticity.

Figure 2: Total Wage Effects of Immigration along the Wage Distribution: Pure Spatial Approach (Dustmann, Frattini and Preston, 2013)

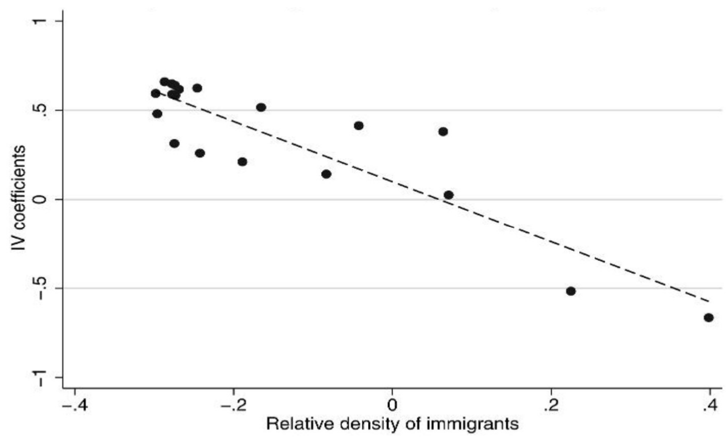
Panel A: The Location of Immigrants in the Native Wage Distribution



Panel B: Total Wage Effects of Immigration Along the Wage Distribution



Panel C: Total Wage Effects of Immigration and Density of Immigrants



Notes: Panel A (a simplified version of Figure 1 in Dustmann, Frattini, and Preston, 2013) shows immigrants' location in the wage distribution of natives. Panel B (corresponding to Figure 2 in Dustmann, Frattini, and Preston, 2013) displays instrumental variable estimates of the total wage effects of immigration along the wage distribution based on the pure spatial approach, where the instrument for the regional immigration shock is constructed based on immigrants' past settlements. Panel C (corresponding to Figure 4 in Dustmann, Frattini, and Preston, 2013) plots IV estimates of the total wage effects of immigration at every fifth percentile of the native wage distribution (from Panel B) against the relative density of immigrants at those percentiles (from Panel A). If viewed through the lens of the canonical model, the slope of the fitted line reflects the inverse elasticity of substitution between skill groups, provided that native labor supply is inelastic. The estimates in Dustmann, Frattini, and Preston (2013) indicate an inverse elasticity of substitution of -1.69.

Table 4: Total Skill-Specific Wage and Employment Effects of Immigration: Pure Spatial Approach (Selected Studies)

(1) Study	(2) Country	(3) Main Data and Time Period	(4) Identification Strategy	(5) Type of immigration shock	(6) Specification of Immigration Shock	(7) Specification of the wage variable	(8) Estimated Wage Effect	(9) Specification of the employent variable	(10) Estimated Employment Effect
Altonji and Card, 1991	US	1970 and 1980 Census (10-year change)	first differences, IV (past immigration share)	low-skilled	change in fraction of foreign-born residents in city	change in log weekly earnings in city, natives	less-skilled: -1.205 (0.342)	change in employment-to-population ratio in city, natives	less-skilled natives 0.085 -0.144
Lalonde and Topel, 1991	US	1% Sample of 1980 Census	OLS cross section, city fixed effects	unspecified (low-skilled)	(log) employment of immigrants in the city for each arrival cohort	individual (log) weekly wage, new immigrants ((relative to established immigrants)	-0.098 (0.043)	not studied	not studied
Cortes, 2008	US	1980-2000 Census	continuous DID, IV (past settlement)	low-skilled	(log) number of low-skilled immigrants and natives in city	individual (log) hourly wage, low-skilled natives individual (log) hourly wage, incumbent low-skilled immigrants	-0.050 (0.071) -0.123 (0.059)	little evidence for employment declines of low-skilled natives	
Dustmann, Frattini and Preston, 2013	UK	Labor Force Survey, 1997-2005 (annual changes)	first differences, IV (past settlement)	immigrants are concentrated at the bottom of the wage distribution	change in immigrant-to-native working-age population ratio in region	change in pth percentile of log wages in region, natives	10th percentile: -0.219 (0.115) 90th percentile: 0.34 (0.125)	not studied	not studied
Dustmann, Schönberg and Stuhler, 2017	Germany	IAB Social Security Records, 1986-1996 (3 years after immigration shock)	first differences, IV (distance to border, before and after border opening)	low-skilled	inflow of Czech workers between 1990-1992 divided by total employment in 1990 in municipality	change in log daily wage in municipality and skill group, natives	unskilled: -0.202 (0.048) skilled: -0.106 (0.051)	change in log employment in municipality and skill group, natives	unskilled natives: -1.371 (0.395) skilled natives: -0.501 (0.214)
Foged and Peri, 2016	Denmark	Administrative Register, 1988-2008	DiD, IV (refugee dispersal policy), worker-municipality fixed effect	low-skilled	immigrant employment share inmunicipality	(log) hourly wage, Danish-born	low-skilled: 0.98 (0.60)	fraction of year worked	low-skilled: 0.794 (0.287)
Beerli, Ruffner, Siegenthaler & Peri, 2021	Switzerland	Swiss Earnings Structure Survey, 1994-2012 (average effect over 6 years after full border opening)	DiD , Reduced Form (distance to border plus policy change)	high-skilled	distance indicator ("reduced form")	change in average log hourly native wages in county, natives	highly educated 0.045 (0.015) Scaled by imm. shock: 0.804 lower educated -0.022 (0.022) Scaled by imm. shock: -0.393	change in log FT equivalents in county, natives	highly educated 0.163 (0.064) Scaled by imm. shock: 2.911 lower educated -0.003 (0.051) Scaled by imm. shock: -0.054
Monras, 2020	US	CPS, 1990-2000 (1 year after immigration shock)	first differences, IV (past share of Mexicans plus Peso crisis)	low-skilled	change in the share of Mexicans among low-skilled workers between 1994 and 1995 in MSA	change in (log) weekly wages in MSA,non-Mexicans	low-skilled: -1.418 (0.331) high-skilled: -0.0111 (0.417)	change in (log) employment rate, natives	low-skilled: 0.0308 (0.554) high-skilled: 0.381 (0.250)

Note: The table summarizes findings from selected studies that utilize the pure spatial approach to estimate total wage effects of immigration by skill. Studies highlighted in dark grey attempt to account for a potential "selectivity bias" described in detail in Section III.2. Studies highlighted in light grey use the skill-specific instead of the total regional immigration shock as right-hand-side variables. While this is similar to the mixture approach, the first difference regression does not include regional fixed effects (or region-by-time fixed effects in a level regression); see also footnote 18.

Table 5: Partial Wage and Employment Effects of Immigration by Skill: Mixture Approach (Selected Studies)

(1) Study	(2) Country	(3) Data	(4) Regional Unit	(5) Skill Groups	(6) Identification Strategy	(7) Definition Immigration Shock	(8) Definition Wages	(9) Estimated Wage Effect	(10) Definition Employment	(11) Estimated Employment	(12) Implied Elasticity of Substitution
Borjas, Freeman and Katz, 1996	US	1980 and 1990 Censuses (10-year changes)	9 regions	4 education groups	DiD (first differences)	change in immigrant population share in region and education group	change in (log) weekly earnings in the education group and region, natives	-0.2058 (0.081)	not studied	not studied	4.859
Card, 2001	US	1990 Census	MSA, 175 largest cities	6 broad occupation groups	cross-sectional regression, IV (past settlements)	immigrant population share in the occupation and city	(log) hourly wage in the education group and MSA, male natives	-0.099 (0.033)	employment-to-population rate in the occupation and city, male natives	-0.202 (0.042)	8.061
Card and Lewis, 2007	US	1980, 1990, and 2000 Census (10-year changes)	MSA. 145 larger cities	high school graduates and dropouts	DiD (first differences), IV (past fractions of Mexican immigrants)	change in (log) labor supply high school graduates relative to dropouts	change in (log) hourly wages of high school graduates relative to dropouts in MSA, natives	-0.04 (0.06)	not studied	not studied	25.000
Card, 2009	US	1980–2000 Censuses, 2005–2006 American Community Surveys	MSA, 124 larger cities	college and high school educated workers	cross-sectional regression, IV (past settlements)	(log) labor supply of college relative to high school graduates	(log) residual wage of college relative to high school graduates in MSA, male natives	-0.42 (0.28)	not studied	not studied	2.381
Lewis, 2011	US	1980-2000 Censuses (10-year changes)	MSA, 143 larger cities	high school dropouts and high school completers	DiD (first differences), IV (past settlements)	change in number of high school dropouts per high school equivalent	change in regression adjusted wage gap between high school dropouts and completers in the city, natives, manufacturing	-0.277 (0.176)	not studied	not studied	12.034
Gonzalez and Ortega, 2011	Spain	2001 and 2006 LFS (5-year change)	47 provinces	3 education groups	DiD (first differences), IV (past settlements)	percentage change in population of the education group in the province	change in (log) daily wage in the education group and province, natives	–0.0599 (0.055)	change in the employment rate in the education group and province, natives	0.0435 (0.048)	16.694
Glitz, 2012	Germany	2% IAB Employment Sample, 1996-2001 (annual changes)	112 West German labor market regions	5 broad occupation groups	DiD (first differences), IV (exogenous allocation to labor market regions of ethnic Germans from Eastern Europe)	change in the (log) occupation-specific labor force shares in the local labor market region	change in (log) daily wage in the occupation and labor market region, residents	-0.211 (0.174)	change in the employment rate in the occupation and labor market region, residents	-0.351 (0.153)	4.739
Dustmann and Glitz, 2015	Germany	IAB Social Security Data, 1985-1995	204 West German labor market regions	3 skill groups	DiD (first differences), IV (past settlements)	percent change in the labor force in the education group	change in (log) daily median wages in the education group and region, natives	Non-tradable industries: -0.411 (0.145) manufacturing: -0.101 (0.060) tradable industries: -0.042 (0.065)	not studied	not studied	Non-tradable industries: 2.43 manufacturing 9.90 tradable industries: 23.81
Monras, 2020	US	CPS, 1990-2000 (up to 6 years after the shock)	MSA	low-skilled	DiD (first differences), IV (past share of Mexicans. Peso crisis)	change in the share of Mexicans among low-skilled workers between 1994 and 1995 in MSA	change in (log) wage gap between low- and high-skilled in MSA	-1.395 (0.387)	not studied	not studied	0.717

Note: The table summarizes findings from selected studies that utilize the mixture approach to estimate partial wage effects of immigration by skill. When inferring the elasticity of substitution in the Column (12), we assume that regional native employment of one skill group relative to another does not adjust following a skill-specific regional immigration shock for studies that do not investigate the partial employment effects of immigration. For the three remaining studies, we assume that natives do not reallocate to other regions in response to a skill-specific immigration shock.

Table 6: Partial Wage and Employment Effects of Immigration: National Skill -Cell Approach (Selected Studies)

Study	Country	Data	Skill Cells	Identification Strategy	Definition Immigration Shock	Definition Wages	Estimated Wage Effect	Definition Employment	Estimated Employment Effect
Panel A: Education-Experience Cells									
Borjas (2003)	US	1960-1990 Census, 1998-2001 CPS	4 education groups, 8 experience groups	DinD (levels)	immigrant share in the labor force in the education-experience group	(log) weekly earnings, male natives	-0.572 (0.162)	fraction of time worked, native-born	-0.529 (0.132)
Aydemir and Borjas (2011)	**Canada**, US	Canadian Census (71, 81, 86, 91, 96, 01)	5 education groups, 8 experience groups	DinD (levels)	immigrant share in the labor force in the education-experience group	(log) weekly wage, male natives	-0.531 (0.064)	not studied	not studied
Bratsberg, Raaum, Røed & Schøne (2014)	Norway	Administrative Registers, 1993-1996	4 education groups, 8 experience groups	DinD (levels)	immigrant share in the labor force in the education-experience group	(log) daily wage, male natives	-0.327 (0.155)	not studied	not studied
Card and Peri (2016)	US	1960-2000 Census, 2009-2011 American Community Survey	5 education groups, 8 experience groups	DinD (First Differences)	immigrant inflow (over 10 years) divided by labor force at baseline in the education-experience group	change in (log) weekly earnings, male natives	-0.124 (0.132)	not studied	not studied
Llull (2018b)	**US**, Canada, selected European countries	1960-2000 Census	3 education groups, 5 experience groups	DinD (levels), 2SLS (push factors: conflict)	immigrant share in the labor force in the education-experience group	(log) monthly wage, male natives	OLS: -0.690 (0.385) IV: -1.430 (0.385)	not studied	not studied
Panel B: Occupation-Experience Cells									
Prantl and Spitz-Oener (2020)	Germany	Qualification and Career Survey, which was carried out by the German Federal Institute for Vocational Education and Training, 85–86, 91–92, and 98–99	46 occupation groups, 6 age groups	DiD (levels), IV (pool of potential East German migrants)	immigration share in employment in the occupation-experience group	(log) hourly wage, natives	OLS: -0.1675 (0.1266) IV: -0.6129 (0.4638) competitive segment, IV: -1.7194 (0.6260)	not studied	not studied
Panel C: Occupation Cells									
Friedberg (2001)	Israel	Israeli Income Survey and Israeli Labor Force Surveys, 1989 and 1994	2-digit occupations	DiD (first difference), IV (occupation in home country)	employment share of Russians in the occupation in 1994	change in (log) hourly wage, natives	OLS: -0.323 (0.086) IV: 0.718 (0.343)	not studied	not studied
Hoen (2020)	Norway	Administrative Registers, 2002-2011	318 occupations	DiD (first difference), IV (language requirements)	change in EU12 employment share in the occupation between 2005 and 2011	change in (log) cumulative annual labor earnings (2002-2005 vs 2006-2011)	OLS: -0.359 (0.048) IV: -0.745 (0.156)	Probability of full-time employment each year in 2006-2011	IV: -0.967 (0.257)
Panel D: Industry Cells									
Bratsberg and Raaum (2012)	Norway	Administrative Registers, 1998-2005	16 activities within construction sector	DiD (levels), IV (licensing)	log (1 plus immigrant employment share in the activity)	log wage, natives	OLS: -0.570 (0.214) IV: -0.573 (0.464)	not studied	not studied

Note: Panel A of the table summarizes findings from selected studies that utilize the national skill-cell approach to estimate partial wage effects of immigration by education and experience. Panels B to D provide examples of studies closely related to the national skill-cell approach that leverage variation in national immigration shocks across occupation-experience cells, occupation cells, or industry cells. Studies highlighted in grey attempt to account for a potential "selectivity bias" described in detail in Section III.2.

Table 7: Simulated Wage Effects of Immigration: Structural Approach

Panel A: Estimates for the Inverse Elasticities of Substitution	between immigrants and natives $(1-\delta)$	experience $(1-\gamma)$	education $(1-\beta)$
Borjas, 2003 (inverse elasticities)	not considered	0.288 (0.115)	0.759 (0.582)
elasticities of substitution		3.5	1.3
Ottaviano and Peri, 2012 (inverse elasticities)	0.053 (0.008)	0.16 (0.05)	0.3 (0.11)
elasticties of substituion	18.868	6.250	3.333
Manacorda, Manning and Wadsworth, 2012 (inverse elasticities)	0.142 (0.065)	0.193 (0.038)	0.203 (0.048)
elasticites of substitution	7.042	5.181	4.926
Piyapromdee, 2020	high-skilled:	men vs women	
elasticities of substitution	6.925 (0.154)	1.973 (0.167)	2.193 (0.109)
	low-skilled:		
	17.87 (0.819)		

Panel B: Simulated Total Wage Effects of Immigration	
Borjas, 2003: United States, 1980-2000, simulated cumulative wage changes	
all workers	-3.2
high school dropouts, 16-20 years of experience	-13.6
high school dropouts, all	-8.9
some college, 36-40 years of experience	0.8
Ottaviano and Peri, 2012: United States, 1990-2006, simulated cumulative wage changes	
natives	0.6 (0.6)
natives, less than highschool	-2.0 (1.0)
natives, some college	1.9 (0.6)
immigrants	-6.8 (1.4)
immigrants, less than high school	-7.4 (1.4)
immigrants, some college	-2.9 (1.1)
Manacorda, Manning and Wadsworth, 2012: United Kingdom, 1974-2005, simulated annual wage changes	
natives	-0.04
natives,university	-0.03
immigrants	-0.89
immigrants, university	-0.83
Piyapromdee, 2021: Increase in ratio of immigrants to natives among high-skilled workers from 0.17 to 0.25; simulated annual wage changes. Gateway cities.	
high-skill male native	0.3
low-skill male native	3.7
high-skill male immigrant	-4.7
low-skill male immigrant	3.8

Note: Panel A of the table reports estimates of the (inverse) elasticities of substitution between immigrants and natives; between experienced and inexperienced workers, and between education groups from four studies that adopt the structural approach. Panel B reports the implied simulated total wage effects of immigration for various worker groups.

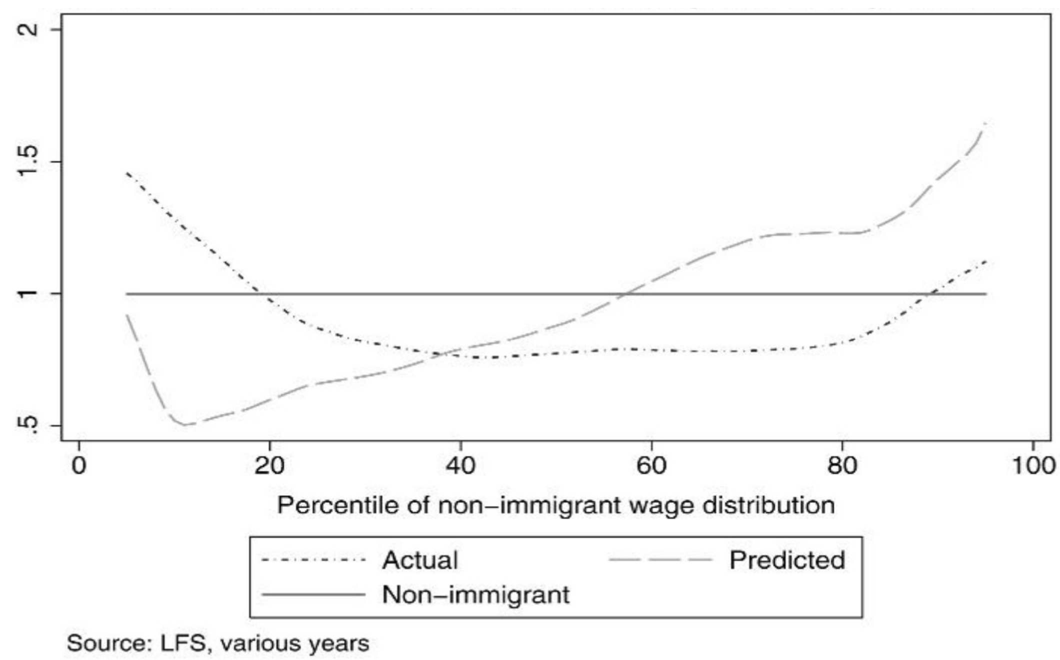
Borjas, 2003: 1960-1990 Census, 1998-2001 CPS. 4 education groups, 8 experience groups.

Ottaviani and Peri, 2012: US Decennial Census 1960–2000, 2006 American Community Survey. 4 education groups, 8 experience groups. Model A.

Manacorda, Manning and Wadsworth, 2012. UK LFS 1974-2005. 2 education groups, 7 age groups.

Piyapromdee, 2021: 1980- 2000 Census, combined 2005–2007 American Community Surveys (ACS). 2 skill groups, men vs women. The elasticity of substitution between immigrants and natives is allowed to vary by skill.

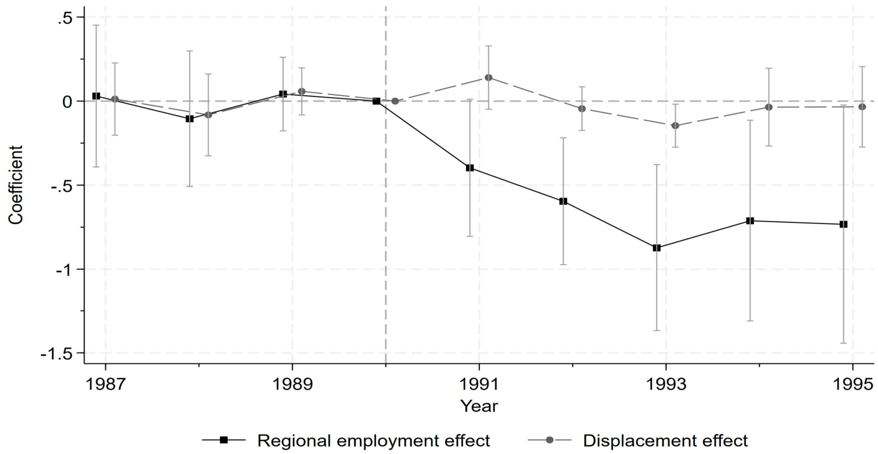
Figure 3: Downgrading of Recent Immigrants in the UK



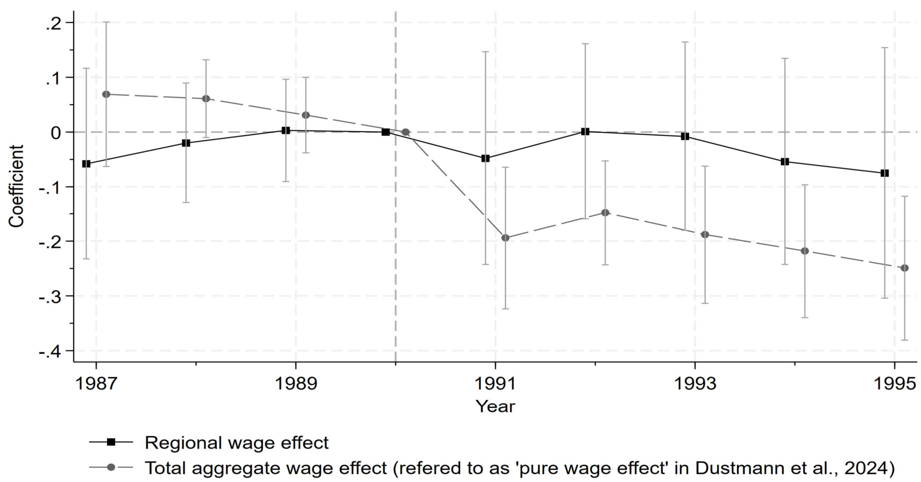
The figure (Figure 1 in Dustmann, Frattini, and Preston, 2013), illustrates immigrant downgrading in the UK. The figure first shows the predicted position of recent immigrants in the native wage distribution, assuming that the returns to education and experience are the same for both immigrants and natives ("Predicted"). It then contrasts this with their actual position ("Actual").

Figure 4: The Impact of Immigration on Native Employment and Wages

Panel A: Regional Employment vs Displacement Effects of Immigration

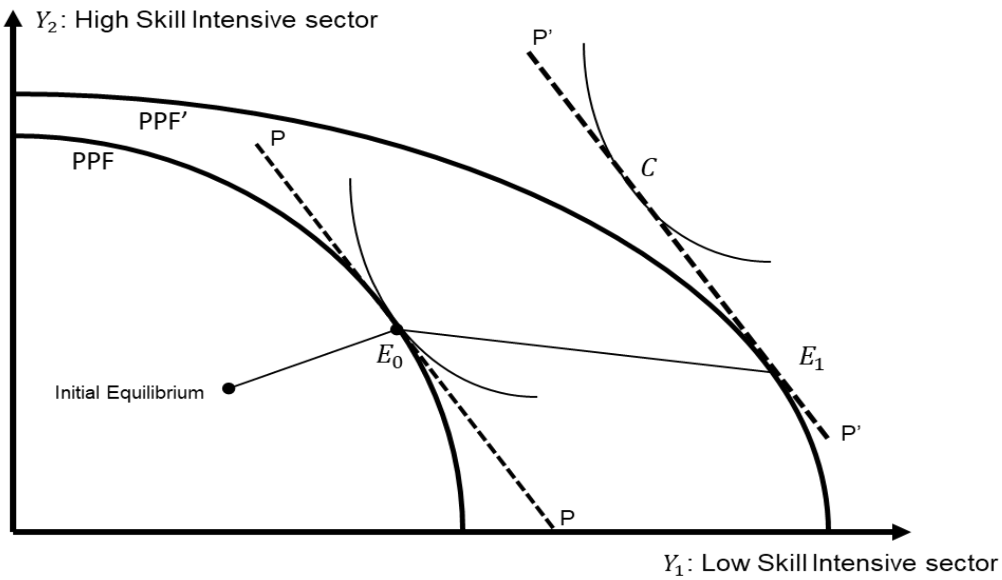


Panel B: Regional vs Total Aggregate Wage Effects of Immigration



Note: Panel A (Figure 1 in Dustmann, Otten, Schönberg, and Stuhler, 2024) contrasts the regional and displacement effects of immigration. The figure indicates strong regional employment declines among native workers following an immigration shock. An increase in the employment share of Czechs by 1 percentage point resulted in a decrease in native employment in the municipality by 0.873% three years and 0.733% five years after the shock ("regional employment effect"). Yet, the immigration shock had little impact on the probability that previously employed natives become non-employed ("displacement effect"). See also Section III.1. Panel B (Figure 2 in Dustmann et al., 2022) contrasts the regional and the total aggregate wage effects of immigration. The regional wage effect of immigration typically estimated in the literature may confound the total aggregate wage effect of immigration and compositional changes in the workforce ("selectivity bias"). In this setting, the total aggregate wage effect of immigration (the pure wage effect in Dustmann, Otten, Schönberg, and Stuhler, 2024) is more negative than the regional wage effect, indicating that immigration improved the composition of employed natives. See also Section III.2.

Figure 5: Immigration to a Small Open Economy with Traded Goods



The figure graphically illustrates the Rybczynski Theorem. In the old equilibrium E0, the slope of the production possibility frontier is equal to the ratio between the product prices in the two sectors. An immigration shock biased toward low-skilled workers shifts out the production possibility frontier but leaves, in a small open economy, relative product prices unchanged. In the new equilibrium E1, output in the sector that uses low-skilled labor intensively has expanded, while output in the sector that uses high-skilled labor intensively has contracted. Assuming homothetic and uniform preferences for immigrants and natives, the economy produces at E1 but consumes at C after the immigration shock. It exports the low-skill-intensive good, and imports the high-skill-intensive good.

The Labor Market Effects of Immigration: Appendix

Christian Dustmann and Uta Schönberg

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Appendix A: Canonical Model (Section II)
Appendix A.1: Derivation of Equations (1a) and (1b) (Section II.2)

Firms choose capital K and low- and high-skilled labor L_L and L_H by maximizing profits, taking the product price p, wage rates w_L and w_H, and the price of capital r as given:

$$\max_{L_L,L_H,K} pAL^{1-\alpha}K^{\alpha} - (rK + w_L L_L + w_H L_H)$$

The first-order condition for capital (suppressing the superscript D denoting *demand* for simplicity) equals:

$$log\, p + log\alpha A + (\alpha - 1)[logK - logL] = logr$$

Totally differentiating this expression, we obtain:

$$(\alpha - 1)[dlogK - dlogL] = dlogr$$

Plugging in the capital supply function d$logr = \lambda\, dlogK$ into this expression, we obtain:

$$dlogK = -\frac{\alpha-1}{1-\alpha+\lambda} dlogL$$

Taking into account that labor L is a CES aggregate of low- and high-skilled labor, such that $L = [\theta L_L^{\beta} + (1-\theta)L_H^{\beta}]^{1/\beta}$, the first-order condition for labor of type g equals:

$$log\, p + \ log(1-\alpha)A + \alpha[logK - logL] + \ log\theta_g + (\beta - 1)\big[logL_g - logL\big] = log\, w_g$$

where $\theta_L = \theta$ and $\theta_H = 1 - \theta$ $(g = L, H)$, respectively, and $1/(1-\beta)$ is the elasticity of substitution between the two skill groups. Totally differentiating this expression, we obtain:

$$\alpha[dlogK - dlogL] + (\beta - 1)\big[dlogL_g - dlogL\big] = dlogw_g$$

Plugging in the expression for d$logK = -\frac{\alpha-1}{1-\alpha+\lambda} dlogL$ yields:

$$-\frac{\alpha\lambda}{1-\alpha+\lambda} dlogL + (\beta - 1)\big[dlogL_g - dlogL\big] = dlog\, w_g$$

Noting that $\varphi = -\frac{\alpha\lambda}{1-\alpha+\lambda}$, we obtain Equation (1a).

From $dlogw = s_L dlogw_L + s_H dlogw_H$, we obtain $dlogw = \varphi dlogL$ (Equation (1b)), as $dlogL = s_L dlogL_L + s_H dlogL_H$. Here $s_L = \frac{\theta L_L^{\beta}}{\left[\theta L_L^{\beta} + (1-\theta)L_H^{\beta}\right]}$ and $s_H = \frac{(1-\theta)L_H^{\beta}}{\left[\theta L_L^{\beta} + (1-\theta)L_H^{\beta}\right]}$ are the CES aggregators.

Appendix A.2 Derivation of Equations (4a) and (4b) (Section II.2)

Let $dI_g := \frac{\Delta M_g}{L_g^N}$ denote the skill-specific immigration shock, where ΔM_g represents the gross inflow of immigrants of skill type g into the economy between two periods, and L_g^R denotes native employment of skill type g at baseline. $dI = s_L dI_L + s_H dI_H$ denotes the total immigration shock in efficiency units of labor, where $s_L = \frac{\theta L_L^\beta}{\left[\theta L_L^\beta + (1-\theta) L_H^\beta\right]}$ and $s_H = \frac{(1-\theta) L_H^\beta}{\left[\theta L_L^\beta + (1-\theta) L_H^\beta\right]}$ are the CES aggregators. From Equations (1a) and (3a), $dlogw_g - dlogw_{g'} =- (1-\beta))(dI_g - dI_{g'} + \eta(dlogw_g - dlogw_{g'}))$. Rearranging, we obtain:

$$dlogw_g - dlogw_{g'} =- \frac{(1-\beta)}{1+\eta(1-\beta)}(dI_g - dI_{g'})$$

Further note that $dlogw = \varphi(dI + \eta dlogw)$. Hence, $dlogw = \frac{\varphi}{1-\varphi\eta} dI$, which is Equation (4b). Combining these two results, we obtain Equation (4a):

$$dlogw_g = \frac{\varphi}{1-\varphi\eta} dI - \frac{(1-\beta)}{1+\eta(1-\beta)}\left(dI_g - dI\right)$$

Appendix A.3: Derivation of Equations (13), (14a) and (14b) (Section III.3.2)

Suppose that labor in each education group g is a CES aggregate of inexperienced and experienced (indexed by the sub-index $a = E$) workers, indexed by the sub-index $a = E, I$:

$$L_g = [\tilde{\theta} L_{gI}^\gamma + (1-\tilde{\theta}) L_{gE}^\gamma]^{1/\gamma}$$

where $-\frac{1}{1-\gamma}$ is the elasticity of substitution between inexperienced and experienced workers within education group g. The first-order condition for labor of type ga equals (suppressing the superscript *D* denoting *demand* for simplicity):

$$logp + log\,(1-\alpha)\,\mathrm{A} + \alpha[logK - logL] + log\,\theta_g + (\beta-\gamma)\left[logL_g - logL\right] + log\,\tilde{\theta}_{\mathrm{a}} + (\gamma-1)[logL_{ga} - logL] = logw_{ga}$$

where $\theta_L = \theta$ and $\theta_H = 1-\theta$ $(g = L, H)$, and $\tilde{\theta}_{\mathrm{I}} = \tilde{\theta}$ and $\tilde{\theta}_{\mathrm{E}} = 1-\tilde{\theta}$ $(a = I, E)$, respectively. Totally differentiating this expression, we obtain:

$$(\beta-\gamma)\left[dlogL_g - dlogL\right] + (\gamma-1)[dlogL_{ga} - dlogL] = \mathrm{d}logw_{ga}$$

Substituting in the expression for $dlogK$ and simplifying, we obtain (recall that $\varphi =- \frac{\alpha\lambda}{1-\alpha+\lambda}$):

$$dlogw_{ga} = \varphi dlogL + (\beta - 1)\big(dlogL_g - dlogL\big) + (\gamma - 1)(dlogL_{ga} - dlogL_g) \qquad \text{(A.1)}$$

Labor supply of education group g and experience group a changes according to (suppressing the superscript *S* denoting *supply* for simplicity):

$$dlogL_{ga} = dI_{ga} + \eta dlogw_{ga}$$

where η is the labor supply elasticity and $dI_{ga} =: \frac{\Delta M_{ga}}{L_{ga}^{N}}$ is the education-experience-specific immigration shock. Similarly, education-specific labor supply shifts according to

$$dlogL_g = d\tilde{I}_g + \eta dlog\widetilde{w}_g$$

where $d\tilde{I}_g = s_{gI}dI_{gI} + s_{gE}dI_{gE}$, $dlog\widetilde{w}_g = s_{gI}dlogw_{gI} + s_{gE}dlogw_{gE}$, and s_{gI} and s_{gE} are the CES aggregators of the second nest ($s_{gI} = \frac{\tilde{\theta}L_{ga}^{\gamma}}{\left[\tilde{\theta}L_{gI}^{\gamma}+(1-\tilde{\theta})L_{gE}^{\gamma}\right]}$ and $s_{gE} = \frac{(1-\tilde{\theta})L_{ga}^{\gamma}}{\left[\tilde{\theta}L_{gI}^{\gamma}+(1-\tilde{\theta})L_{gE}^{\gamma}\right]}$).Total labor supply changes according to:

$$dlogL = d\tilde{I} + \eta dlog\widetilde{w}$$

where $d\tilde{I} = s_L d\tilde{I}_L + s_H d\tilde{I}_H, dlog\widetilde{w} = s_L dlog\widetilde{w}_L + s_H dlog\widetilde{w}_H,$ and s_L and s_H are CES aggregates of the first nest ($s_g = \frac{\theta_g L_g^{\beta}}{\left[\theta_R L_R^{\beta}+\theta_A L_A^{\beta}\right]}$). From these relationships, we first obtain:

$$dlogw_{ga} - dlogw_{ga'} =- (1-\gamma)(\, dI_{ga} - dI_{ga'} + \eta(dlogw_{ga} - dlogw_{ga'}))$$

Rearranging yields Equation (14a) in the text:

$$\frac{dlogw_{gE} - dlogw_{gI}}{dI_{gE} - dI_{gI}} = \left.\frac{dlogw_{ga}}{dI_{ga}}\right|_{d\tilde{I},d\tilde{I}_g} =- \frac{(1-\gamma)}{1+\eta(1-\gamma)}$$

Further observe that

$$dlog\widetilde{w}_g - dlog\widetilde{w}_{g'} =- (1-\ \beta))(\, \mathrm{d}\tilde{\mathrm{I}}_g - \mathrm{d}\tilde{\mathrm{I}}_{g'} + \eta(dlog\widetilde{w}_g - dlogw\widetilde{w}_{g'}))$$

It follows that

$$dlog\widetilde{w}_g - dlog\widetilde{w}_{g'} =- \frac{(1-\ \beta)}{1-(\beta-1)\eta}\,(d\tilde{I}_g - d\tilde{I}_{g'})$$

Also note that

$$dlogw = \varphi(d\tilde{I} +\ \eta dlogw)$$

It follows that

$$dlogw = \frac{\varphi}{1-\varphi\eta}\, d\tilde{I}$$

In consequence,

$$dlogw_{ga} = \frac{\varphi}{1-\varphi\eta}\, d\tilde{I} - \frac{(1-\beta)}{1-(\beta-1)\eta}\left(d\tilde{I}_g - d\tilde{I}\right) - \frac{(1-\gamma)}{1+\eta(1-\gamma)}\left[dI_{ga} - d\tilde{I}_g\right]$$

which is Equation (13) in the text.

Appendix A.4: Derivation of Equation (15) (Section III.4)

When immigrants and natives are imperfect substitutes within education-experience groups, the first-order condition for labor of type (subscript) g (education groups), (subscript) a (experience groups) and (superscript) k (immigrants M vs. natives N) equals:

$$logp + log\,(1-\alpha)\,A + \alpha[logK - logL] + log\,\theta_g\; + (\beta-\gamma)\left[logL_g - logL\right] + \; + log\,\tilde{\theta}_a \\ + (\gamma-\delta)\left[logL_{ga} - logL\right] + \; log\,\hat{\theta}_k + (\delta-1)\left[logL_{ga}^k - logL\right] = log\,w_{ga}^k$$

Where $\theta_L = \theta$ and $\theta_H = 1-\theta$ $(g = L, H)$; $\tilde{\theta}_{\mathrm{I}} = \tilde{\theta}$ and $\tilde{\theta}_E = 1-\tilde{\theta}$ $(a = I, E)$; $\hat{\theta}_N = \hat{\theta}$ and $\hat{\theta}_M = 1-\hat{\theta}$ $(k = N, M)$, respectively. Totally differentiating this expression yields:

$$\alpha[dlogK - dlogL] + (\beta-\gamma)\left[dlogL_g - dlogL\right] + (\gamma-\delta)\left[dlogL_{ga} - dlogL\right] \\ + (\delta-1)\left[dlogL_{ga}^k - dlogL\right] = dlog\,w_{ga}^k$$

Substituting in the expression for $dlogK$=$\varphi dlogL$ and simplifying, we obtain:

$$dlog\,w_{ga}^k = \varphi dlogL - (1-\beta)\left(dlogL_g - dlogL\right) - (1-\gamma)\left[dlogL_{ga} - dlogL_g\right] \\ - (1-\delta)\left[dlogL_{ga}^k - dlogL_{ga}\right]$$

Computing $dlogw_{ga}^M - dlogw_{ga}^N$, we obtain Equation (15) in the text:

$$dlogw_{ga}^M - dlogw_{ga}^N = -\,(1-\delta)\left(dlog\,L_{ga}^M - dlog\,L_{ga}^N\right)$$

Appendix B: The Effect of Immigration on Capital and Output (Section V.2)

Recall from Appendix A.1 that the first-order condition for capital can be written as:

$$dlogK = -\frac{\alpha-1}{1-\alpha+\lambda} dlogL$$

Further note that labor supply shifts out according to:

$$dlogL = dI + \eta dlogw = (1 + \frac{\varphi\eta}{1-\varphi\eta})dI = \frac{dI}{1-\varphi\eta}$$

where we have used that $dlogw = \frac{\varphi}{1-\varphi\eta}dI$ (see Equation (4b)). Combining the two equations and recognizing that $\varphi = -\frac{\alpha\lambda}{1-\alpha+\lambda}$ yields the expression $\frac{dlogK}{dI} = \frac{1-\alpha}{1-\alpha+\lambda(1+\alpha\eta)}$ in the text. The expression for $\frac{dlogr}{dI}$ follows from the capital supply function $dlogr = \lambda\, dlogK$. To obtain the comparative static for output, $\frac{dlogY}{dI}$, totally differentiate (log) output:

$$dlogY = (1-\alpha)dlogL + \alpha dlogK$$

Substituting $dlogL = (1 + \frac{\varphi\eta}{1-\varphi\eta})dI$ (see Equation (5b) for the impact of immigration on native employment), $dlogK = \frac{1-\alpha}{1-\alpha+\lambda(1+\alpha\eta)}dI$ and $\varphi = -\frac{\alpha\lambda}{1-\alpha+\lambda}$, we obtain $\frac{dlogY}{d\tilde{I}} = \frac{(1-\alpha)(1+\lambda)}{1-\alpha+\lambda(1+\alpha\eta)}$, as shown in the text.

Appendix C: Endogenous Technology Adoption (Section V.3)

Appendix C.1: The Total Aggregate Wage Effect of Immigration (Section (V.3.1)

Appendix C.1.1: The Aggregate Production Function

We adopt a simplified version of the static task-based framework (Acemoglu and Restrepo, 2018). The production process of the final good is comprised of a unit measure of tasks, $y(x)$, with an elasticity of substitution $\rho \in (0, \infty)$:

$$Y = A\left(\int_0^1 y(x)^{\frac{\rho-1}{\rho}} dx\right)^{\frac{\rho}{\rho-1}}$$

The production function of each task is given by $y(x) = k(x) + \psi(x)l(x)$, where $l(x)$ denotes labor employed in task x, $k(x)$ denotes capital used in the production of task x, and $\psi(x)$ is the relative productivity of labor in task x. We assume $\psi(x)$ is positive, continuous, differentiable, and strictly increasing in x. Consequently, labor has a comparative advantage in tasks with higher indices (i.e., more complex tasks). We further assume that $\frac{w}{\psi(1)} < r < \frac{w}{\psi(0)}$ to ensure an interior solution where w and r denote the wage rate and the rental rate of capital, respectively. In consequence, there is a unique cut-off such that tasks in $[0, \theta)$ are produced by capital, and tasks in $(\theta, 1]$ are produced by labor. Following Acemoglu and Restrepo (2018), the aggregate production function is:

$$Y = A\left[\theta^{\frac{1}{\rho}} K^{\frac{\rho-1}{\rho}} + \left(\int_\theta^1 \psi(x)^{\rho-1} dx\right)^{\frac{1}{\rho}} L^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}$$

where θ is endogenously determined by $\psi(\theta) = \frac{w}{r}$, $L = \int_0^1 l(x)dx$ and $K = \int_0^1 k(x)dx$. Taking logs of the production function and totally differentiating yields:

$$dlogY = s^K dlogK + s^L dlogL$$

where $s^K = \frac{rK}{pY} = A^{\frac{\rho-1}{\rho}} \theta^{\frac{1}{\rho}} \left(\frac{K}{Y}\right)^{\frac{\rho-1}{\rho}}$ and $s^L = \frac{wL}{pY} = A^{\frac{\rho-1}{\rho}} \left(\int_\theta^1 \psi(x)^{\rho-1} dx\right)^{\frac{1}{\rho}} \left(\frac{L}{Y}\right)^{\frac{\rho-1}{\rho}}$ are the capital and labor output shares ($s^K + s^L = 1$).

If the elasticity of substitution ρ approaches 1, the production function will approach a Cobb-Douglas production function, as we assumed in the canonical model outlined in Section II.2. However, unlike in the canonical model, capital's output share α is no longer exogenous but a choice variable of the firm. In the following, we analyze the firm's maximization problem for the more general case of $\rho \in (0, \infty)$. We then simplify expressions, assuming that $\rho = 1$.

Appendix C.1.2: Firms' Maximization Problem and Choice of Technology

Firms choose capital and labor by maximizing profits, taking the product price p, the wage rate w, and the price of capital r as given:

$$\max_{L,K} pA\left[\theta^{\frac{1}{\rho}} K^{\frac{\rho-1}{\rho}} + \left(\int_\theta^1 \psi(x)^{\rho-1} dx\right)^{\frac{1}{\rho}} L^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} - (rK + wL)$$

The first-order condition for capital is:

$$logr = logp + \frac{\rho-1}{\rho} logA + \frac{1}{\rho} logY + \frac{1}{\rho} log\theta - \frac{1}{\rho} logK$$

Totally differentiating this expression, we obtain:

$$dlogr = \frac{1}{\rho} dlogY + \frac{1}{\rho}\frac{1}{\theta} d\theta - \frac{1}{\rho} dlogK$$

Plugging in the expression for $dlogY = s^K dlogK + s^L dlogL$, and using that capital is supplied according to $dlogr = \lambda dlogK$, we obtain:

$$dlogK = \frac{s^L}{\lambda\rho + s^L} dlogL + \frac{1}{\theta}\frac{1}{\lambda\rho + s^L} d\theta$$

In the case of Cobb-Douglas production function ($\rho = 1$), $s^L = 1 - \alpha$ and $\theta = \alpha$. This expression then becomes:

$$dlogK = \frac{1-\alpha}{\lambda + 1 - \alpha} dlogL + \frac{1}{\alpha}\frac{1}{\lambda + 1 - \alpha} d\alpha$$

Using $dlogr = \lambda dlogK$:

$$dlogr = \frac{\lambda(1-\alpha)}{\lambda+1-\alpha}dlogL + \frac{1}{\alpha}\frac{\lambda}{\lambda+1-\alpha}d\alpha$$

The first-order condition for labor is:

$$logw = logp + \frac{\rho-1}{\rho}logA + \frac{1}{\rho}logY + \frac{1}{\rho}log\left(\int_{\theta}^{1}\psi(x)^{\rho-1}dx\right) - \frac{1}{\rho}logL$$

Totally differentiating this expression, we obtain:

$$dlogw = \frac{1}{\rho}dlogY - \frac{1}{\rho}dlogL - \frac{1}{\rho}\frac{\psi(\theta)^{\rho-1}}{\int_{\theta}^{1}\psi(x)^{\rho-1}dx}d\theta$$

Plugging in the expression for $dlogY = s^K dlogK + s^L dlogL$, and using that $dlogK = \frac{s^L}{\lambda\rho+s^L}dlogL + \frac{1}{\theta}\frac{1}{\lambda\rho+s^L}d\theta$, yields:

$$dlogw = -\frac{\lambda s^K}{\lambda\rho+s^L}dlogL - \frac{\lambda}{\lambda\rho+s^L}\frac{\psi(\theta)^{\rho-1}}{\int_{\theta}^{1}\psi(x)^{\rho-1}dx}d\theta$$

In the case of Cobb-Douglas production function ($\rho = 1$), this expression becomes

$$dlogw = -\frac{\lambda\alpha}{\lambda+1-\alpha}dlogL - \frac{\lambda}{\lambda+1-\alpha}\frac{1}{1-\alpha}d\alpha \equiv \varphi dLogL + \frac{\varphi}{\alpha(1-\alpha)}d\alpha$$

where $\varphi \equiv -\frac{\lambda\alpha}{\lambda+1-\alpha}$ denotes the inverse labor demand elasticity.

Combine the expressions for $dlogw$ and $dlogr$ (for $\rho = 1$) with the aggregate labor supply function $dlogL = dI + \eta dlogw$ (where dI is the total immigration shock and η is the labor supply elasticity) to obtain:

$$dlogw = -\frac{\lambda\alpha}{\lambda+1-\alpha+\lambda\eta\alpha}dI - \frac{\lambda}{\lambda+1-\alpha+\lambda\eta\alpha}\frac{1}{1-\alpha}d\alpha$$
$$dlogr = \frac{\lambda(1-\alpha)}{\lambda+1-\alpha+\lambda\eta\alpha}dI - \frac{\lambda\eta(1-\alpha)}{\lambda+1-\alpha}\frac{\lambda}{\lambda+1-\alpha+\lambda\eta\alpha}\frac{1}{1-\alpha}d\alpha + \frac{1}{\alpha}\frac{\lambda}{\lambda+1-\alpha}d\alpha$$

From $\psi(\alpha) = \frac{w}{r}$, $log\psi(\alpha) = logw - logr$. Totally differentiating this expression, we obtain:

$$\frac{\psi'(\alpha)}{\psi(\alpha)}d\alpha = dlogw - dlogr$$

Plugging in the expressions for $dlogw$ and $dlogr$ gives:

$$\frac{\psi'(\alpha)}{\psi(\alpha)}d\alpha =- \frac{\lambda}{\lambda+1-\alpha+\lambda\eta\alpha}dI - \frac{\lambda}{\lambda+1-\alpha+\lambda\eta\alpha}\frac{1}{\alpha(1-\alpha)}d\alpha$$

Rearrange to get:

$$d\alpha =- \frac{\lambda}{\lambda+1-\alpha+\lambda\eta\alpha}\left[\frac{\psi'(\alpha)}{\psi(\alpha)} + \frac{\lambda}{\lambda+1-\alpha+\lambda\eta\alpha}\frac{1}{\alpha(1-\alpha)}\right]^{-1} dI$$

This expression highlights that $\frac{d\alpha}{dI} < 0$. An immigration-induced labor supply shock will increase the share of tasks performed by labor, implying a more labor-intensive production technology.

Appendix C.1.3: The Total Aggregate Wage Effect of Immigration

To derive the total aggregate wage effect of immigration, recall that:

$$dlogw =- \frac{\lambda\alpha}{\lambda+1-\alpha+\lambda\eta\alpha} - \frac{\lambda}{\lambda+1-\alpha+\lambda\eta\alpha}\frac{1}{1-\alpha}d\alpha$$

Using that $\varphi =- \frac{\alpha\lambda}{1-\alpha+\lambda}$, where φ denotes the inverse labor demand elasticity, we get:

$$dlogw = \frac{\varphi}{1-\varphi\eta}dI + \frac{\varphi}{1-\varphi\eta}\frac{1}{\alpha(1-\alpha)}\frac{d\alpha}{dI}dI$$

The total aggregate wage effect of immigration thus becomes:

$$\frac{dlogw}{dI} = \frac{\varphi}{1-\varphi\eta}\left(1 + \frac{1}{\alpha(1-\alpha)}\frac{d\alpha}{dI}\right)$$

which is the expression in the text.

Appendix C.2: The Partial Wage Effect of Immigration by Skill (Section V.3.2)

To study firms' incentives to switch to a less skill-intensive technology if low-skilled labor is abundant, we adopt a simplified version of the static task-based framework (Acemoglu and Restrepo, 2018). The production process of the final good is comprised of a unit measure of tasks, $y(x)$, with an elasticity of substitution $\sigma = \frac{1}{1-\beta}$ between tasks:

$$Y = A\left(\int_0^1 y(x)^{\frac{\sigma-1}{\sigma}}dx\right)^{\frac{\sigma}{\sigma-1}}$$

The production function in each task is $y(x) = l_L(x) + \psi(x) l_H(x)$, where $l_L(x)$ denotes low-skilled labor employed in task x, $l_H(x)$ denotes high-skilled labor used in the production of task x, and $\psi(x)$ is the relative productivity of high-skilled labor in task x. We assume $\psi(x)$ is positive, continuous, differentiable, and strictly increasing in x, which implies that high-skilled labor has a comparative advantage in tasks with higher indices (the index x can be interpreted as the complexity of tasks). We further assume that $\frac{w_H}{\psi(1)} < w_L < \frac{w_H}{\psi(0)}$ to ensure an interior solution. Following Acemoglu and Restropo (2018), the aggregate production function is:

$$Y = A\left[\theta^{\frac{1}{\sigma}} L_L^{\frac{\sigma-1}{\sigma}} + \left(\int_\theta^1 \psi(x)^{\sigma-1} dx\right)^{\frac{1}{\sigma}} L_H^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

where θ is endogenously determined by $\psi(\theta) = \frac{w_H}{w_L}$, $L_L = \int_0^1 l_L(x)dx$ and $L_H = \int_0^1 \psi(\theta) l_H(x)dx$.

Firms choose skill-specific labor by maximizing profits, taking the product price p and the wage rates w_H and w_L as given:

$$\max_{L_L, L_H} pA\left[\theta^{\frac{1}{\sigma}} L_L^{\frac{\sigma-1}{\sigma}} + \left(\int_\rho^1 \psi(x)^{\sigma-1} dx\right)^{\frac{1}{\sigma}} L_H^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} - (w_H L_H + w_L L_L)$$

The first-order conditions for high-skilled and low-skilled labor are:

$$logw_L = logp + \frac{\sigma-1}{\sigma} logA + \frac{1}{\sigma} logY + \frac{1}{\sigma} log\theta - \frac{1}{\sigma} logL_L$$
$$logw_H = logp + \frac{\sigma-1}{\sigma} logA + \frac{1}{\sigma} logY + \frac{1}{\sigma} log\left(\int_\theta^1 \psi(x)^{\sigma-1} dx\right) - \frac{1}{\sigma} logL_H$$

Totally differentiating these two equations, we obtain:

$$dlogw_L = \frac{1}{\sigma} dlogY - \frac{1}{\sigma} dlogL_L + \frac{1}{\sigma}\frac{1}{\theta} d\theta,$$
$$dlogw_H = \frac{1}{\sigma} dlogY - \frac{1}{\sigma} dlogL_H - \frac{1}{\sigma}\frac{\psi(\theta)^{\sigma-1}}{\int_\theta^1 \psi(x)^{\sigma-1} dx} d\theta.$$

Combining the above two equations, we get:

$$dlogw_L - dlogw_H = -\frac{1}{\sigma}(dlogL_L - dlogL_H) + \frac{1}{\sigma}\left(\frac{1}{\theta} + \frac{\psi(\theta)^{\sigma-1}}{\int_\theta^1 \psi(x)^{\sigma-1} dx}\right) d\theta.$$

Skill-specific labor evolves according to $dlogL_g = dI_g + \eta dlogw_g$, $g = L, H$, where η is the labor supply elasticity. Hence, $dlogL_L - dlogL_H = dI_L - dI_H + \eta(dlogw_L - dlogw_H)$. Combining these two equations to eliminate $dlogL_L - dlogL_H$ yields:

$$-(\sigma+\eta)(dlogw_H - dlogw_L) = (dI_H - dI_L) + \left(\frac{1}{\theta} + \frac{\psi(\theta)^{\sigma-1}}{\int_\theta^1 \psi(x)^{\sigma-1}dx}\right)d\theta$$

Take the logarithm of $\psi(\theta) = \frac{w_H}{w_L}$ and totally differentiate to get:

$$\frac{\psi'(\theta)}{\psi(\theta)}d\theta = dlogw_H - dlogw_L$$

Plugging this expression into the one above and rearranging terms, we obtain:

$$\left[(\sigma+\eta)\frac{\psi'(\theta)}{\psi(\theta)} + \left(\frac{1}{\theta} + \frac{\psi(\theta)^{\sigma-1}}{\int_\theta^1 \psi(x)^{\sigma-1}dx}\right)\right]d\theta = (dI_L - dI_H)$$

This expression highlights that $\frac{d\theta}{dI_L - dI_H} > 0$ as stated in the text. An increase in low-skilled immigration relative to high-skilled immigration will increase the share of tasks allocated to low-skilled labor and induce firms to switch to a less-skilled production technology.

When θ is endogenously determined, the partial wage effect of immigration by skill becomes:

$$\left.\frac{dlogw_g}{dI_g}\right|_{dI} = \frac{dlogw_L - dlogw_H}{dI_L - dI_H} =- \frac{1}{\sigma+\eta} + \frac{1}{\sigma+\eta}\left(\frac{1}{\theta} + \frac{\psi(\theta)^{\sigma-1}}{\int_\theta^1 \psi(x)^{\sigma-1}dx}\right)\frac{d\theta}{dI_L - dI_H}$$

Using $\sigma = \frac{1}{1-\beta}$:

$$\left.\frac{dlogw_g}{dI_g}\right|_{dI} =-- \frac{1-\beta}{1+\eta(1-\beta)}\left[1 - \left(\frac{1}{\theta} + \frac{\psi(\theta)^{\sigma-1}}{\int_\theta^1 \psi(x)^{\sigma-1}dx}\right)\frac{d\theta}{dI_L - dI_H}\right]$$

which is the expression in the text.

Appendix D: Changes in Product Prices: A Closed Economy (Section V.5)

Firms choose capital and labor by maximizing profits, taking the product price p, the wage rate w, and the price of capital r as given:

$$\max_{L,K} \quad pAK^\alpha L^{1-\alpha} - (rK + wL)$$

The first-order conditions for labor and capital are:

$$w = (1-\alpha)pAK^{\alpha}L^{-\alpha}$$
$$r = \alpha pAK^{\alpha-1}L^{1-\alpha}$$

Taking logarithms and totally differentiating these two expressions, we obtain:

$$(\mathrm{D.1}) \qquad dlogw - dlogp = \alpha(dlogK - dlogL)$$
$$(\mathrm{D.2}) \qquad dlogr = dlogp + (\alpha-1)(dlogK - dlogL)$$

Further note that labor supply shifts out according to:

$$(\mathrm{D.3}) \qquad dlogL = dI + dlogL^{N} = dI + \eta(dlogw - dlogp)$$

where η is the labor supply elasticity. Capital supply adjusts according to:

$$(\mathrm{D.4}) \qquad dlogr = \lambda dlogK$$

where λ is the inverse capital supply elasticity. Product demand, $Y = \mu p^{-\tau}$, in turn, shifts out according to:

$$(\mathrm{D.5}) \qquad dlogY = dlog\mu - \tau dlogp$$

where τ is the product demand elasticity and μ is a product demand shifter. These five expressions pin down the five equilibrium outcomes ($dlogL$, $dlogK$, $dlogw$, $dlogr$, $dlogp$).

Plug in the expressions for $dlogr$ and $dlog$w (Equations (D.3) and (D.4) into the first-order conditions for capital and labor (Equations (D.2) and (D.1)):

$$dlogp + (\alpha-1)(dlogK - dlogL) = \lambda dlogK$$
$$(\mathrm{D.6}) \qquad \alpha(dlogK - dlogL) = \frac{1}{\eta}(dlogL - dI)$$

Using $dlogY = \alpha dlogK + (1-\alpha)dlogL$, solve Equation (D.5) for $dlogp$ and substitute into the first expression above:

$$(\mathrm{D.7}) \qquad \lambda dlogK = -\frac{1}{\tau}(\alpha dlogK + (1-\alpha)dlogL - dlog\mu) + (\alpha-1)(dlogK - dlogL)$$

Equations (D.6) and (D.7) now contain only two unknowns, $dlogK$ and $dlogL$. Solving for $dlogL$ and $dlogK$, we obtain:

$$\frac{dlogL}{dI} = \frac{\tau(1-\alpha)+\alpha+\lambda\tau}{\alpha\eta\lambda\tau+\alpha\eta+\tau(1-\alpha)+\alpha+\lambda\tau} + \frac{\alpha\tau}{\alpha\eta\lambda\tau+\alpha\eta+\tau(1-\alpha)+\alpha+\lambda\tau}\frac{dlog\mu}{dI}$$

$$\frac{dlogK}{dI} = \frac{\tau(1-\alpha)+\alpha-1}{\alpha\eta\lambda\tau+\alpha\eta+\tau(1-\alpha)+\alpha+\lambda\tau} + \frac{\alpha\tau+1}{\alpha\eta\lambda\tau+\alpha\eta+\tau(1-\alpha)+\alpha+\lambda\tau}\frac{dlog\mu}{dI}$$

We can then solve for $dlogr$, $dlogw$ and $dlogp$:

$$\frac{dlogr}{dI} = \frac{-\alpha\lambda\tau+\alpha\lambda+\lambda\tau-\lambda}{\alpha\eta\lambda\tau+\alpha\eta+\tau(1-\alpha)+\alpha+\lambda\tau} + \frac{\alpha\eta\tau+\lambda}{\alpha\eta\lambda\tau+\alpha\eta+\tau(1-\alpha)+\alpha+\lambda\tau}\frac{dlog\mu}{dI}$$

$$\frac{dlogw}{dI} = \frac{-\alpha\lambda\tau+\alpha\lambda-\lambda-1}{\alpha\eta\lambda\tau+\alpha\eta+\tau(1-\alpha)+\alpha+\lambda\tau} + \frac{\alpha\eta\tau+\lambda+1}{\alpha\eta\lambda\tau+\alpha\eta+\tau(1-\alpha)+\alpha+\lambda\tau}\frac{dlog\mu}{dI}$$

$$\frac{dlogp}{dI} = \frac{\alpha\lambda+\alpha-\lambda-1}{\alpha\eta\lambda\tau+\alpha\eta+\tau(1-\alpha)+\alpha+\lambda\tau} + \frac{\alpha\eta\lambda-\alpha+\lambda+1}{\alpha\eta\lambda\tau+\alpha\eta+\tau(1-\alpha)+\alpha+\lambda\tau}\frac{dlog\mu}{dI}$$

The last expression corresponds to the expression for $\frac{dlogp}{dI}$ shown in the text. Computing $\frac{dlogw}{dI} - \frac{dlogp}{dI}$ yields the expression for $\frac{dlog\frac{w}{p}}{dI}$ shown in the text. The expression for the impact of immigration on native employment $\frac{dlogL^N}{dI}$ simply follows from the labor supply curve of natives, $dlogL^N = \eta(dlogw - dlogp)$, or from subtracting 1 from the expression for $\frac{dlogL}{dI}$.

Appendix E: Changes in the Industry Structure: A Two-Sector Heckscher-Olin Model (Section V.6)

Consider a small and open two-sector economy in which output in each sector is produced according to a constant return-to-scale CES production function combining low- and high-skilled labor:

$$Y_j = A_j[\theta_j L_{jL}^{\beta} + (1-\theta_j)L_{jH}^{\beta}]^{1/\beta}, \;\; j = 1,2$$

Assume that sector 2 is more skill-intensive than sector 1 (i.e., $\theta_1 > \theta_2$).

Appendix E.1 Efficient Utilization of Low- and High-Skilled Labor

Firms choose low- and high-skilled labor by minimizing costs subject to the output constraint:

$$\min_{L_{Lj},L_{Hj}} \quad w_L L_{Lj} + w_H L_{Hj} \quad \text{s.t.} \quad Y_j = A_j[\theta_j L_{jL}^{\beta} + (1-\theta_j)L_{jH}^{\beta}]^{1/\beta} = 1$$

Cost minimization implies that the ratio between the wage rates for low- and high-skilled labor is equal to the marginal rate of technical substitution (*MRTS*) in each sector:

$$\frac{w_H}{w_L} = MRTS_j = \frac{\partial Y_j/\partial l_{Lj}}{\partial Y_j/\partial l_{Hj}}$$

where $\partial Y_j/\partial L_{Hj} = A_j(1-\theta_j)L_{jH}^{\beta-1}[\theta_j L_{jL}^{\beta} + (1-\theta_j)L_{jH}^{\beta}]^{1/\beta-1}$ and $\partial Y_j/\partial L_{Lj} = A_j\theta_j L_{jL}^{\beta-1}[\theta_j L_{jL}^{\beta} + (1-\theta_j)L_{jH}^{\beta}]^{1/\beta-1}$. Rearranging, we obtain:

$$\frac{L_{Hj}}{L_{Lj}} = \left(\frac{(1-\theta_j)}{\theta_j}\frac{w_L}{w_H}\right)^{1/(1-\beta)}$$

Substitute into the production function constraint, $1 = A_j[\theta_j L_{jL}^{\beta} + (1-\theta_j)L_{jH}^{\beta}]^{1/\beta}$, and solve for optimal (i.e., cost-minimizing) labor inputs to produce one unit of output, l_{Lj}^{*} and l_{Hj}^{*}, for the given wage rates:

$$l_{Lj}^{*} = \frac{1}{A_j}\left((1-\theta_j)\left(\frac{1-\theta_j}{\theta_j}\frac{w_L}{w_H}\right)^{\beta/1-\beta} + \theta_j\right)^{-1/\beta} \qquad \text{(E.1)}$$

$$l_{Hj}^{*} = \frac{1}{A_j}\left(\frac{1-\theta_j}{\theta_j}\frac{w_L}{w_H}\right)^{\beta/1-\beta}\left((1-\theta_j)\left(\frac{1-\theta_j}{\theta_j}\frac{w_L}{w_H}\right)^{\beta/1-\beta} + \theta_j\right)^{-1/\beta} \qquad \text{(E.2)}$$

Appendix E.2 Zero Profit Condition and Factor Price Equalization

Write the firm's per unit cost function as:

$$c_j(w_L, w_H) = w_L l_{Lj}^{*} + w_H l_{Hj}^{*} = \frac{1}{A_j}(\theta_j^{\sigma} w_L^{1-\sigma} + (1-\theta_j)^{\sigma} w_H^{1-\sigma})^{\frac{1}{1-\sigma}}$$

where $\sigma = \frac{1}{1-\beta}$ is the elasticity of substitution between low- and high-skilled workers. Firms make zero profits if their costs of producing one unit of output is equal to the product price. Their zero-profit conditions in the two sectors can thus be expressed as:

$$\frac{1}{A_1}((1-\theta_1)^{\sigma} w_H^{1-\sigma} + \theta_1^{\sigma} w_L^{1-\sigma})^{\frac{1}{1-\sigma}} = p_1$$
$$\frac{1}{A_2}((1-\theta_2)^{\sigma} w_H^{1-\sigma} + \theta_2^{\sigma} w_L^{1-\sigma})^{\frac{1}{1-\sigma}} = p_2$$

These two conditions uniquely pin down the wage rates w_L and w_H, provided that both goods are produced in positive quantities and there are no factor intensity reversals. Thus, product prices as opposed to input endowments uniquely determine input factor prices (*factor price equalization*).

Appendix E.3 Full Utilization of Labor and Capital

In equilibrium, both types of labor must be fully utilized, $L_{L1}^* + L_{L2}^* = \bar{L}_L$ and $L_{H1}^* + L_{H2}^* = \bar{L}_H$, where $L_{gj}^* = l_{gj}^* Y_j$. Using Equations (E.1) and (E.2) to substitute for l_{Lj}^* and l_{Hj}^*, we get:

$$\frac{1}{A_1}\left((1-\theta_1)\left(\frac{1-\theta_1}{\theta_1}\frac{w_L}{w_H}\right)^{\beta/1-\beta} + \theta_1\right)^{-1/\beta} Y_1 + \frac{1}{A_2}\left((1-\theta_2)\left(\frac{1-\theta_2}{\theta_2}\frac{w_L}{w_H}\right)^{\beta/1-\beta} + \theta_2\right)^{-1/\beta} Y_2 = \bar{L}_L \qquad \text{(E.3)}$$

$$\frac{1}{A_1}\left(\frac{1-\theta_1}{\theta_1}\frac{w_L}{w_H}\right)^{\beta/1-\beta}\left((1-\theta_1)\left(\frac{1-\theta_1}{\theta_1}\frac{w_L}{w_H}\right)^{\beta/1-\beta} + \theta_1\right)^{-1/\beta} Y_1 + \frac{1}{A_2}\left(\frac{1-\theta_2}{\theta_2}\frac{w_L}{w_H}\right)^{\beta/1-\beta}\left((1-\theta_2)\left(\frac{1-\theta_2}{\theta_2}\frac{w_L}{w_H}\right)^{\beta/1-\beta} + \theta_2\right)^{-1/\beta} Y_2 = \bar{L}_H \qquad \text{(E.4)}$$

These two conditions uniquely determine how much output Y_1 and Y_2 is produced in each sector.

Appendix E.4 An Exogenous Immigration Shock and the Rybczynski Theorem

Next, consider exogenous immigration shock dI_L and dI_H that increases the stock of low-and high-skilled labor $\bar{L}_L$ and $\bar{L}_H$. Totally differentiate Equations (E.3) and (E.4) to obtain:

$$\kappa_{L1}\frac{dY_1}{Y_1} + \kappa_{L2}\frac{dY_2}{Y_2} = \frac{d\bar{L}_L}{\bar{L}_L}$$
$$\kappa_{H1}\frac{dY_1}{Y_1} + \kappa_{H2}\frac{dY_2}{Y_2} = \frac{d\bar{L}_H}{\bar{L}_H}$$

where $\kappa_{Lj} := \frac{Y_j l_{Lj}^*}{\bar{L}_L}$ and $\kappa_{Hj} := \frac{Y_j l_{Hj}^*}{\bar{L}_H}$ are the shares of low- and high-skilled labor devoted to sector j, respectively, and where l_{Lj}^* and l_{Hj}^* are the optimal labor inputs to produce one unit of output given by Equations (E1) and (E2). Rewrite this system of equations as $BY = c$, where:

$$B = \begin{pmatrix} \kappa_{L1} & \kappa_{L2} \\ \kappa_{H1} & \kappa_{H2} \end{pmatrix}, Y = \begin{pmatrix} dlogY_1 \\ dlogY_2 \end{pmatrix}, \quad \text{and } c = \begin{pmatrix} dlog\bar{L}_L \\ dlog\bar{L}_H \end{pmatrix}$$

The inverse of matrix B is equal to (note that $\kappa_{L1} = 1 - \kappa_{L2}$ and $\kappa_{H1} = 1 - \kappa_{H2}$):

$$B^{-1} = \frac{1}{\kappa_{L1}\kappa_{H2} - \kappa_{L2}\kappa_{H1}}\begin{pmatrix} \kappa_{H2} & -\kappa_{L2} \\ -\kappa_{H1} & \kappa_{L1} \end{pmatrix} = \frac{1}{\kappa_{L1} - \kappa_{H1}}\begin{pmatrix} \kappa_{H2} & -\kappa_{L2} \\ -\kappa_{H1} & \kappa_{L1} \end{pmatrix}$$

Further note that since $\theta_1 > \theta_2$, sector 1 uses low-skilled labor more intensively while sector 2 uses high-skilled labor more intensively. Hence, $\kappa_{L1} > \kappa_{L2}$ and $\kappa_{H1} < \kappa_{H2}$. Using

$dlog\bar{L}_L: = dI_L$ and assuming that the stock of high-skilled labor is fixed for simplicity (i.e., $dlog\bar{L}_H = 0$), we can solve for $dlogY_j/dI_L$:

$$\frac{dlogY_1}{dI_L} = \frac{\kappa_{H2}}{\kappa_{L1} - \kappa_{H1}} > 1$$
$$\frac{dlogY_2}{dI_L} = -\frac{\kappa_{H1}}{\kappa_{L1} - \kappa_{H1}} < 0$$

Hence, output in sector 1 that uses low-skilled labor intensively will increase more than proportionally, whereas output in sector 2 that uses high-skilled labor intensively will decline following an immigration-induced labor supply shock.

Appendix F: Monopsonistic Labor Markets (Section VI.1)

Appendix F.1 The Impact of Immigration on Wages and Employment in the Short Run

Totally differentiate the first-order condition ($log(1-\alpha) + logA\bar{K} - \alpha logl = log(\frac{\beta+1}{\beta}) + logw$) and the market-clearing condition ($log(Jl) = log\bar{L} + log(J \cdot w^{\beta}) - log(b + Jw^{\beta})$) to obtain:

$$-\alpha dlogl = dlogw$$
$$dlogl = dlog\bar{L} + \beta dlogw - \frac{1}{b + Jw^{\beta}}(w^{\beta}dJ + \beta Jw^{\beta}dlogw)$$

Immigration increases the total number of workers who could potentially work in the local labor market, $\bar{L}$. Adopting our earlier notation, $dlog\bar{L}: = dI.$ Combining these two expressions, we can express $dlogw$ and $dlogw$ as functions of dI and dJ:

$$dlogw = -\frac{\alpha(b+Jw^{\beta})}{(1+\alpha\beta)b+Jw^{\beta}}dI + \frac{\alpha w^{\beta}}{(1+\alpha\beta)b+Jw^{\beta}}dJ \qquad \text{(F.1)}$$
$$dlogl = \frac{b+Jw^{\beta}}{(1+\alpha\beta)b+Jw^{\beta}}dI - \frac{w^{\beta}}{(1+\alpha\beta)b+Jw^{\beta}}dJ \qquad \text{(F.2)}$$

Suppose that in the short run, the number of firms is fixed ($dJ = 0$). Hence:

$$dlogw = -\frac{\alpha\left(b + Jw^{\beta}\right)}{(1+\alpha\beta)b + Jw^{\beta}}dI$$

Derive the labor supply elasticity to the market from the labor supply curve to the market ($logL^S = log\bar{L} + log(Jw^{\beta}) - log(b + Jw^{\beta})$):

$$\eta: = \frac{dlogL^S}{dlogw} = \frac{b\beta}{b + Jw^{\beta}}$$

Thus, we can re-write the expression for $dlogw$ as:

$$\frac{dlogw}{dI} = -\frac{\alpha}{1+\alpha\eta}$$

which is the expression in the text.

Total (i.e., immigrant and native) employment in the economy increases due to immigration according to $dlogL^S = dI + \eta dlogw$. The impact of immigration on native employment is therefore equal to

$$\frac{dlogL^N}{dI} = \eta\frac{dlogw}{dI} = -\frac{\eta\alpha}{1+\alpha\eta}$$

which is the expression in the text.

Next, consider the effect of immigration on profits, $\Pi = Al^{1-\alpha} - wl - C$. Using the first-order condition for the firm's employment choice, $(1-\alpha)Al^{-\alpha} = \frac{\beta+1}{\beta}w$, re-write firm profits as:

$$\Pi = \left(\frac{1}{1-\alpha}\frac{\beta+1}{\beta} - 1\right)wl - C$$

As $\frac{1}{1-\alpha}\frac{\beta+1}{\beta} > 1$, Π is increasing in wl. Use Equations (F.1) and (F.2) to obtain an expression for $dlogwl$:

$$dlogwl = \frac{(1-\alpha)\left(b + Jw^{\beta}\right)}{(1+\alpha\beta)b + Jw^{\beta}}dI - \frac{(1-\alpha)w^{\beta}}{(1+\alpha\beta)b + Jw^{\beta}}dJ$$

Hence, the wage bill wl, and thereby, firm profits are increasing in the labor pool and decreasing in the number of firms. In the short run, the number of firms is constant (i.e., $dJ = 0$). Immigration will thus increase firm profits in the short run; that is, $\frac{dlog\Pi_j}{dI} > 0$.

Appendix F.2 The Impact of Immigration on Wages and Employment in the Long Run

In the long run, positive profits will induce more firms to enter the economy. The number of firms, J, is determined by the zero-profit condition ($Al^{1-\alpha} = wl + C$). Take the logarithm and totally differentiate the zero-profit condition:

$$(1-\alpha)dlogl = \frac{wl}{wl+C}dlogl + \frac{wl}{wl+C}dlogw$$

Re-arrange the terms:

$$[(1-\alpha)C - \alpha wl]dlogl = wldlogw$$

Substitute the expressions for $dlogl$ and $dlogw$ from Equations (F.1) and (F.2) into the above expression:

$$dJ = \frac{b + Jw^{\beta}}{w^{\beta}} dI$$

Substitute back into the expressions for $dlogl$ and $dlogw$ (Equations (F.1) and (F.2)):

$$dlogl = \frac{b + Jw^{\beta}}{(1 + \alpha\beta)b + Jw^{\beta}} dI - \frac{w^{\beta}}{(1 + \alpha\beta)b + Jw^{\beta}} \frac{b + Jw^{\beta}}{w^{\beta}} dI = 0$$
$$dlogw = -\frac{\alpha\left(b + Jw^{\beta}\right)}{(1 + \alpha\beta)b + Jw^{\beta}} dI + \frac{\alpha w^{\beta}}{(1 + \alpha\beta)b + Jw^{\beta}} \frac{b + Jw^{\beta}}{w^{\beta}} dI = 0$$

Hence, in the long run, immigration will increase the number of firms operating in the market. However, it does not affect the equilibrium wage; nor does it affect employment in each firm. Moreover, immigration will have no impact on native employment:

$$\frac{dlogL^{N}}{dI} = \eta \frac{dlogw}{dI} = 0$$