RATIONALITY & COMPETITION
CRC TRR 190

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Discussion Paper No. 352

December 22, 2022

Collaborative Research Center Transregio 190 | www.rationality-and-competition.de
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September 6, 2022

Abstract

Low-skilled immigrants indirectly affect public finances through their effect on resident wages & labor supply. We operationalize this indirect fiscal effect in a model of immigration and the labor market. We derive closed-form expressions for this effect in terms of estimable statistics. An empirical quantification for the U.S. reveals an indirect fiscal benefit for one average low-skilled immigrant of roughly $750 annually. The indirect fiscal benefit may outweigh the negative direct fiscal effect that has previously been documented. This challenges the perception of low-skilled immigration as a fiscal burden.

JEL codes: H20, J31, J61

Keywords: Immigration, Fiscal Impact, General Equilibrium

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1 Introduction

Low-skilled immigrants are widely considered a fiscal burden in the United States.[1] In his widely-read blog, Paul Krugman (2006) concludes the following on this issue: "the fiscal burden of low-wage immigrants is also pretty clear... I think that you'd be hard pressed to find any set of assumptions under which Mexican immigrants are a net fiscal plus." The existing economic literature supports this perception, see e.g. Storesletten (2000). More recently, an influential report by the National Academy of Sciences (NAS) on the economic and fiscal consequences of immigration in the U.S. (National Academy of Sciences, 2017) estimates the fiscal impact of immigration to the U.S. For most of the scenarios that the report considers, low-skilled immigrants have negative effects on public finances. The report was cited by Donald Trump in his address to congress in 2017, where he stated: "(a)ccording to the National Academy of Sciences, our current immigration system costs America's taxpayers many billions of dollars a year."[2]

The NAS report focuses on direct fiscal effects: taxes paid by the immigrants minus costs for benefits and services they receive. It abstracts from indirect fiscal effects: changes in residents' tax payments that result from general equilibrium effects. The authors write:

> *"However, a comprehensive accounting of fiscal impacts is more complicated. Beyond the taxes they pay and the programs they use themselves, the flow of foreign-born also affects the fiscal equation for many natives... Because new additions to the workforce may increase or decrease the wages or employment probabilities of the resident population, the impact on income tax revenues from immigrant contributions may be only part of the picture. (National Academy of Sciences, 2017, p.248)*

In this paper we analyze these so far neglected indirect fiscal effects and challenge the view of low-skilled immigrants as a fiscal burden. We find that one average low-skilled immigrant that enters the U.S. adds roughly $750 annually to public finances through this indirect effect. For low-skilled immigrants with a high school degree, this may outweigh the direct fiscal costs estimated in the NAS report. Accounting for indirect fiscal effects also significantly reduces – but does not eliminate – the fiscal burden for high school dropouts.

To arrive here, we build an equilibrium model with heterogeneous workers. Workers of different skill groups are imperfectly substitutable in production and individual productivity levels are continuously distributed conditional on skill, as in Acemoglu and Autor (2011). Low-skilled immigration changes the wage structure by changing factor ratios, and therefore changes the effective tax payments of resident workers.[3] We derive a closed-form solution for the fiscal effect arising from these changes in native tax payments. The effect boils down

[1] Alesina, Miano, and Stantcheva (2018) found that 15% of survey respondents believed that an average immigrant received more than twice as much transfers as the average U.S. citizen. According to a 2019 Gallup poll, the share of Americans that believed immigration made the tax situation worse, was larger than the share who believed immigration made the US worse off in terms of the economy in general, job opportunities, and social & moral values (`news.gallup.com/poll/1660/immigration.aspx`).

[2] https://www.whitehouse.gov/briefings-statements/remarks-president-trump-joint-address-congress/

[3] We generally use the term "residents" to refer to all individuals already in the country at the time of an immigrant inflow, including foreign-born workers who immigrated earlier. In Sections A.2 and A.4, we distinguish between domestic-born and foreign-born workers. This distinction has been highlighted as having

to the size of the wage effects as measured by the elasticity of substitution between low- and high-skilled labor and the progressivity of the tax system as measured by the income-weighted averages of marginal effective tax rates of the two skill types.[4]

We then extend the model such that workers can respond to immigrant inflows via both intensive and extensive labor supply adjustments. These resident labor supply responses mitigate the initial wage shocks.[5] Additionally, these labor supply responses have fiscal consequences themselves; if immigration decreases resident labor force participation, e.g., this would decrease tax revenue. Thus low-skilled immigration leads to indirect fiscal effects through both general equilibrium changes in the wage structure and in resident labor supply.[6] We derive a closed-form solution for the indirect fiscal effects in this setting by supplementing our baseline formula with the following estimable statistics: income-weighted averages of (i) labor supply elasticities, and (ii) products of participation (marginal) tax rates and extensive (intensive) marginal labor supply elasticities – all conditional on skill level. These two additional components capture (i) that the changes in factor ratios are partially mitigated by resident labor supply responses and (ii) fiscal effects that arise from changes in resident labor supply.

We evaluate these formulas for the indirect fiscal benefit by combining data from the American Community Survey (ACS), the 1979 National Longitudinal Survey of Youth (NLSY79), and the Survey of Income and Program Participation (SIPP). We use the tax calculator TAXSIM to assign effective tax rates to each individual in our main dataset, the ACS. Immigration can also affect social security, welfare transfers, and government-provided healthcare received by residents, but TAXSIM does not account for these additional programs. We therefore use the SIPP to estimate Supplementary Nutrition Assistance Program (SNAP), Temporary Assistance for Needy Families (TANF), and Medicaid receipt as a function of income and household characteristics. We use the NLSY79 and the ACS to understand how changes in current income, combined with the distribution of the individual's earnings over the life cycle, affect their receipt of social security payments in the future. Another main component of the empirical quantification regards the labor supply elasticities along both the intensive and the extensive margin. We consider different values from the empirical literature and allow these elasticities to vary with family structure, gender and income.

We combine our empirical quantification of the model with our closed-form solutions to calculate the indirect fiscal effect. For the baseline case when labor supply is exogenous,

important wage implications in the more recent literature (Peri and Sparber, 2009; Card, 2009; Ottaviano and Peri, 2012; Manacorda, Manning, and Wadsworth, 2012; Dustmann, Schönberg, and Stuhler, 2016).

[4]High-skilled immigration also leads to indirect fiscal effects. Since low-skilled immigration is much more politically controversial, we focus on low-skilled immigrants. As we discuss in the conclusion, high-skilled immigrants could lead to indirect fiscal effects through their effect on productivity and innovation, in addition to their effect on relative wages and labor supply.

[5]E.g. Dustmann, Schönberg, and Stuhler (2016, p. 44) emphasize that "wage and employment responses need to be studied jointly to obtain an accurate picture of the labor market impacts of immigration".

[6]The endogenous labor supply decision of residents creates a nontrivial fixed point problem as wages are determined in equilibrium by the continuum of labor supply decisions. We follow sachs2020nonlinear and formalize this fixed point problem in terms of integral equations.

our preferred estimate indicates an indirect fiscal effect of \$753 per year for one low-skilled immigrant — equal to nearly 30% of the yearly federal tax payments of the median low-skilled worker in the US.[7] When we allow for endogenous labor supply responses, we find indirect fiscal effects that are slightly larger than in the case with fixed labor supply.

We set these numbers into relation to the direct fiscal effects as reported by the National Academy of Sciences (2017). The report considers a number of scenarios which vary the marginal cost of public goods and the education of the immigrant. For high school graduates, accounting for the indirect fiscal effects can turn the *total* fiscal effect from a fiscal burden to a fiscal surplus. We find that high school dropouts are a fiscal negative even after accounting for the indirect effects, though accounting for indirect fiscal effects significantly reduces their fiscal burden.

There is some controversy in the literature over the appropriate model to analyze and estimate the wage effects of immigration. A natural concern is that the indirect fiscal effects are also sensitive to these modeling choices. Therefore, we analyze the robustness of our results to a variety of different production functions and labor supply responses. Across a variety of models which allow for alternative skill stratifications (Borjas, 2003; Dustmann et al., 2013), domestic- and foreign-born complementarity (Ottaviano and Peri, 2012), endogenous occupation choice (Peri and Sparber, 2009; Llull, 2018), and decreasing returns to scale, we find indirect fiscal effects in the range of \$750 to \$1,900.

Related Literature The literature that studies the fiscal effects of immigration has primarily focused on the direct fiscal effect. Economists have employed a variety of methods to measure this direct fiscal impact of immigration. Preston (2014) provides a comprehensive overview on the topic. Auerbach and Oreopoulos (1999), Lee and Miller (2000), and National Academy of Sciences (1997) emphasize the importance of accounting for an immigrant's total direct fiscal effect summed over their time in the country, rather than at a given point in time.[8] Borjas and Hilton (1996) quantify how much more likely immigrants are to participate in welfare programs. Dustmann and Frattini (2014) provide a detailed accounting approach for the UK and find that EEA (non EEA) immigrants on average contributed more (less) to public finances than public costs they cause. They emphasize the importance of accounting for the use of public goods and potential congestion externalities.[9]

Storesletten (2000) takes a model-based perspective and quantifies the net present value of fiscal contributions of an immigrant as a function of age of immigration and education for the

[7]We calculate that the median low-skilled worker in our ACS sample pays \$2,590 in federal income taxes yearly.

[8]National Academy of Sciences (2017) updates the results of National Academy of Sciences (1997) with more recent data and updated methods.

[9]Ruist (2015) estimates the fiscal burden of refugee immigration to be 1% of GDP in Sweden. Monras, Vázquez-Grenno, and Elias (2018) find that a policy which legalized 600,000 undocumented immigrants in Spain led to increases in payroll tax revenues, which includes both direct and indirect fiscal effects.

U.S.[10] He finds that low-skilled immigrants are a fiscal burden in net present value, regardless of the age at which they immigrate. While indirect fiscal effects are present in the general equilibrium model in Storesletten (2000), indirect fiscal effects arising from changes in the relative wages of imperfectly subsititutable workers are not included.[11] This is the mechanism we focus on this paper and we show this mechanism leads to positive, and quantitatively large fiscal effects.

More recently, Busch, Krueger, Ludwig, Popova, and Iftikhar (2020) analyze the 2015-2016 German refugee wave through the lens of a quantitative OLG model which features imperfectly substitutable workers and a quantification of the Germany tax-transfer system.[12] Indirect fiscal effects are present in their model, which focuses on quantifying the welfare effects of the refugee wave. Our contribution is to explicitly work out the size of the indirect fiscal effects and the mechanism behind it. While such indirect fiscal effects have been mentioned previously in the literature, the conjecture was that the effects are of second order compared to the direct fiscal effects.[13] In ongoing work, Clemens (2021) quantifies fiscal effects resulting from the increase in capital that arises in response to immigration.

This paper is also related to a large literature on the effects of immigration on resident wages. A number of papers find that low-skilled immigration leads to increases in wages inequality, but there is less consensus on which workers bear the largest incidence of low-skilled immigration (see e.g. Card (1999), Borjas (2003), Ottaviano and Peri (2012), Dustmann et al. (2013)). Among other things, the different results come from different assumptions on skill stratification (2 vs. 4 education levels or the wage percentile as skill measure)[14] and the assumptions of whether natives and immigrants, conditional on skill, are (im)perfect substitutes. Further, this literature emphasizes the importance of labor supply and employment responses in understanding the effects of immigration (Borjas, Freeman, and Katz, 1997; Peri and Sparber, 2009; Dustmann, Schönberg, and Stuhler, 2016; Llull, 2018; Piyapromdee, 2020; Monras, 2020). We show analytically how endogenous labor supply choices mitigate the wage changes but also lead to fiscal effects themselves.

[10] Storesletten (2003) provides a similar calculation for Sweden.

[11] Storesletten (2000) assumes that all workers are perfect substitutes and therefore the mechanism we highlight is absent in his model. In Storesletten (2000), the capital supply does not respond to immigration. Indirect fiscal effects occur because immigration decreases the capital-labor ratio and therefore 1) increases interest rates, thereby increasing the cost of servicing government debt, and 2) wage rates decrease, thereby decreasing tax revenue. As such, the indirect fiscal effects of immigration calculated in Storesletten (2000) are negative. We discuss the role of physical capital in our setting in Section 5.2.

[12] Chojnicki, Docquier, and Ragot (2011) and Battisti, Felbermayr, Peri, and Poutvaara (2018) also use quantitative equilibrium models to study the welfare effects of immigration in the presence of progressive taxation.

[13] Preston (2014, p. 580) writes "(w)hile interesting, the implied tax effects are not plausibly large relative to the effects that will be found by a simple accounting approach."

[14] Card (1999) finds that the overall impact of immigration to the United States on wage inequality has been small. This is largely due to the fact that the skill composition of immigrants is similar to that of natives. Therefore, immigration overall has not lead to large changes in factor ratios in the United States. This does not imply that low-skilled immigration in isolation does not affect inequality. In fact, the value of the elasticity of substitution that we use in our main model are those that are favored by Card (1999).

We rely on this large empirical literature to guide our modeling decisions while also doing justice to the fact that there is some disagreement in this literature over the appropriate model to analyze the effects of immigration. We show that our main results are robust to different modeling choices and parameter estimates from the empirical immigration literature.

2 Model

We consider an equilibrium model of the labor market with two imperfectly-substitutable skill levels corresponding to individuals with and without college education.[15] As in Acemoglu and Autor (2011), there are continuous distributions of productivity conditional on skill. Within skill, all individuals are perfect substitutes. More formally, the economy is populated by individuals who are indexed by their type $i \in \mathcal{I}$. A type is associated with a skill level, either low-skilled or high-skilled: $e_i \in \{u, s\}$. Additionally, types vary in their productivity and the tax-transfer system they face. The latter reflects e.g. that individuals with different family status face different tax schedules.

Let h_i denote the hours worked, ν_i denote the participation rate, and ω_i denote the productivity level of type i. Denote by $L_i = h_i \nu_i m_i$ aggregate labor of type i, where m_i is the measure of type i. Aggregate effective labor of each skill level is given by:

$$\mathscr{L}_e = \int_{\mathcal{I}_e} L_i \omega_i di$$

for $e \in \{u, s\}$, where $\mathcal{I}_u$ ($\mathcal{I}_s$) is a subset of $\mathcal{I}$ made up of low-skilled (high-skilled) types.

Production of the single consumption good, whose price is normalized to one, is described by a constant returns to scale production function $Y = F(\mathscr{L}_u, \mathscr{L}_s)$.[16] We assume that low- and high-skilled labor are imperfect substitutes in production of the single final good, the price of which is normalized to one. In equilibrium, profits are zero, wages are equal to marginal products ($w_e = \frac{\partial \mathscr{F}}{\partial \mathscr{L}_e}$), and aggregate income is given by $Y_e = w_e \mathscr{L}_e$. Conditional on working, an individual of type i has gross income $y_i = h_i \omega_i w_{e_i}$, where the third element, the skill price w_e is endogenous w.r.t. the skill ratio, $\frac{\mathscr{L}_s}{\mathscr{L}_u}$.

We incorporate a flexible nonlinear tax and transfer system $T(y, i)$ that maps a tax payment (which could be negative, i.e. transfer receipt) to each level of gross income y and type i. We assume throughout that this tax and transfer system is fixed and does not change in response to immigrant inflows. This represents not only taxes and monetary transfers, but also per-person costs such as public goods or schooling costs associated with each individual. The

[15] Throughout the paper, we follow Borjas (2003), Peri and Sparber (2009), and Ottaviano and Peri (2012), and define low-skilled workers as those without any college experience and define high-skilled workers as workers with at least some college experience. In Appendix D.4, we consider an alternative skill classification, in which we divide workers with some college between the two skill groups as in Katz and Murphy (1992) or Card (2009). In Section A.3, we define worker skills by their position in the wage distribution, rather than their education.

[16] We discuss the role of physical capital in our setting in Section 5.2.

dependence of the transfer system on the type i reflects that even conditional on income, different types may face a different tax schedule because of family status, living in a different state etc. Tax revenue in this economy is given by

$$\mathscr{R} = \int_{\mathcal{I}_u} \left(T(y_i, i)\nu_i + T(0, i)(1 - \nu_i)\right) m_i di + \int_{\mathcal{I}_s} \left(T(y_i, i)\nu_i + T(0, i)(1 - \nu_i)\right) m_i di,$$

where $T(0, i)$ is the effective tax paid by type i if they earn zero income.

2.1 Fixed Labor Supply

In this section, we first focus on the case of exogenous labor supply of residents and therefore set $\nu_i = 1$ for all i. We interpret the fiscal effects with fixed resident labor supply as the short-run indirect fiscal effects. In Section 2.2, we allow for hours worked and participation to endogenously respond to immigrant inflows. We interpret these results as the long-run indirect fiscal effects.

We formally study how tax revenue $\mathscr{R}$ changes due to the immigration of low-skilled immigrants of type i. This influx has a direct fiscal effect

$$d\mathscr{R}_{dir}(i) = T(y_i, i). \tag{1}$$

One low-skilled immigrant of type i contributes $T(y_i, i)$ to the public budget. As stated above, this direct fiscal effect has already received much attention in the literature and is not the subject of this paper.[17]

The immigration influx also has an indirect fiscal effect. Given that labor of different skill levels are imperfect substitutes in production, the increase of the low-skilled workforce decreases (increases) the wage of low-skilled (high-skilled) workers and therefore their tax payment. We are interested in the sum of these two effects, which reads as

$$d\mathscr{R}^{ex}_{ind}(i) = \frac{\partial w_u}{\partial \mathscr{L}_u}\omega_i h_i \int_{\mathcal{I}_u} \frac{\partial T(y_j, j)}{\partial y_j} h_j \omega_j m_j dj + \frac{\partial w_s}{\partial \mathscr{L}_u}\omega_i h_i \int_{\mathcal{I}_s} \frac{\partial T(y_j, j)}{\partial y_j} h_j \omega_j m_j dj, \tag{2}$$

where h_i and ω_i are the hours worked and productivity of an immigrant of type i, respectively.

The following lemma helps to relate the size of the wage decrease of the low-skilled and the wage increase of the high-skilled.

[17] The report of the National Academy of Sciences (2017) includes federal, state and local taxes, incarceration costs, scholarship and student loan costs, education costs, government healthcare costs, veteran's benefits, refugee support costs, public good costs, and a variety of federal and state level transfer programs in their calculation of direct fiscal effects.

Lemma 1. *If the production function is characterized by constant returns to scale, then aggregate resident labor income is unchanged:*

$$\mathscr{L}_u \frac{\partial w_u}{\partial \mathscr{L}_u} + \mathscr{L}_s \frac{\partial w_s}{\partial \mathscr{L}_u} = 0 \tag{3}$$
$$\Rightarrow \gamma_{s,cross} = |\gamma_{u,own}| \times \frac{w_u \mathscr{L}_u}{w_s \mathscr{L}_s},$$

where $\gamma_{u,own}$ *is the own-wage elasticity of low-skilled labor and defined by* $\gamma_{u,own} = \frac{\partial w_u}{\partial \mathscr{L}_u} \frac{\mathscr{L}_u}{w_u}$ *and* $\gamma_{s,cross}$ *is the cross-wage elasticity of high-skilled labor and defined by* $\gamma_{s,cross} = \frac{\partial w_s}{\partial \mathscr{L}_u} \frac{\mathscr{L}_u}{w_s}$.

Proof. Note that with constant returns to scale one has $F(\mathscr{L}_u, \mathscr{L}_s) = w_u \mathscr{L}_u + w_s \mathscr{L}_s$. Differentiating both sides w.r.t. to $\mathscr{L}_u$ and using $\frac{\partial F}{\partial \mathscr{L}_u} = w_u$ yields the result. □

Intuitively, immigrants obtain their marginal product and do not affect the size of the overall pie accruing to residents. Immigrants only affect the distribution of the pie between high- and low-skilled residents. The income loss of one group equals the income gain of the other group.[18] This relation is formally given by (3) and it provides a direct relation between the cross-wage elasticity of high-skilled labor $\gamma_{s,cross}$ and the own-wage elasticity of low-skilled labor $\gamma_{u,own}$.

It will be useful to relate these own-wage elasticities to the elasticity of substitution between low- and high-skilled labor, which is commonly used to measure the effects of factor changes on wage ratios (see e.g. Katz and Murphy (1992), Card (2009)). Lemma 2 shows how these own-wage elasticities can be written in terms of the the elasticity of substitution between low- and high-skilled labor.

Lemma 2. *The own-wage elasticity of low-skilled labor can be written as*

$$\gamma_{u,own} = -\frac{1}{\sigma}\kappa_s,$$

where σ *is the elasticity of substitution between high-skilled and low-skilled labor and* κ_s *is the income share of high-skilled labor.*

Proof. Appendix B.1. □

The lemma shows that the absolute value of the own-wage elasticity is decreasing in the elasticity of substitution σ. A larger value of σ implies low- and high- skilled labor are more substitutable and therefore increases in low-skilled labor will not lead to large changes in wages. Importantly, this relation does not require the elasticity of substitution to be constant – we are not imposing a CES production function.

[18] If the immigration influx is not infinitesimal, then there would indeed be an immigration surplus, i.e. aggregate resident labor income would increase. However, the immigration surplus would be second order compared to the distributional implications, see e.g. (Borjas, 2014, Chapter 7).

Using Lemma 1 and Lemma 2, we can simplify the indirect fiscal effect and rewrite it as stated in the following proposition.[19]

Proposition 1. *Assume that labor supply of residents is exogenous. The fiscal effect of one immigrant of type i with low education (i.e. $e_i = u$) is given by:*

$$d\mathscr{R}^{ex}_{ind}(i) = \frac{\kappa_s}{\sigma} \times y_i \times \left(\bar{T}'_s - \bar{T}'_u\right), \tag{4}$$

where $\bar{T}'_e$ is the income-weighted average marginal tax rate of education group e.

Proof. See Appendix B.2.1. □

The formula for the indirect fiscal effect (4) with exogenous labor supply is simple and allows for a straightforward interpretation.[20] First, the change in wages caused by the immigrant inflow is proportional to the product of the immigrant's income, y_i, and the term $\frac{\kappa_s}{\sigma}$, which equals the own-wage elasticity of low-skilled wages. An immigrant with higher income y_i supplies a higher amount of effective labor and therefore has a larger effect on resident wages. Together, the product of these two terms ($\frac{\kappa_s}{\sigma} \times y_i$) tells us how much aggregate high-skilled native income decreases and therefore how much low-skilled native income increases.

How these income changes translate into government revenue is given by the difference in income-weighted marginal tax rates of high- and low-skilled workers, $\bar{T}'_s - \bar{T}'_u$. Note that because overall income of natives is unaffected as shown in Lemma 1, the change in tax payment of natives would be zero if $\bar{T}'_s = \bar{T}'_u$. However, if taxes are progressive in the sense that $\bar{T}'_s > \bar{T}'_u$, aggregate tax payment of natives increases. High-skilled individuals, whose income increases, are taxed at a higher rate than low-skilled individuals, whose income decreases.

Why are the correct objects to translate wage changes to tax revenue given by the income-weighted average marginal tax rates? Intuitively, wages of all college (high-school) workers increase (decrease) by the same factor. An individual with a higher income level will therefore experience a larger absolute change in earnings. To calculate the fiscal effect, the marginal tax rate of an individual with a higher income therefore receives a higher weight.

Relation to the Marginal Value of Public Funds (MVPF) If low-skilled immigration can potentially lead to fiscal gains, a natural question to ask is whether low-skilled immigration

[19] As discussed in Footnote 4, we focus on low-skilled immigration since it is more politically controversial. However, it is straightforward to do the analysis for high-skilled immigrants, where the formula would read as $\frac{\kappa_u}{\sigma} \times y_i \times \left(\bar{T}'_u - \bar{T}'_s\right)$, where κ_u is the income share of low-skilled labor.

[20] This can also be written in terms of the own-wage elasticity as $d\mathscr{R}^{ex}_{ind}(i) = |\gamma_{u,own}| \times y_i \times \left(\bar{T}'_s - \bar{T}'_u\right)$. A result that may be surprising, is that it is independent of the size of the resident population. To understand this intuitively, consider two countries where skills are distributed in the same way, but the first country is twice as large as the second. In the first country, the wage changes of residents due to one immigrant are smaller by a factor of two – one immigrant is 'smaller' in relative terms in country 1 as compared to country 2. However, at the same time, there are twice as many residents whose tax payment is affected in country 1. Thus, the fiscal effect is the same in both economies.

could be an effective way to raise government revenue. For this, we turn to the concept of the MVPF (Hendren and Sprung-Keyser, 2020; Finkelstein and Hendren, 2020), which is given by

$$MVPF = \frac{WTP}{\text{Net Cost}},$$

where WTP is the sum of individuals' willingness to pay for a given government program, and Net Cost is the net cost to the government of the program.[21] In the case of a government program which raises revenue (Net Cost < 0), the MVPF typically measures the sum of the monetized utility losses of individuals affected by the program divided by total revenue raised. A lower MVPF is desirable in this case, as it implies that government revenue can be raised with lower utility costs. In the context of low-skilled immigration, we can use the MVPF to measure the total utility costs to residents per dollar of government revenue raised as a result of a low-skilled immigrant entering the country.[22] We will focus on the case where total fiscal revenue is positive, as clearly low-skilled immigration is not an effective tool to raise revenue in the case in which government revenue is negative.[23]

To calculate the MVPF of one low-skilled immigrant of type i, first note that the aggregate willingness to pay of residents is simply equal to the total change in resident post-tax income resulting from the change in wages:

$$WTP(i) = y_i \times \frac{\kappa_s}{\sigma} \times \left((1 - \overline{T'_s}) - (1 - \overline{T'_u}) \right) = -d\mathscr{R}_{ind}^{ex}(i) .$$

Note that this aggregate willingness to pay is negative whenever $(1 - \overline{T'_s}) < (1 - \overline{T'_u})$ because the net-income losses of the low skilled outweigh the net-income gains of the high skilled. The net cost to the government of this immigrant is simply the sum of the direct and indirect fiscal costs:

$$\text{NetCosts}(i) = -d\mathscr{R}_{dir}(i) - d\mathscr{R}_{ind}^{ex}(i) .$$

The MVPF is then given by

$$MVPF(i) = \frac{1}{1 + \frac{d\mathscr{R}_{dir}(i)}{d\mathscr{R}_{ind}^{ex}(i)}}. \tag{5}$$

Every dollar of net tax revenue imposes a cost equivalent to $MVPF(i)$ for the natives.

To gain intuition, consider the special case when there are no direct fiscal effects. In this case, the MVPF is equal to one: what the government gains through the indirect fiscal effect

[21] In Appendix B.3, we provide an alternative welfare analysis based on marginal social welfare weights (Saez and Stantcheva, 2016; Hendren, 2015, 2020) and relate to the concept of the immigration surplus (Borjas, 2014).

[22] Our measure of MVPF only accounts for residents' willingness to pay, not for the willingness to pay of the immigrant themselves. The welfare gains of immigrating to the United States for low-skilled individuals are likely to be very large, given that low-skilled immigrants experience massive income gains after moving to the United States (Hendricks and Schoellman, 2018).

[23] Low-skilled immigration could also be considered an effective policy in terms of the MVPF if net costs are positive and the WTP is also positive. In this case, immigration could be thought of as a spending program and a higher MVPF would imply the program is more cost-effective.

is exactly what the residents lose. More generally, with fixed labor supply, when low-skilled immigration leads to direct fiscal effects, we can see that a larger indirect fiscal effect implies a higher MVPF. We will show that this is not the case when we allow for endogenous resident labor supply in the following subsection.

2.2 Incorporating Endogenous Resident Labor Supply

We now consider the case in which individuals can respond to immigrant inflows via their intensive and extensive labor supply decisions.[24] With endogenous labor supply, changes in the wages affect labor supply decisions along the intensive and extensive margin. The implied changes in labor supply, in turn, affect the equilibrium wages again, which then triggers a change in labor supply and so on and so forth. All these adjustment effects will imply additional fiscal effects.

To capture these issues formally, it suffices to define the respective elasticities. Let ε_i be type i's hours elasticity, η_i be their participation elasticity and $\xi_i = \varepsilon_i + \eta_i$ be their total hours elasticity. This formulation places no restrictions on how elasticites vary across individuals and therefore allows for elasticities to differ w.r.t. to education, income, gender and family status, for example.

The following lemma states how tax payments of residents change due to low-skilled immigration.

Lemma 3. *Consider a low-skilled immigrant with effective labor supply L^{Im} that implies equilibrium changes in wages of $\frac{dw_u}{w_u}$ and $\frac{dw_s}{w_s}$. The implied change in tax payment of residents is given by:*

$$\begin{aligned} d\mathscr{R}_{ind} = & \int_{\mathcal{I}_u} T'(y_i, i) y_i \frac{dw_u}{w_u} (1 + \varepsilon_i) \nu_i m_i di + \int_{\mathcal{I}_s} T'(y_i, i) y_i \frac{dw_s}{w_s} (1 + \varepsilon_i) \nu_i m_i di \\ & + \int_{\mathcal{I}_u} T_{part}(y_i, i) y_i \frac{dw_u}{w_u} \eta_i \nu_i m_i di + \int_{\mathcal{I}_s} T_{part}(y_i, i) y_i \frac{dw_s}{w_s} \eta_i \nu_i m_i di, \end{aligned} \tag{6}$$

where $T_{part}(y_i) = \frac{T(y_i,i) - T(0,i)}{y_i}$ is the participation tax rate of a type i individual that earns y_i.

Proof. See Appendix B.2.2. □

In the first line, the indirect fiscal effects as described in Proposition 1 are scaled up by the intensive margin elasticities. The second line of (6) captures the change in tax revenue due to changes in labor force participation of residents. Note that the relevant tax rate here is not the marginal tax rate, but the participation tax rate. The participation tax rate captures the increase in public finances that occurs if the individual starts to work.

[24] Dustmann, Schönberg, and Stuhler (2016) highlight that it is important to allow for labor supply responses that vary between different groups of natives. Dustmann, Schönberg, and Stuhler (2017) demonstrate the importance of this heterogeneity in labor supply responses empirically in the German context.

An important issue, however, is that the wage changes $\frac{dw_u}{w_u}$ and $\frac{dw_s}{w_s}$ are endogenous w.r.t. to the labor supply responses. To obtain an expression for these wage changes and hence obtain a closed form solution, we follow Sachs, Tsyvinski, and Werquin (2020) and formalize the associated fixed point in terms of integral equations.[25] First, note that these equilibrium wage changes can be divided into the effects arising from immigrant inflows, low-skilled resident labor supply responses, and high-skilled resident labor supply responses as

$$\frac{dw_u}{w_u} = \gamma_{u,own}\frac{L^{Im}}{\mathscr{L}_u} + \gamma_{u,own}\int_{\mathcal{I}_u}\frac{dL_j}{L_j}\frac{L_j\omega_j}{\mathscr{L}_u}dj + \gamma_{u,cross}\int_{\mathcal{I}_s}\frac{dL_j}{L_j}\frac{L_j\omega_j}{\mathscr{L}_s}dj. \tag{7}$$

The first term captures the wage change induced by immigration directly since $\frac{L^{Im}}{\mathscr{L}_u}$ captures the relative increase in effective low-skilled labor supply due to one immigrant with effective labor L^{Im}. The second term captures the own-wage effects implied by the change in low-skilled aggregate labor of residents and the third term captures the cross-wage effects implied by the change in high-skilled aggregate labor. Similarly, the equilibrium wage change for high-skilled workers is given by

$$\frac{dw_s}{w_s} = \gamma_{s,cross}\frac{L^{Im}}{\mathscr{L}_u} + \gamma_{s,cross}\int_{\mathcal{I}_u}\frac{dL_j}{L_j}\frac{L_j\omega_j}{\mathscr{L}_u}dj + \gamma_{s,own}\int_{\mathcal{I}_s}\frac{dL_j}{L_j}\frac{L_j\omega_j}{\mathscr{L}_s}dj. \tag{8}$$

How the equilibrium changes in relative wages translate into labor supply changes directly follows from the definition of labor supply elasticities. The integral equations that describes the relative change in total hours worked for low-skilled workers can therefore be written as:

$$\forall i \in \mathcal{I}_u : \frac{dL_i}{L_i} = \xi_i\left(\gamma_{u,own}\frac{L^{Im}}{\mathscr{L}_u} + \gamma_{u,own}\int_{\mathcal{I}_u}\frac{dL_j}{L_j}\frac{L_j\omega_j}{\mathscr{L}_u}dj + \gamma_{u,cross}\int_{\mathcal{I}_s}\frac{dL_j}{L_j}\frac{L_j\omega_j}{\mathscr{L}_s}dj\right). \tag{9}$$

The bracket on the right hand side captures the equilibrium change in the relative wage $\frac{dw_u}{w_u}$. The relative change in labor supply of type i individuals is then simply given by the total hours elasticity ξ_i multiplied with the relative wage change. Equivalently, for high-skilled labor, the integral equation reads as

$$\forall i \in \mathcal{I}_s : \frac{dL_i}{L_i} = \xi_i\left(\gamma_{s,cross}\frac{L^{Im}}{\mathscr{L}_u} + \gamma_{s,cross}\int_{\mathcal{I}_u}\frac{dL_j}{L_j}\frac{L_j\omega_j}{\mathscr{L}_u}dj + \gamma_{s,own}\int_{\mathcal{I}_s}\frac{dL_j}{L_j}\frac{L_j\omega_j}{\mathscr{L}_s}dj\right). \tag{10}$$

The expressions given by (9) and (10) constitute a system of integral equations. In Appendix B.2.3 we derive the following result on the wage changes in general equilibrium.

[25] Sachs, Tsyvinski, and Werquin (2020) study nonlinear tax reforms in a general equilibrium setting with endogenous labor supply and also highlight that a decrease in the skill ratio can trigger tax revenue effects in the case of progressive taxation.

Lemma 4. *Consider a small influx of a low-skilled immigrant with effective labor L^{Im}. The equilibrium changes in wages are described by*

$$\frac{dw_u}{w_u} = \frac{\gamma_{u,own}}{1 + \bar{\xi}^u|\gamma_{u,own}| + \bar{\xi}^s|\gamma_{s,own}|}\frac{L^{Im}}{\mathscr{L}_u}$$

$$\frac{dw_s}{w_s} = \frac{\gamma_{s,cross}}{1 + \bar{\xi}^u|\gamma_{u,own}| + \bar{\xi}^s|\gamma_{s,own}|}\frac{L^{Im}}{\mathscr{L}_u},$$

where $\bar{\xi}^u$ and $\bar{\xi}^s$ are the income-weighted total hours elasticities of the two skill groups.[26]

Proof. See Appendix B.2.3. □

Note that absent resident labor supply responses, an immigrant inflow leads to a relative wage change for low-skilled workers of $\frac{\hat{dw_u}}{w_u} = \gamma_{u,own}\frac{L^{Im}}{\mathscr{L}_u}$ and a relative wage change for high-skilled workers of $\frac{\hat{dw_s}}{w_s} = \gamma_{s,cross}\frac{L^{Im}}{\mathscr{L}_u}$. We'll refer to these wage effects without labor supply responses as "first-round effects". This lemma shows that, with labor supply responses, the changes in equilibrium wages are given by these first-round effects scaled by $\frac{1}{1+\bar{\xi}^u|\gamma_{u,own}|+\bar{\xi}^s|\gamma_{s,own}|} < 1$, capturing how much these first-round effects are mitigated by labor supply responses. Greater labor supply responsiveness, as measured by the income-weighted total hours elasticities of the different groups, implies a larger mitigation of the first round effects. This effect plays an important role because it mitigates the indirect fiscal effects that follow from the wage changes.

However, in addition to mitigating wage effects, the labor supply changes of residents also have fiscal implications themselves. The changes in equilibrium hours, participation, and aggregate labor supply directly follow from Lemma 4 and the definition of the elasticities

$$\forall i \in \mathcal{I}_e : \frac{dh_i}{h_i} = \varepsilon_i\frac{dw_e}{w_e}, \quad \frac{d\nu_i}{\nu_i} = \eta_i\frac{dw_e}{w_e}, \quad \frac{dL_i}{\nu_i} = \xi_i\frac{dw_e}{w_e}$$

for $e \in \{u, s\}$ and where $\frac{dw_e}{w_e}$ is defined as in Lemma 4.

We now combine Lemma 1, Lemma 4, and these equilibrium labor supply changes to rewrite the expression in Lemma 3 and obtain our main result.

Proposition 2. *The indirect fiscal effect of a low-skilled immigrant of type i is given by:*

$$d\mathscr{R}_{ind}(i) = \frac{y_i \times \frac{\kappa_s}{\sigma}}{1 + \bar{\xi}^u\frac{\kappa_s}{\sigma} + \bar{\xi}^s\frac{\kappa_u}{\sigma}}\left(\bar{T}'_s - \bar{T}'_u + \overline{\varepsilon_s T'}_s - \overline{\varepsilon_u T'}_u + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}}\right),$$

where

$$\overline{\eta_e T_{part,e}} = \frac{\int_{\mathcal{I}_e} T_{part}(y_i, i) y_i \eta_i \nu_i m_i di}{Y_e}$$

[26]Formally, these are given by $\bar{\xi}^e = \frac{\int_{\mathcal{I}_e} y_i(\eta_i+\varepsilon_i)\nu_i m_i di}{Y_e}$ for $e \in \{u, s\}$.

is the income-weighted average of the product of the participation tax rate and the participation elasticity of education group e and

$$\overline{\varepsilon_e T'_e} = \frac{\int_{\mathcal{I}_e} T'(y_i, i) y_i \varepsilon_i \nu_i m_i di}{Y_e}$$

is the income-weighted average of the product of of the marginal tax rate and the hours elasticity of education group e.

Proof. See Appendix B.2.4. □

How does this formula differ from that in Proposition 1? First of all the indirect fiscal effect is scaled down by $\frac{1}{1+\bar{\xi}^u \frac{\kappa_s}{\sigma} + \bar{\xi}^s \frac{\kappa_u}{\sigma}}$ since the wage effects are mitigated.[27] Second, in addition to the difference of the income-weighted marginal tax rates $\bar{T}'_s - \bar{T}'_u$, the formula accounts for the fiscal effects caused by resident labor supply responses, which can be thought of as fiscal externalities. The term $\overline{\varepsilon_s T'_s}$ captures that high-skilled residents increase their hours worked and pay more taxes while $\overline{\varepsilon_u T'_u}$ captures that low-skilled residents decrease their hours worked and pay less taxes. The term $\overline{\eta_s T_{part,s}}$ ($\overline{\eta_u T_{part,u}}$) captures the increase (decrease) in labor force participation of high-skilled (low-skilled).

Note that this formula can be straightforwardly calculated without resorting to simulation methods once the empirical objects have been quantified. We describe our quantification of this indirect fiscal effect in Section 3 and present the results in Section 4. Before turning to our quantification, for the interested reader, we show how the indirect fiscal effects can be embedded into modern welfare analysis (Hendren, 2015, 2020; Saez and Stantcheva, 2016).

We can decompose the indirect fiscal effect into the effect arising from differences in relative wages and the fiscal externalities as

$$d\mathscr{R}_{ind}(i) = \text{RelWages}(i) + \text{FiscExternalities}(i)$$

where

$$\text{RelWages}(i) = \frac{y_i \times \frac{\kappa_s}{\sigma}}{1 + \bar{\xi}^u |\gamma_{u,own}| + \bar{\xi}^s |\gamma_{s,own}|} \left(\overline{T'_s} - \overline{T'_u} \right),$$

and

$$\text{FiscExternalities}(i) = \frac{y_i \times \frac{\kappa_s}{\sigma}}{1 + \bar{\xi}^u |\gamma_{u,own}| + \bar{\xi}^s |\gamma_{s,own}|} \left(\overline{\varepsilon_s T'_s} - \overline{\varepsilon_u T'_u} + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}} \right). \quad (11)$$

[27] Note that this formula can be written in terms of own-wage elasticities as

$$d\mathscr{R}_{ind}(i) = \frac{y_i \times |\gamma_{u,own}|}{1 + \bar{\xi}^u |\gamma_{u,own}| + \bar{\xi}^s |\gamma_{s,own}|} \left(\bar{T}'_s - \bar{T}'_u + \overline{\varepsilon_s T'_s} - \overline{\varepsilon_u T'_u} + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}} \right).$$

These fiscal externalities have different welfare implications than the indirect fiscal effects that come from changes in relative wages holding labor supply fixed; they constitute welfare effects even in the absence of distributional considerations. Intuitively, residents do not internalize this externality on the government budget when adjusting their labor supply to the new wages. We now describe this in greater detail.

MVPF with Endogenous Labor Supply We now analyze how the MVPF of low-skilled immigration changes when we allow for endogenous resident labor supply. In this case, the aggregate willingness to pay of residents is equal to the sum of their income changes resulting from changes in wages, holding labor supply constant. This is an implication of the envelope theorem; changes in resident labor supply do not have a first-order effect on residents' utility. We can therefore write

$$WTP(i) = \frac{y_i \times \frac{\kappa_s}{\sigma}}{1 + \bar{\xi}^u|\gamma_{u,own}| + \bar{\xi}^s|\gamma_{s,own}|}\left((1 - \overline{T'}_s) - (1 - \overline{T'}_u)\right) = -\text{RelWages}(i).$$

The net cost of low-skilled immigration is still equal to the sum of direct and indirect fiscal costs and can written as

$$\text{NetCosts}(i) = -d\mathscr{R}_{dir}(i) - d\mathscr{R}^{ex}_{ind}(i) = -d\mathscr{R}_{dir}(i) - \text{RelWages}(i) - \text{FiscExternalities}(i).$$

Taken together, we can write the MVPF with endogenous labor supply as

$$MVPF(i) = \frac{\text{RelWages}(i)}{d\mathscr{R}_{dir}(i) + d\mathscr{R}^{ex}_{ind}(i)} = \frac{1}{1 + \frac{d\mathscr{R}_{dir}(i) + \text{FiscExternalities}(i)}{\text{RelWages}(i)}}. \tag{12}$$

The differences between the MVPF with endogenous labor supply given by (12) and that with exogenous labor supply given by (5) reflects that resident labor supply responses lead to a fiscal externality; changes in labor supply do not have a first-order effect on resident utility, but do have first-order implications for government revenue. Therefore, fiscal externalities do not affect the aggregate willingness to pay, but do affect the net cost of low-skilled immigration. All else equal, a larger fiscal externality leads to a lower MVPF of low-skilled immigration.

3 Empirical Quantification

To quantify the formula of Proposition 1, we need earnings distributions conditional on education and marginal tax rates along these earnings distributions. Note that even conditional on education and income, there is a distribution of tax rates since family status, age, location, etc. are also determinants of an individual's tax burden. Finally, we need a value for the elasticity of substitution between low- and high-skilled labor.[28] Further, in order to quantify the indirect fiscal effect with endogenous labor supply given by Proposition 2, we additionally need assumptions about labor supply elasticities and participation tax rates along the earnings distributions.

In Section 3.1, we make assumptions on parameters such as labor supply elasticities for different groups and wage elasticities. The calibrated values are based on existing empirical evidence.

Regarding the values of marginal and participation tax rates, we conduct our own empirical analysis.[29] To obtain our sample of residents, we use data from the American Community Survey (ACS). To assign effective marginal and participation tax rates to all individuals in the sample, we make use of NBER's TAXSIM. However, TAXSIM does not account for the effective tax rates that are implied by welfare-transfer programs nor the fiscal cost associated with Medicaid. Programs like the Supplementary Nutrition Assistance Program (SNAP) or Temporary Assistance for Needy Families (TANF) imply an increase in effective marginal tax rates since transfers are phased out as income increases. Further, Medicaid eligibility is subject to means testing, implying that the fiscal cost of Medicaid is decreasing in household income. To account for these programs, we use data from the Survey of Income and Program Participation (SIPP). With the SIPP, we estimate effective transfer phase-out rates and Medicaid take-up rates conditional on household size and income. Another important detail that is not captured in TAXSIM is that the payroll tax is not a pure tax because higher earnings imply not only higher taxes but also higher benefits when retired (see e.g. Feldstein and Samwick (1992)). Accounting for this requires estimates of individuals' life-cycle earnings, which determine how current income affects future social security benefits. To predict the life-cycle earnings paths of the individuals in our sample, we make use of panel data from the NLSY79. We describe all the sample selection in Section 3.2 and the effective tax rate calibration in Section 3.3.[30]

3.1 Calibrated Parameters

Elasticity of Substitution For the elasticity of substitution σ, Card (2009) concludes that values are likely to be between 1.5 and 2.5. We will therefore treat $\sigma = 2$ as our "preferred" estimate but will also show results for $\sigma = 1.5$ and $\sigma = 2.5$. We estimate as $\kappa_s = 0.79$, using

[28] The raw data and code necessary to calculate effective marginal tax rates for all individuals in the ACS, calculate the income-weight effective tax rates, and calculate the main results in Table 2 are available for download at `https://sites.google.com/site/markyaucolas/research`.

[29] The Congressional Budget Office estimates effective marginal tax rates for low- and medium- income workers in the U.S. (Congressional Budget Office, 2015). We cannot use their estimates directly as they only provide the median, 10th and 90th percentile of marginal tax rates for different income groups. Further their calculations do not include workers with income over 450% of the Federal Poverty Line and do not account for TANF of SSI payments.

[30] Our quantification could be extended to account for the taxation of interest and pension income, and estate taxes. Accounting for income and pension income and estate taxes would likely lead to larger indirect fiscal effects, given higher savings rates of high-skilled individuals and the progressivity of estate taxes.

our ACS sample (see description in the next section). Together, this range of values for σ and this estimate of κ_s imply own-wage elasticities ranging from -.51 ($\sigma = 1.5$) to -.31 ($\sigma = 2.5$) for these two polar cases.[31]

Labor Supply Elasticities In our baseline specification, we assume all individuals have common intensive and extensive labor supply elasticities. Specifically, we set the intensive margin elasticity of $\varepsilon_i = .33$ and an extensive margin elasticity of $\eta_i = .25$, for all individuals i, based on the pooled estimates in Chetty (2012).[32]

A number of papers emphasize that labor supply elasticities differ across genders, marital statuses, and income levels but few papers have actually estimated these elasticities across the income distribution for both genders. Therefore, in Appendix C.5, we instead use estimates of intensive and extensive labor supply elasticities by gender, marital status and quintile of the income distribution from Bargain, Orsini, and Peichl (2014).

Other parameters. We assume that agents start receiving social security at age 66. We assume the real discount rate for the government to be 1%.[33] Finally, the formula in Proposition 2 shows that the income of the immigrants also plays a role beyond the education status. Since the exact income of an immigrant is not foreseeable before an immigrant has entered the country, we consider the case of taking expected immigrant income as reasonable. Using again data from the ACS, we find that the average annual gross income of a low-skilled immigrant worker in our sample is $30,317. We also consider the indirect fiscal effects of high school dropout immigrants and high school graduate immigrants, who have average incomes of $25,861 and $33,442, respectively.

3.2 Data and Sample

ACS Our main data source is the 2017 ACS, which includes information on income and demographics for a nationally representative sample of 1% of the U.S. population. As is standard, we focus on individuals between 18 and 65 years old and eliminate individuals living in group quarters. In order to ensure that we can accurately determine an individual's tax-filing status, we limit our sample to heads of households and their spouses. This leaves us with a sample of over 1.2 million individuals.[34] We utilize data on each individual's earnings,

[31]Katz and Murphy (1992), for example, find an elasticity of substitution of 1.4. Card and Lemieux (2001) estimate an elasticity of substitution between 1.15 and 1.6 in their pooled sample of men and women.

[32]In fact, these numbers of Chetty (2012) refer to compensated, Hicksian elasticities while the elasticities in our formulas are uncompensated elasticities. As argued e.g. by Chetty et al. (2013), uncompensated elasticities are likely to be only slightly smaller than compensated elastiticies as microeconometric evidence shows income effects are small. Accounting for this would push our results below in Table 2 with endogenous labor supply closer to the values with exogenous labor supply in the same table.

[33]The real interest rate on 30 year bonds was on average 0.99 (0.81) in the last ten (five) years. See `https://home.treasury.gov/policy-issues/financing-the-government/interest-rate-statistics`. We show our main results under the assumption of a 2% interest rate in Appendix D.3

[34]Additional details on sample selection in the ACS are included in Appendix C.1.

income from other sources, marital status, age, location, number and ages of children, and age and income of the individual's spouse, all of which determine an individual's tax liability and eligibility for various tax credits and deductions.[35] We also utilize data on each individual's education, which we use to determine an individual's skill group. We define low-skilled workers as those without any college experience and define high-skilled workers as workers with at least some college experience.[36]

Figure 1 shows the density of individual earnings for high-skilled and low-skilled workers given our baseline definition of skills. Overall, low-skilled individuals have average earnings of \$35,600 while high-skilled individuals have average earnings of \$65,800.

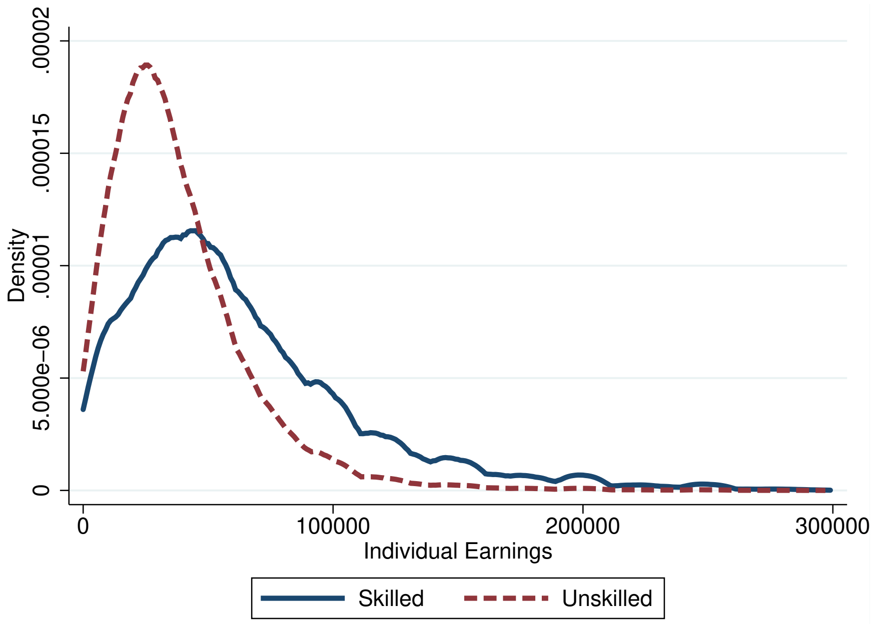


Figure 1: Kernel density plot of individual earnings for low-skilled and high-skilled individuals in our sample conditional on having positive earnings. We truncate the graph at income of \$300,000. We define low-skilled individuals as those without any college experience and define high-skilled individuals as workers with at least some college experience.

SIPP We also incorporate data from the SIPP, a nationally representative sample with detailed data on respondents' participation in income transfer programs, thereby allowing us to understand how benefits receipt varies across the earnings distribution. In particular, we utilize data from waves 1-4 of the 2014 SIPP, which includes monthly data on approximately 53,000 households from 2013 to 2016. From this dataset, we utilize data on household size,

[35]Top wage incomes are underrepresented in most survey data sets. We therefore append Pareto tails to the wage income distribution, starting at the highest wage income value that is not top-coded in each state, as is relatively common practice in the optimal tax literature (Piketty and Saez, 2013). We assume a shape parameter of $\alpha = 1.5$.

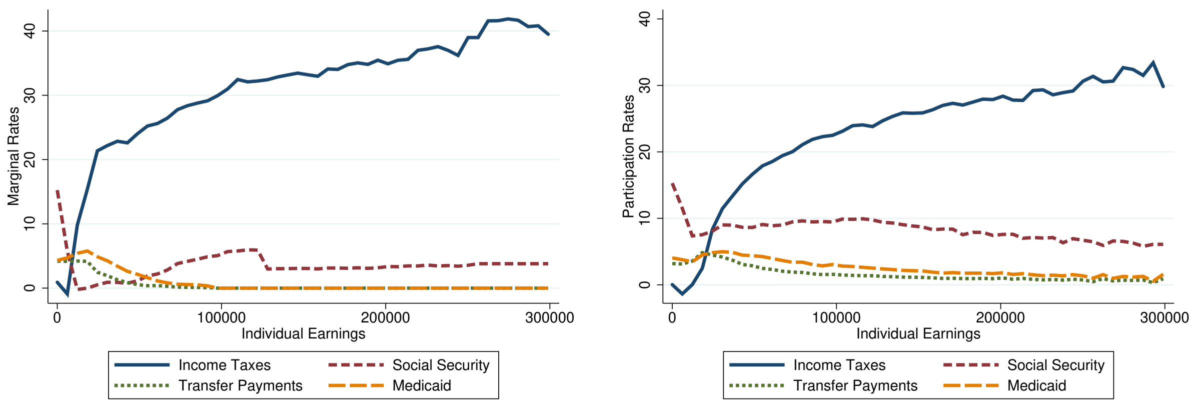
[36]An alternative approach to defining skills, employed by Katz and Murphy (1992) and Card (2009), is to divide workers with some college between the two skill groups. We consider this skill classification in Appendix D.4.

household earnings, and receipt of TANF, SNAP, and Medicaid benefits over the year. We convert all monetary values to 2017 dollars.

NLSY79 Our final data source is the NLSY79, a nationally representative panel dataset with data on over 12,000 individuals. Respondents were first interviewed in the year 1979, when respondents were between ages 14 and 22. The panel structure of the NLSY79 allows us to observe an individual's earnings over their life cycle, which determines an individual's social security benefit after retirement. Since we need data on as much of an individual's work history as possible, we drop individuals from our sample who drop out of the survey before age 50.[37] In addition to data on earnings, we utilize data on education, gender, marital status, age, and number of children over the life cycle. We use these variables to map estimates of earnings over the life cycle to individuals in the ACS.

3.3 Tax-Transfer System

Income Taxes and the EITC. To calculate marginal income and payroll tax rates, we use NBER's TAXSIM, a tax calculator that replicates the federal and state tax codes in a given year, accounting for differential tax schedules and tax deductions and credits afforded by various demographic groups, e.g. by marital status or number of dependents. Additional details are included in Appendix C.1.



(a) Marginal Taxes (b) Participation Taxes

Figure 2: Marginal and participation tax rates by individual earnings. Panel (a) gives the marginal effective tax rates implied by income taxes, the social security system, and transfer programs. Panel (b) reports the participation tax rates implied by income taxes, the social security system, and transfer programs. Income taxes here are the sum of state and federal income taxes (including tax credits), social security is defined as payroll taxes minus the discounted sum of future social security benefits, and transfer payments are the sum of TANF and SNAP phase outs.

[37]There are two complications in the NLSY that we need to deal with. First, we must deal with the fact that individuals are only interviewed on even numbered years after 1994. We therefore assume that data in odd numbered years post 1994 is the same as in the previous year. Further, in 2016, the last year from which data are available, respondents are between age 53 and 60. We therefore do not have income information for the last few years of individual's working lives. We therefore assume that income for the remainder of the working life is equal to a respondent's last observed income.

Object	Skilled	Unskilled
Taxes		
Federal Income Tax	27.3	20.4
State Income Tax	4.9	4.1
Transfers		
Food stamps (SNAP)	0.3	1.1
Welfare (TANF)	0.0	0.1
Medicaid	0.7	2.6
Social Security		
Payroll Tax	10.4	13.9
Marginal Replacement Rate	7.0	11.9
Total	36.6	30.3

Table 1: Estimates of income weighted effective marginal tax rates. Each entry shows the income weighted average marginal tax rates arising from each source of effective tax rates in our sample of ACS data. See text for details.

The solid blue line in Panel (a) of Figure 2 shows the average marginal tax rate arising from federal and state income taxes, including tax credits, as a function of individual labor income. Panel (b) shows the same relationship for participation tax rates. As can be seen both are increasing in income, reflecting the progressivity of federal income tax schedule.[38]

Rows 1-2 of Table 1 give the income-weighted average marginal federal and state income taxes for high-skilled and low-skilled workers. Consistent with the progressivity of these taxes, we find marginal federal income tax rates of 27.3% for high-skilled workers and 20.4% for low-skilled workers. State income tax systems are less progressive. We find marginal state income tax rates of 4.9% and 4.1% for high- and low-skilled workers, respectively.

Welfare Programs. SNAP benefits are declining in income; in the phase-out region of the SNAP benefit schedule, a dollar increase in monthly income is associated with a 24 cent reduction in monthly SNAP benefits. Similarly, TANF benefits are determined as a function of income, though the formula differs by state. However, take-up of these programs is far from 100% (Currie, 2006), and therefore the implied changes in the effective tax rates are less than these statutory values suggest. Therefore, in order to estimate SNAP and TANF benefits as a function income, while taking into account differences in eligibility and take-up across households, we estimate realized benefits as a function of income and household characteristics using data from the SIPP. Details on the procedure can be found in Appendix C.2.

The dashed green line in the left of Figure 2 gives the marginal phase-out rate of social transfers, where social transfers are given by the sum of TANF and SNAP benefits. We can see that the marginal phase-out rate of transfer payments is positive but small for low levels

[38]Appendix D.2 shows the total marginal and participation tax rates by individual earnings as the sum of the effective tax rates arising from income taxes, social security, and transfer payments.

of income before approaching 0 for higher income levels.[39] The dashed green line in the right panel of Figure 2 gives the social transfer phase-out associated with labor force participation, which is also small and mostly decreasing as a function of income.

The income-weighted average marginal SNAP and TANF phase-out rates are shown in rows 3 and 4 in Table 1. The estimates of the average marginal phase-out rates of SNAP are small, at 0.3% for high-skilled workers and 1.1% for low-skilled workers. This might seem surprising, given that the phase out rate of SNAP for those who receive SNAP as a function of income is quite large. However, the relevant statistic for the marginal effect of immigration is the average *income-weighted* marginal benefit and the high phase-out rates of SNAP occur at relatively low income levels.[40] The estimates for TANF are even smaller— the average income weighted TANF benefits 0.1% for low-skilled workers and less than that for high-skilled workers. As with SNAP, TANF recipients have low incomes and therefore receive little weight in the calculation of the income-weighted average marginal phase-out rate. Furthermore, only 2.5 million individuals received TANF in the average month in 2017.[41] Therefore, while the marginal phase-out rates of TANF and SNAP for a given individual can potentially be large, the income-weighted averages are quite small.

Medicaid Medicaid eligibility standards vary across states, though there are federally-required minimum standards. In general, individuals must have sufficiently low income to quality for Medicaid.[42] To calculate the fiscal costs associated with Medicaid, we combine estimates of Medicaid take-up from the SIPP with estimates of government cost per Medicaid recipient from the Kaiser Family Foundation. Details are included in Appendix C.3.

The marginal and participation fiscal costs associated with Medicaid are shown by the dashed orange lines in the two panels of Figure 2. The costs associated with Medicaid are quite high at low-income levels, reflecting both that households may become ineligible for Medicaid and that households may be less likely to take up Medicaid conditional on eligibility as their income levels increase. We estimate income-weighted average fiscal costs of 2.6% and 0.7% for low- and high-skilled workers, respectively.

[39]The fact that the phase-out rate is so low reflects the facts that 1) take-up of TANF and SNAP is less than 100% and 2) the plot shows the phase-out as a function of individual's earnings, holding spouses earnings constant. Regarding 1), one reason could be that individuals "bank" their eligibility for the future since there are are time limits in most states (Low, Meghir, Pistaferri, and Voena, 2018). Regarding 2): as TANF and SNAP eligibility are generally determined by household income, many individuals would not be eligible for these benefits even if their individual income dropped to 0.

[40]To better see this, consider the average income weighted phase-out rate of SNAP for households with four members. As with other demographic groups, the phase-out rate for those on SNAP is 24%. However, given that take-up is less than 100%, we estimate an average phase-out rate of only 15% for households whose income places them in the phase-out region of the SNAP formula. Among four-member households, only households with gross monthly income below $2,633 were eligible for SNAP. These households therefore receive little weight when calculating the income weighted marginal phase-out rates.

[41]Source: `https://www.acf.hhs.gov/sites/default/files/ofa/2017_recipient_tan.pdf`

[42]Some individuals are exempt from the standard financial eligibility criteria, such as those with sufficient medical need.

Social Security. Finally, our calculation of effective marginal tax rates includes social security benefits and payroll taxes. Payroll taxes are mostly decreasing with income; payroll taxes have a constant marginal tax rate of 15.3% until the maximum taxable earnings threshold after which the marginal rate drops to 2.9%.[43]

However, payroll taxes are not a pure tax because higher earnings are also associated with higher social security benefits after retirement. More specifically, an individual's social security benefits are calculated as an increasing function of the individual's average indexed monthly earnings (AIME), the average monthly earnings over the individual's 35 highest earnings years of their career, adjusted for overall growth in the economy over time. Therefore, if current year earnings are one of the individuals 35 highest earning years, an increase in current earnings can increase an individual's AIME and lead to a larger benefits payment after the individual retires. As these social security payments will be received in the future, the relevant calculation for our purposes is the discounted sum of the benefits. We describe how we use data from the NLSY79 and the ACS to calculate this discounted marginal replacement rate in Appendix C.4.

The dotted green line in the two panels of Figure 2 display the marginal tax rates and participation tax rates associated with the social security system, which we define as payroll taxes minus the marginal replacement rates.[44] At very low incomes, both marginal and participation tax rates are very high. This occurs because very low income levels are unlikely to be one of an individual's 35 highest earning years, and therefore do not increase their future social security benefits. Eventually, the social security tax begins to increase with income, as higher earnings imply higher social security benefits post-retirement. At the maximum taxable earnings threshold of $127,200, the payroll tax drops precipitously, leading to a drop in the marginal effective tax associated with social security.[45] The social security participation tax rate exhibits a kink, rather than a drop, at the maximum taxable earnings threshold, because individuals still pay payroll taxes on earnings up to this threshold.

The final two rows of Table 1 give the income-weighted average payroll tax rates and marginal discounted replacement rates. We find a higher marginal payroll tax rate for low-skilled workers than high-skilled workers, at 13.9% for low-skilled workers and 10.4% for high-skilled workers, reflecting that payroll taxes drop dramatically at the maximum taxable earnings threshold. We estimate an income weighted marginal social security replacement rate of 11.9% for low-skilled workers and 7.0% for high-skilled workers, reflecting that marginal benefits rates are decreasing in AIME. Taken together, this implies an income weighted average effective social security tax of 2.0% for low-skilled and 3.4% for high-skilled workers.

[43] The maximum taxable earnings threshold was $127,200 in the year 2017. At higher income levels, individuals must pay an Additional Medicare Tax, which increases the marginal tax rate by an additional 0.9%.

[44] Note that payroll taxes also fund other programs, such as Medicare, in addition to Social Security.

[45] After this threshold, the marginal tax rate is mostly flat, reflecting that further income increases do not count for social security purposes.

	Elasticity of Substitution		
	1.5	2.0	2.5
I. No Labor Supply Responses	1003	753	602
II. Endogenous Labor Supply	1132	913	765

Table 2: Indirect Fiscal Effects of low-skilled immigrants. The three columns show the indirect fiscal effect under different assumptions of the elasticity of substitution, ranging from $\sigma = 1.5$ to $\sigma = 2.5$. Each row displays the indirect fiscal effect for different assumptions about the labor supply elasticity.

The final row of Table 1 displays $\bar{T}'_s$ and $\bar{T}'_u$, the income-weighted effective marginal tax rates, as the sum of these elements. We obtain $\bar{T}'_u = 30.3\%$ for low-skilled workers and $\bar{T}'_s = 36.6\%$ for high-skilled workers, implying a difference in marginal tax rates of 8.2%.

4 Results

We now present the quantification of our formulas in Proposition 1 and Proposition 2. We then compare these numbers to direct fiscal effects in Section 4.2.

4.1 Indirect Fiscal Effects

Table 2 displays estimates for the indirect fiscal effect under different assumptions on the elasticity of substitution between workers and labor supply elasticities. The three columns show the indirect fiscal effect under different assumptions of the elasticity of substitution, ranging from $\sigma = 1.5$ to $\sigma = 2.5$. Each row displays the results for different assumptions about the labor supply elasticity.

In the first row, we display the indirect fiscal effect with exogenous labor supply, based on Proposition 1, which we interpret as the short-run indirect fiscal effects. We find an indirect fiscal benefit of \$753 given our preferred specification with $\sigma = 2$. This is an economically meaningful effect: it is equal to 29% of the federal tax payments of the median low-skilled worker in our sample.[46]

The second row displays the results with endogenous labor supply adjustments, which we interpret as the long-run indirect fiscal effects. We find an indirect fiscal benefit of \$913 given $\sigma = 2$ with endogenous labor supply.

Tables 15 and 16 in Appendix D.5 repeat the analysis for the average high school dropout immigrant and the average high school graduate immigrant. With fixed (endogenous) labor supply and $\sigma = 2$, we find an indirect fiscal effect of \$830 (\$1,006) for high school graduates, and \$641 (\$778) for high school dropout immigrants.

[46] The median federal tax payment of low-skilled workers in our sample is \$2,590 in federal taxes annually.

4.2 Relation to Direct Fiscal Effects

We now relate our results about the indirect fiscal effects to the direct fiscal effects of the report by the National Academy of Sciences (2017).

Our approach is as follows: we first consider the lifetime direct fiscal effect of a low-skilled immigrant who arrives at age 23 and lives until the age of 79. We choose 23 since this is the median age of arrival for low-skilled immigrants in the ACS and we chose 79 years because the life expectancy at age 23 in the U.S. is roughly 79.[47] We make use of Figure 8-21 of the NAS report, which provides us with the net direct fiscal impact by age for both high school graduates and high school dropouts. These calculations account for the immigrant's federal, state and local taxes, incarceration costs, veteran's benefits, refugee support costs, government healthcare costs, and a variety of federal and state level transfer programs over an individual's life-cycle.[48] Further, we need to make an assumption about how immigrants affect government spending on public goods.[49] We consider four different scenarios, similar to the NAS report: (i) there are zero marginal costs of public goods and hence no costs are assigned to immigrants, (ii) marginal costs are equal to 25% the average costs of public goods, (iii) marginal costs are equal to 50% of average costs, and (iv) marginal costs equal average costs.[50] For all of these four scenarios, we can calculate the net present value (NPV) direct fiscal effect of low-skilled immigrants. To make this number comparable to our annual indirect fiscal effect, we calculate the annuity value for the period of 23 until 65 (labor market period) that corresponds to the NPV of the lifetime direct fiscal effect.

Table 3 contains these annuitized values for the four different scenarios. The first column gives the results for a high school dropout immigrant, the next column gives the results for high school graduates, and the last column gives the results for the average low-skilled immigrant. We can clearly see that low-skilled immigrants imply a direct fiscal burden in nearly every scenario – only high school graduates are a small fiscal surplus for the first scenario. Recall that we calculate indirect fiscal effects of roughly \$640 for high school dropouts and \$830 for high school graduates in our preferred specification with fixed labor supply. Comparing the numbers in Table 3 with the numbers in Table 2, one can see that accounting for indirect fiscal effects has important implications for the fiscal effect of immigration. To illustrate this, consider the fiscal effect of a high school graduate. In the extreme case with zero marginal costs of immigration where the direct fiscal effect is \$695, we find a total effect of \$1625 with

[47]In 2017, the life expectancy at age 23 was 77.06 for men and 81.72 for women. This yields a simple average of 79.39. Source: `https://www.ssa.gov/oact/STATS/table4c6.html`

[48]National Academy of Sciences (2017) also accounts for schooling costs, but these are less relevant here given that we consider low-skilled immigrants from age 23 onwards.

[49]Dustmann and Frattini (2014) give a detailed discussion about this for the UK and point out that the exact specification matters significantly. Referring to assumptions on the marginal cost of public goods, the NAS report states "In fact, such assumptions are likely to swamp the impact of most of the other assumptions and data issues that arise in fiscal impact analyses." (National Academy of Sciences, 2017, p. 266).

[50]Case (i) relates to scenario 6 and case (iv) relates to scenario 2 of Box 8-1 of National Academy of Sciences (2017). Cases (ii) and (iii) are intermediate cases of those two.

an MVPF of 0.54. In the case when marginal costs are equal to 25% of average costs and the direct fiscal effect is -$86, we find a total fiscal effect of $744 with an MVPF of 1.11. In other cases, the total effect of immigration is negative, but one can see that the indirect fiscal effects are are economically meaningful in comparison to the direct fiscal effects and should therefore be taken into account.

The total fiscal effects of low-skilled immigration are slightly more positive when we allow for endogenous labor supply. In this case, we calculate a total effect of $1701 with an MVPF of 0.36 when the direct effect is equal to $695, and a total effect of $920 with an MVPF of 0.71 when the direct effect is equal to -$86. These differences in MVPF between the cases with and without endogenous labor supply illustrate the importance of accounting for fiscal externalities.[51]

Public Goods Scenario	High School Dropout	High School Graduate	Average
Zero Marginal Costs	-4,151	695	-1,388
MC = 0.25 × AC	-4,922	-86	-2,165
MC = 0.5 × AC	-5,693	-867	-2,942
MC = AC	-7,235	-2,429	-4,496

Table 3: Annuitized direct fiscal effect of an immigrant that arrives at age 23 and dies at age 79. We use a discount rate of 1%. Only direct fiscal contributions are accounted for and rely on Figure 8-21 of National Academy of Sciences (2017). We calculate the annuity value for the period of 23 until 65 (age of retirement).

5 Robustness and Discussion

Subsection 5.1 discusses the sensitivity of our results to several alternative specifications of the labor market and production from the immigration literature. The formulas for indirect fiscal effects and additional details and results for each specification are included in Appendix A. Subsection 5.2 discusses the role of physical capital. Appendix A.7 discusses further issues.

5.1 Alternative Specifications

We calculate the indirect fiscal effects of low-skilled immigrants using a variety of alternative models from the immigration literature. These extensions and the associated indirect fiscal effects are summarized in Table 4. First, we consider three alternative production specifications: 1) production with four imperfectly substitutable education groups and imperfect substitutability between experience levels, as utilized by Borjas (2003), 2) production with imperfectly substitutable foreign-born and domestic-born workers, as in Ottaviano and Peri (2012), and 3) production where skills are defined by an individual's position in the wage

[51] As we show in Appendix D.1, we find that the fiscal externalities amount to roughly one third of the indirect fiscal effect.

Specification	Indirect Effect	Section	Main Reference/Source of Estimates
Baseline Model		Sections 2 - 4	Acemoglu and Autor (2011), Card (2009)
Exogenous Resident Labor Supply	$753		
Endogenous Resident Labor Supply	$913		
Education and Experience Groups	$1,304	Appendix A.1	Borjas (2003)
Domestic- and Foreign-Born Complementarity	$758	Appendix A.2	Ottaviano and Peri (2012)
Skills by Position in Wage Distribution	$774	Appendix A.3	Dustmann, Frattini, and Preston (2013)
Endogenous Task Supply	$1,918	Appendix A.4	Peri and Sparber (2009)
Decreasing Returns to Scale	$801	Appendix A.5	Burnside (1996)

Table 4: Estimates of annual indirect fiscal effect of one low-skilled immigrant under different model specifications. For the "Baseline Model" we use our results associated with an elasticity of substitution between high-skilled and low-skilled workers of 2, the central value we use in our quantification. For all specifications, we show the indirect effect for the average low-skilled immigrant. See text for details on each specification.

distribution, rather than their education, as in Dustmann, Frattini, and Preston (2013). The details are in Appendices A.1, Appendix A.2, and Appendix A.3, respectively. We show that our formula extends naturally to these more elaborate production technologies. For all three specifications, we find annual indirect fiscal effects of the average low-skilled immigrant in the range of $750 to $1,300.

Peri and Sparber (2009) and Llull (2018) highlight the importance of occupation adjustments in mitigating the wage effects of immigration.[52] In Appendix A.4, we therefore consider a model with endogenous task supply as in Peri and Sparber (2009). In the model, low-skilled workers may react to additional low-skilled immigration by 'upgrading' their occupation. We find an indirect fiscal benefit of over $1,900 in this framework, roughly half of which is due to occupation upgrading of domestic-born workers.

Finally, in Appendix A.5, we calculate the indirect fiscal effect when production exhibits decreasing returns to scale. In this case, immigrant inflows not only change the relative wages between imperfectly substitutable worker groups, but also increase firm profits at the cost of total worker compensation. We show that this additional effect can be accommodated with an additional term in our indirect fiscal benefits formula which accounts for this shift in distribution of national income from workers to firms. Using an estimate of marginal profit tax rates, we show that the indirect fiscal effect with decreasing returns is unlikely to be significantly different from the case with constant returns to scale.

[52]See also Foged and Peri (2016) and Patt, Ruhose, Wiederhold, and Flores (2020) for evidence of task supply responses to immigrant inflows. Llull (2018) estimates the effects of immigration on wages and welfare using a dynamic equilibrium model which includes occupation, education, and labor force participation decisions. We discuss the implications of endogenous education choice on indirect fiscal effects in Section A.6.

5.2 The Role of Physical Capital

We have abstracted away from the role of capital in production. Here we show how physical capital can be accommodated into our formulas. This does not significantly change our results.

Elastically Supplied Physical Capital Consider a constant returns production function $Y = F(\mathscr{L}_u, \mathscr{L}_s, K)$ that uses physical capital, K, as an input in addition to low- and high-skilled labor. Suppose the supply of capital is perfectly elastic. Since $F(\cdot)$ exhibits constant returns to scale, the firm's optimal choice of capital level can be written as a function of the levels of high- and low-skilled labor, $K^\star(\mathscr{L}_s, \mathscr{L}_u)$. Therefore, one can redefine production in terms of labor quantities given the endogenous capital level as

$$\tilde{F}(\mathscr{L}_u, \mathscr{L}_s) = F(\mathscr{L}_u, \mathscr{L}_s, K^\star(\mathscr{L}_s, \mathscr{L}_u)).$$

Note that $\tilde{F}$ is a function of only labor quantities and exhibits constant returns to scale. Therefore, Proposition 2 can still be applied if we interpret the own-wage elasticity as the wage elasticity given optimal capital adjustments.[53]

As a simple example, consider the case with the Cobb-Douglas production function $F(\mathscr{L}_u, \mathscr{L}_s, K) = K^\alpha (G(\mathscr{L}_u, \mathscr{L}_s))^{1-\alpha}$, where $G(\cdot)$ is a CRS labor aggregate. With elastic capital supply, the ratio of capital to the labor aggregate is constant. As we show in Appendix B.8, we can therefore rewrite the production function as $\tilde{F}(\mathscr{L}_u, \mathscr{L}_s) = \bar{A}G(\mathscr{L}_u, \mathscr{L}_s)$ where $\bar{A}$ is a positive multiplicative constant.

In addition, low-skilled immigration will lead to an increase in physical capital which may lead to increased tax revenue. This channel is explored in ongoing work by Clemens (2021) who shows that this implies quantitatively large increases in capital tax revenue.

Inelastically Supplied Physical Capital Lewis (2011) argues that capital stocks adjust quickly to immigrant inflows, and therefore the case with elastic capital supply is appropriate for most settings. Yet, it is interesting to get a sense of how our results would change if capital supply is inelastic. Consider again the Cobb-Douglas production function that combines physical capital, K, with a labor aggregate G

$$Y = K^\alpha G(\mathscr{L}_u, \mathscr{L}_s)^{1-\alpha},$$

where $\alpha \in (0, 1)$ is a parameter and G is a constant returns to scale function. We assume capital is supplied inelastically and capital payments are taxed at rate τ_k.

[53] As we show in Appendix B.8, $\gamma^{elast}_{u,own} = -\frac{1}{\sigma}\kappa_s$, where κ_s is the share of total labor income that is received by high-skilled workers. Note that the above does not rely on a particular production function (such as Cobb-Douglas) or separability of capital in the production function more generally. The above arguments also apply to cases with non-separable capital and capital-skill complementarity, as in the models in Lewis (2011) and Lewis (2013).

As we show in Appendix B.8, the indirect fiscal benefit with inelastic labor supply for an immigrant of type i is given by

$$d\mathscr{R}_{ind}^{inelast}(i) = y_i \left[\underbrace{\left(\bar{T}_s' - \bar{T}_u'\right) |\gamma_{u,own}^{elast}|}_{\text{Skill Ratio Effect}} + \underbrace{\alpha\left(\tau_k - \bar{T}_I'\right)}_{\text{Capital Labor Ratio Effect}} \right], \tag{13}$$

where $\gamma_{u,own}^{elast} = \frac{\partial \log \frac{\partial G}{\partial \mathscr{L}_u}}{\partial \log \mathscr{L}_u}$ is the own-wage elasticity of low-skilled labor when capital supply is perfectly elastic. This is simply equal to $\gamma_{u,own}^{elast} = -\frac{1}{\sigma}\kappa_s$, where κ_s is again the share of total labor income that is received by high-skilled workers. Therefore, the indirect fiscal effect generated by the "skill ratio effect" is simply equal to the indirect fiscal effect with elastic capital supply.[54]

6 Conclusion

In this paper, we explore the indirect fiscal effect of immigration that works through the impact on the resident wages and labor supply. Applying these formulas to the U.S., we find that the indirect fiscal effects of low-skilled immigration are sizable and positive. For some plausible scenario they turn low-skilled immigration from a fiscal burden to a fiscal surplus.

Future work could extend our analysis to other countries, where the tax system, labor supply responses and wage effects of immigration may differ from the U.S. case. Our approach could also be extended to calculate the indirect fiscal effects of high-skilled immigrants. In thinking about the indirect effects of high-skilled immigration, it would seem natural to allow for high-skilled immigrants to affect factor productivity, in addition to factor ratios (Kerr and Lincoln, 2010; Peri, Shih, and Sparber, 2015; Bound, Khanna, and Morales, 2017; Khanna and Lee, 2018). We leave these extensions for future research.

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[54]One reasonable assumption is that when physical capital supply is inelastic, returns to physical capital have a similar tax rate as firm profits. Therefore using the marginal tax rate for profit we calculated of 36.8% in Appendix A.5, and capital share parameter of $\alpha = .33$, we find that the indirect fiscal effect of an average low-skilled immigrant with inelastic capital supply will increase by $y_i\alpha\left(\tau_k - \bar{T}_I'\right) = \$161$ compared to the case with elastic capital supply.

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Appendix for Online Publication

A Extensions Appendix

In this Appendix, we evaluate the indirect fiscal effects using several alternative model specifications. Appendices A.1 through A.3 consider alternative production functions utilized in the immigration literature. As we focus on differences in production functions, we consider the case with exogenous resident labor supply. Appendix A.4 considers the case when workers can endogenously choose their supply of communication- and manual-intensive tasks. Appendix A.5 considers the case with decreasing returns to scale. For the sake of readability, we have relegated most proofs to Appendix B.

A.1 Imperfectly Substitutable Education and Experience

In this Appendix, we evaluate the indirect fiscal effects using the model from Borjas (2003). Production takes the form of a two-level nested CES function.[55] The top level of the production function combines labor supplies of four education groups: high school dropouts, high school graduates, some college, and college graduates. Letting e index education groups, output Y is given by

$$Y = \left(\sum_e \theta_e \mathscr{L}_e^{\frac{\sigma_E - 1}{\sigma_E}} \right)^{\frac{\sigma_E}{\sigma_E - 1}},$$

where $\mathscr{L}_e$ is the labor aggregate of labor of education group e, σ_E is the elasticity of substitution between education groups, and θ_e is a factor-intensity parameter. Due to this finer stratification of skill groups, an increase in the number of high school dropouts, for example, affects the relative wages of dropouts to high school graduates, in addition to the relative wages of high-skilled versus low-skilled workers.

In turn, each education-specific labor aggregate is itself an aggregator of experience levels within a given education group. As in Borjas (2003), we divide workers into 8 experience levels consisting of 5-year experience intervals, starting with 1-5 years experience until 36-40 years of experience. Letting a index these experience levels, we can write

$$\mathscr{L}_e = \left(\sum_a \theta_{ae} \mathscr{L}_{ae}^{\frac{\sigma_X - 1}{\sigma_X}} \right)^{\frac{\sigma_X}{\sigma_X - 1}}$$

where $\mathscr{L}_{ae}$ gives the labor supply of a given experience-education group and is given by $\mathscr{L}_{ae} = \int_{\mathcal{I}_{ae}} L_i \omega_i di$, and where $\mathcal{I}_{ae}$ is the set of types within a given experience-education group. The parameter σ_X is equal to the elasticity of substitution of experience levels within the same education group and θ_{ae} is a factor-intensity parameter. Therefore, within the

[55] We abstract away from physical capital (or alternatively assume that capital supply is perfectly elastic) in Sections A.1 through A.5. We discuss the role of capital in Section 5.2.

Experience Group	HS Dropout	HS Graduate
1-5	1086	1042
6-10	1122	1183
11-15	918	1200
16-20	971	1275
21-25	951	1366
26-30	1073	1552
31-35	1223	1683
36-40	1370	1749
Education Average	1094	1445
Overall Average	1304	

Table 5: Indirect Fiscal Effects using model from Borjas (2003). Each entry gives the indirect fiscal effect associated with a worker in each narrow education and experience group. The "Education Average" gives the weighted average indirect fiscal effect within each education group and the "Overall Average" is the weighted average across all groups.

same education level, workers of different experience levels are imperfectly substitutable in production. Immigrant inflows therefore change the relative wages of different experience groups within the same education level.

As we show in Appendix B.4, if labor supply is inelastic, the indirect fiscal benefit of an immigrant of type i in experience group a and education group e is given by

$$d\mathscr{R}_{ind}^{\text{Borjas}}(a,e,i) = y_i \left[\underbrace{\left(\bar{T}'_{a'\neq a,e} - \bar{T}'_{ae}\right)|\tilde{\gamma}_{ae,own}|}_{\text{Experience Effect}} + \underbrace{\left(\bar{T}'_{e'\neq e} - \bar{T}'_{e}\right)|\gamma_{e,own}|}_{\text{Education Effect}} \right], \tag{14}$$

where $\tilde{\gamma}_{ae,own}$ is the own-wage elasticity of experience group a and education group e, holding the overall ratio of education groups constant, $\bar{T}'_{a'\neq a,e}$ is the income weighted average tax rate of all other experience groups in education group e, $\bar{T}'_{e'\neq e}$ is the income weighted tax rate of all other education groups, $\gamma_{e,own}$ is the own-wage elasticity of education group e, where the wage of an education group is defined as $\frac{\partial Y}{\partial \mathscr{L}_e}$. Therefore, we can decompose the indirect fiscal effect into two separate effects. The first effect, which we label the "experience effect" comes from the fact that an immigrant inflow of experience group a increases the supply of experience group a relative to all other experience groups within education group e. The "education effect" captures that the immigrant inflow also increases the ratio of labor from education group e relative to all other education groups.

Results Following Borjas (2003), we set $\sigma_X = 3.5$ and set $\sigma_E = 1.3$. The indirect fiscal effect associated with a worker in each of the experience groups for both high school dropouts and high school graduates are given in Table 5. The first column gives the indirect fiscal effect associated with high school dropouts and the second column gives the effect associated with high school graduates. Across all experience groups, the average high school dropout is associated with a \$1,445 indirect fiscal benefit and the high school graduate with a \$1,094 indirect fiscal benefit. The average low-skilled immigrant across education groups leads to a fiscal benefit of \$1,304.

To better understand why the indirect fiscal effect here is larger than in the previous sections, we now perform several alternative calculations. First, to understand the role of the "experience effect", we calculate the indirect fiscal benefit when experience groups are perfect substitutes within education, by setting $\frac{1}{\sigma_X} = 0$. This has only a slight effect on the indirect fiscal effect: the average indirect fiscal effect increases from \$1,304 in the baseline case to \$1,326 in the case when experience groups are perfect substitutes within education group. Next, to understand the role of the elasticity of substitution parameter, we calculate the indirect fiscal benefit under the assumption that the elasticity of substitution is equal to 2 by setting $\sigma_E = 2$. This reduces the average fiscal benefit to \$862, similar in magnitude to the effect we found in Section 2. Therefore, despite the key differences between the production function here and that presented in Section 2, both production functions lead to similar estimates of the indirect fiscal effect of low-skilled immigration, once we use comparable parameter estimates.

A.2 Domestic-Born and Foreign-Born Complementarity

Ottaviano and Peri (2012) consider a model in which domestic- and foreign-born workers are imperfect substitutes within education and experience groups. Ultimately the production function takes the form of a four-level nested CES labor aggregate function, with a top nest corresponding to skill groups (high skill and low skill), a second nest corresponding with education groups within these two skill groups (high school graduate and dropout within low-skilled workers, some college and college graduate within high-skilled), a third nest corresponding with 8 experience groups within each education group, and a final nest aggregating domestic- and foreign-born workers.[56]

Specifically, the top nest of the production functions combines a high-skilled labor aggregate $\mathscr{L}_s$ and a low-skilled labor aggregate $\mathscr{L}_u$ using the following production function

$$Y = \left(\theta_s \mathscr{L}_s^{\frac{\sigma-1}{\sigma}} + \theta_u \mathscr{L}_u^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}.$$

$\mathscr{L}_s$ aggregates some college and college graduate labor while $\mathscr{L}_u$ aggregates high school dropout and high school graduate labor. Let e_1, e_2, e_3, and e_4 denote high school dropout, high school graduate, some college and college graduate labor, respectively. Then we can write

$$\mathscr{L}_s = \left(\theta_{e3} \mathscr{L}_{e3}^{\frac{\sigma_S-1}{\sigma_S}} + \theta_{e4} \mathscr{L}_{e4}^{\frac{\sigma_S-1}{\sigma_S}} \right)^{\frac{\sigma_S}{\sigma_S-1}}$$

[56]We focus on "Model B" from Ottaviano and Peri (2012), which the authors show is the most consistent with the data. We use their estimates from column 7 of Table 6.

and

$$\mathscr{L}_u = \left(\theta_{e_1}\mathscr{L}_{e_1}^{\frac{\sigma_U-1}{\sigma_U}} + \theta_{e_2}\mathscr{L}_{e_2}^{\frac{\sigma_U-1}{\sigma_U}}\right)^{\frac{\sigma_U}{\sigma_U-1}}.$$

Each of these education aggregates combine labor from 8 experience groups, indexed by a, as

$$\mathscr{L}_e = \left(\sum_a \theta_{ae}\mathscr{L}_{ae}^{\frac{\sigma_{EXP}-1}{\sigma_{EXP}}}\right)^{\frac{\sigma_{EXP}}{\sigma_{EXP}-1}}.$$

for $e \in \{e_1, e_2, e_3, e_4\}$. Finally, each of the education, experience labor aggregates, $\mathscr{L}_{ae}$ combines nativity groups (domestic-born and foreign-born) labor using

$$\mathscr{L}_{ae} = \left(\theta_{aef}\mathscr{L}_{aef}^{\frac{\sigma_{N,U}-1}{\sigma_{N,U}}} + \theta_{aed}\mathscr{L}_{aed}^{\frac{\sigma_{N,U}-1}{\sigma_{N,U}}}\right)^{\frac{\sigma_{N,U}}{\sigma_{N,U}-1}}$$

and low-skilled labor ($e \in \{e_1, e_2\}$) and

$$\mathscr{L}_{ae} = \left(\theta_{aef}\mathscr{L}_{aef}^{\frac{\sigma_{N,S}-1}{\sigma_{N,S}}} + \theta_{aed}\mathscr{L}_{aed}^{\frac{\sigma_{N,S}-1}{\sigma_{N,S}}}\right)^{\frac{\sigma_{N,S}}{\sigma_{N,S}-1}}$$

for high-skilled labor ($e \in \{e_3, e_4\}$). $\mathscr{L}_{aen}$ gives the labor supply of a given education-experience-nativity group ($n \in \{d, f\}$) and is given by $\mathscr{L}_{aen} = \int_{\mathcal{I}_{aen}} L_i \omega_i di$, and where $\mathcal{I}_{aen}$ is the set of types i within a given education-experience-nativity group.

The indirect fiscal benefit of an immigrant of type i in experience group a' and education group e' is given by

$$d\mathscr{R}_{ind}(a', e', i) = \frac{y_i}{\bar{y}_{a'e'f}} \sum_a \sum_e \sum_n \bar{T}'_{aen} \frac{N_{aen}}{N_{a'e'f}} \bar{y}_{aen} \gamma_{aen,a'e'f}$$

where $\bar{y}_{aen}$ is the average income of workers of experience group a, education group e, and nativity n, $\bar{T}'_{aen}$ is the income-weighted average marginal tax of workers in this group, and $\gamma_{aen,a'e'f} = \frac{\partial w_{aen}}{\partial L_{a'e'f}} \frac{L_{a'e'f}}{w_{aen}}$ is the elasticity of wages of workers of experience group a and education e and nativity n with respect to labor supply of foreign-born workers of experience group a' and education e'. We refrain from further simplifying the formula in this case.

Results We quantify the model using parameters estimates from Ottaviano and Peri (2012). Table 6 gives the indirect fiscal effect associated with an immigrant with average income in each experience group for both high school dropouts and high school graduates. The average high school dropout immigrant leads to an indirect fiscal benefit of \$651 while the average high school graduate immigrant leads to an indirect fiscal benefit of \$830. Taken together, this implies the average low-skilled immigrant leads to an average indirect fiscal effect of \$758.

Experience Group	HS Dropout	HS Graduate
1-5	627	624
6-10	702	696
11-15	583	685
16-20	574	752
21-25	555	765
26-30	637	874
31-35	738	971
36-40	789	1020
Education Average	651	830
Overall Average	758	

Table 6: Indirect Fiscal Effects using model from Ottaviano and Peri (2012). Each entry gives the indirect fiscal effect associated with a worker in each narrow education and experience group. The "Education Average" gives the weighted average indirect fiscal effect within each education group and the "Overall Average" is the weighted average across all groups. We focus on "Model B" from Ottaviano and Peri (2012), which the authors show is the most consistent with the data. We use estimates from column 7 of Table 6, which gives an elasticity of substitution between skill levels of 1.85.

To better understand the implications of the nesting structure on the indirect fiscal effects, we sequentially recalculate the indirect fiscal effects under the assumptions that labor supplies in each of the CES nests are perfectly substitutable. First, we assume domestic- and foreign-born workers within experience-education-skill groups are perfect substitutes. This leads to a fiscal benefit of \$788. Next, we additionally assume workers of difference experience groups within the same education level are perfect substitutes. This implies a fiscal benefit of \$798. Finally, we remove imperfect substitutability between narrow education groups. This model now shares the same structure as the model presented in Section 2, as all workers within the two skill groups are perfectly substitutable. In this case the indirect fiscal benefit is \$797.

A.3 Skills Defined by Position in Wage Distribution

In this Appendix, we calculate the indirect fiscal effects using the model presented in Dustmann et al. (2013), in which a worker's skill is given by her position in the wage distribution. Let total output be given by the CES aggregator

$$Y = \left(\sum_j \theta_j \mathscr{L}_j^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}},$$

where $\mathscr{L}_j$ gives the labor supply of a given skill group, and skill groups are defined by position in the wage distribution (for example percentiles or deciles). Formally, $\mathscr{L}_j$ is given by $\mathscr{L}_j = \int_{\mathcal{I}_j} L_i \omega_i di$, where $\mathcal{I}_j$ is the set of workers types within skill group j. The parameter σ gives the elasticity of substitution between skill groups and each θ_j parameter measures the factor

Dustmann: Decile of Wage Distribution	Indirect Fiscal Effect	% of LS Immigrants
1	970	20
2	1182	22
3	1366	17
4	1625	10
5	1825	9
6	1768	7
7	1460	5
8	643	4
9	-588	3
10	-10924	2
Overall Average	1017	

Table 7: Indirect Fiscal Effects using model from Dustmann, Frattini, and Preston (2013). The second columns gives the indirect fiscal effect for an immigrant in each decile of the wage distribution. The right column gives the percent of total low-skilled immigrants in each wage decile. The bottom row gives the weighted average of the indirect fiscal effects across the wage distribution.

intensity of skill type j. As we show in Appendix B.5, the indirect fiscal benefit associated with an immigrant of type i in skill group j is given by

$$d\mathscr{R}_{ind}^{\text{DFP}}(j,i) = y_i \times |\gamma_{j,own}| \times \left(\bar{T}'_{k\neq j} - \bar{T}_j\right),$$

where y_i is the income level of workers of type i, $\bar{T}'_{k\neq j}$ is the income weighted average marginal tax rate of all other groups $k \neq j$, and $\bar{T}'_j$ is the income weighted average marginal tax rate income group j. Given the CES production function, the own-wage elasticity has the simple expression $\frac{1-\kappa_j}{\sigma}$, where κ_j is the income share of workers in skill group j.

Results We define skill groups using deciles of the wage distribution.[57] The results are not sensitive to the grouping of j. We use our central value for the elasticity of substitution between skill groups and set $\sigma = 2$.[58] Table 7 gives the indirect fiscal effect associated with the average immigrant of each decile of the wage distribution. The indirect fiscal effect is increasing in wage decile up until the 5th decile, reflecting the fact that income is increasing in the wage decile. Starting with the 6th decile, the indirect fiscal benefit decreases as the average marginal tax rates increase relative to the average marginal tax rates of other groups. The weighted average indirect fiscal effect is $1,017, similar to the fiscal effect found in Section 2 when we set $\sigma = 2$.

[57] We calculate wages as total wage and self-employment income divided by weeks worked and average hours worked. In the 2017 ACS, weeks worked are intervalled, we use the midpoint of the interval.

[58] Using data from the UK, Dustmann, Frattini, and Preston (2013) find that an elasticity of substitution between skill group of 0.6 fits their reduced form evidence best. Using this value as the elasticity of substitution yields and an average indirect fiscal benefit of low-skilled immigrants of $2,580. We believe the value of $\sigma = 2$ to be more appropriate for the US context.

A.4 Endogenous Occupational Choice of Residents

In this Appendix, we evaluate the indirect fiscal effects in a model with endogenous occupation choice, as in Peri and Sparber (2009). Perfectly competitive firms produce a numeraire output good using cognitive, communication and manual tasks. Cognitive tasks are supplied by high-skilled individuals. Communication and manual tasks are performed by low-skilled individuals. Denote by M total manual task supply and by C total communication task supply. In the bottom nest of the production function, these tasks combine to form the aggregate of low-skilled labor, $\mathscr{L}_u$, as

$$\mathscr{L}_u = \left(\theta_u M^{\frac{\sigma_u - 1}{\theta_u}} + (1-\theta_u)\, C^{\frac{\sigma_u - 1}{\sigma_u}}\right)^{\frac{\sigma_u}{\sigma_u - 1}} . \tag{15}$$

The parameter σ_u measures the elasticity of substitution between communication and manual tasks and θ_u measures the factor intensity of manual tasks. The task supplies M and C are given by the sum of each task supplied by both low-skilled domestic-born and foreign-born workers. Letting d index low-skilled domestic-born workers, and f index low-skilled foreign-born workers, we can write the total manual task supply as $M = N_f m_f + N_d m_d$ where N_f and N_d are the total number of low-skilled foreign-born and domestic-born workers in the economy and m_f and m_d are the amounts of manual tasks supplied by each low-skilled foreign- and domestic-born worker, respectively. Similarly, we can write the supply of communication tasks as $C = N_f c_f + N_d c_d$ where c_f and c_d are the endogenous amounts of communication tasks supplied by each low-skilled foreign- and domestic-born worker, respectively.

Each high-skilled worker inelastically supplies one unit of the cognitive task; aggregate high-skilled labor $\mathscr{L}_s$ is simply the total cognitive task supplied in the economy. High-skilled labor $\mathscr{L}_s$ and the aggregate of low-skilled labor, $\mathscr{L}_u$, are aggregated according to:

$$Y = A\left(\theta \mathscr{L}_u^{\frac{\sigma-1}{\sigma}} + (1-\theta)\, \mathscr{L}_s^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} , \tag{16}$$

where Y is the produced amount of the numeraire output good. The parameter σ corresponds with the elasticity of substitution between high-skilled labor and the low-skilled aggregate. Total factor productivity is given by A and θ gives the factor intensity of low-skilled labor.

Let w_c, w_m and w_s denote the compensation for one unit of communication, manual and cognitive tasks. As firms are perfectly competitive, these task prices are given by the marginal products of each task. Since high-skilled workers supply exactly one unit of the cognitive task, their income equals the task wage, hence we have $y_s = w_s$. For low-skilled workers, income is given by the sum of the worker's task supplies multiplied by the appropriate task prices. Letting $j \in \{f, d\}$ index low-skilled worker types (foreign-born or domestic-born), we can write the agent's income as $y_j = c_j w_c + m_j w_m$.

The indirect fiscal benefit resulting from an inflow of dN_f workers is given by

$$d\mathscr{R}_{ind}^{\mathrm{PS}} = T'_s N_s \frac{dy_s}{dN_f} dN_f + T'_f N_f \frac{dy_f}{dN_f} dN_f + T'_d N_d \frac{dy_d}{dN_f} dN_f. \quad (17)$$

That is, the total indirect fiscal effect is given by the change in income of each type of worker multiplied by the number of workers of that type and the marginal tax rate. It's important to note that changes in income for low-skilled workers, $\frac{dy_f}{dN_f}$ and $\frac{dy_d}{dN_f}$, arise for two reasons. First, low-skilled immigrant inflows change task prices w_c and w_m, and therefore the incomes of foreign- and domestic-born workers. Second, income will change as a result of changes in task supplies in response to these inflows. For example, if low-skilled domestic-born workers respond to immigrant inflows by increasing the amount of communication task they supply (perhaps by moving into managerial occupations), this will lead to an additional change in their income in response to immigrant inflows. We show in Appendix B.6 how this formula can be written as a function of structural parameters and task supply elasticities.

Quantification We quantify the indirect fiscal effects by utilizing estimates of task intensities from ONET and selected parameter estimates from Peri and Sparber (2009). The procedure we use for estimating income and marginal tax rates are similar to those in other sections. Details can be found in Appendix C.6. Here we focus on the parameter estimates we take from Peri and Sparber (2009).

Peri and Sparber (2009) estimate the elasticity of substitution between manual and communication tasks, σ_u, using state level variation in immigrant inflows. We set $\sigma_u = 1$ and set the elasticity of substitution between low- and high-skilled workers as $\sigma = 1.75$, based on their estimates. Peri and Sparber (2009) also use this variation to estimate the elasticities of task supplies with respect to the immigrant share of low-skilled workers. We directly use these estimates of task supply elasticities. Most notably, they find that domestic-born workers respond to low-skilled immigrant inflows by increasing their communication task supply and that foreign-born workers do not change their task supplies in response to immigrant inflows.

Results First of all, we calculate the indirect fiscal effect which would result if workers did not adjust their occupation. We find this number to be \$857, which is in a similar ballpark as the numbers we found in Section 4. However, once we allow for endogenous occupation choice, low-skilled domestic-born workers respond by switching into higher-paying communication-intensive occupations. This increases their incomes and thus their tax payments. Holding task prices constant, this occupation upgrading leads to an additional fiscal effect of \$967. Finally, these occupation changes lead to additional changes in the equilibrium task prices leading to an additional fiscal effect of \$93.[59] Ultimately, the indirect fiscal effect is equal to $d\mathscr{R}_{ind}^{PS}$ =\$1,918 with endogenous occupation choice.

[59]This term is positive because the increase in supply of communication tasks by low-skilled workers implies an increase in cognitive wages, an increase in manual wages but a decrease in communication wages.

A.5 Decreasing Returns to Scale

Consider a homogeneous production function with two inputs,

$$Y = F\left(\mathscr{L}_u, \mathscr{L}_s\right),$$

where, as before, $\mathscr{L}_u = \int_{\mathcal{I}_u} L_i \omega_i di$ and $\mathscr{L}_s = \int_{\mathcal{I}_s} L_i \omega_i di$. Let λ be the degree of homogeneity: $F\left(t\mathscr{L}_u, t\mathscr{L}_s\right) = t^{\lambda} F\left(\mathscr{L}_u, \mathscr{L}_s\right)$. With decreasing returns to scale ($\lambda < 1$), an immigrant inflow can also lead to changes in firm profits in addition to changes in wages. Therefore, holding labor supply constant, the indirect fiscal effects of immigration with decreasing returns are given by:

$$d\mathscr{R}_{ind}^{\text{DRS}}(i) = h_i \omega_i \left[\tau_p \frac{\partial \pi}{\partial \mathscr{L}_u} + \int_{\mathcal{I}_s} T'\left(y_i, i\right) \frac{\partial w_s}{\partial \mathscr{L}_u} h_i \omega_i m_i di + \int_{\mathcal{I}_u} T'\left(y_i, i\right) \frac{\partial w_u}{\partial \mathscr{L}_u} h_i \omega_i m_i di\right],$$

where π represents total firm profits and τ_p is the tax rate on firm profits.

In the case of constant returns to scale, the indirect fiscal effects arose because of a change in relative incomes of high-skilled and low-skilled workers. With decreasing returns to scale, there is a second effect arising from an increase in firm profits relative to worker income. As we show in Appendix B.7 the indirect fiscal effect of an immigrant of type i with decreasing returns to scale is given by

$$d\mathscr{R}_{ind}^{\text{DRS}}(i) = y_i \left[\underbrace{\left(\bar{T}_s' - \bar{T}_u'\right)\left|\tilde{\gamma}_{u,own}\right|}_{\text{Factor Ratio Effect}} + \underbrace{(1-\lambda)\left(\tau_p - \bar{T}_I'\right)}_{\text{Scale Effect}}\right]. \tag{18}$$

Consider the first term of (18), which we refer to as the "factor ratio effect". The term $\tilde{\gamma}_{u,own}$ gives the own-wage elasticity for low-skilled workers, holding total labor income constant. Specifically, this term is given by $\tilde{\gamma}_{u,own} = \gamma_{u,own} + \kappa_u (1-\lambda)$, where $\kappa_u = \frac{\mathscr{L}_u w_u}{\mathscr{L}_s w_s + \mathscr{L}_u w_u}$ is the labor income share of low-skilled labor.[60] This factor ratio effect gives the indirect fiscal effect as a result of changing the relative wages of high-skilled relative to low-skilled workers.

In addition to changing the factor ratio, an influx of low-skilled labor also increases the scale of production and therefore increases profits at the cost of worker income. We refer to the resulting fiscal effect as the "scale effect", which is the second term in (18). The term $\bar{T}_I'$ gives the income-weighted average marginal tax of all workers. A smaller value of λ implies lower returns to scale and therefore a greater redistribution of surplus from workers to firms. The fiscal effects of the redistribution are scaled by the differences in the average tax rates between firms and workers, $\left(\tau_p - \bar{T}_I'\right)$.

[60]Note that $-\kappa_u (1-\lambda)$ is the effect of immigration on low-skilled income that occurs through the scale effect – if total income changes but the share going to low-skilled workers stays constant. Therefore, we can think of $\tilde{\gamma}_{u,own}$ as as the change in low-skilled income from immigration minus the scale effect. Note that if the production function exhibits constant returns to scale, then this elasticity is independent of scale and we have $\tilde{\gamma}_{u,own} = \gamma_{u,own}$.

Results To calculate the fiscal effects with decreasing returns to scale, we need estimates of the profit tax τ_p, income weighted marginal tax rates, the returns to scale, λ, and $\tilde{\gamma}_{u,own}$, the own-wage elasticity of low-skilled labor, holding labor income constant. For the profit tax, we use the weighted average of the state and federal corporate tax rates and the business income weighted average income tax rate, which is the tax rate that applies for pass-through businesses.[61] This gives us an estimate of $\tau_p = 36.8\%$. We estimate a marginal tax rate for all workers as $\bar{T}'_I = 35.3\%$. Finally, we take our value of $\lambda = .9$ from Burnside (1996), who estimates returns to scale for US industries.[62] Finally, $\tilde{\gamma}_{u,own} = -\frac{1}{\sigma}\kappa_s$, where again σ is the elasticity of substitution between low- and high-skilled labor.[63] Therefore, $\tilde{\gamma}_{u,own}$ is the same as the own-wage elasticity with constant returns to scale, given the same value for σ.

Putting this together, we estimate that if production exhibits decreasing returns to scale, the indirect fiscal effect associated with the average low-skilled immigrant is equal to \$801 given an elasticity of substitution of $\sigma = 2$. Recall that with constant returns to scale and $\sigma = 2$, we calculated an indirect fiscal effect with exogenous labor supply of \$753. The small increase in the fiscal effect with decreasing returns is due to the scale effect: profits increase relative to labor income and profits face a higher marginal tax rate than labor income.[64]

A.6 Further Potential Extensions

Endogenous Education Low-skilled residents may respond to low-skilled immigrant inflows by adjusting their education level (Llull, 2018). Natives further investing in their education in response to immigration would likely increase the indirect fiscal effects of immigration as increased education leads to increased lifetime income and therefore increased tax payments. As shown in Colas, Findeisen, and Sachs (2021), this fiscal externality associated with attending college is quantitatively important.[65]

Monopsonistic Labor Markets Amior and Manning (2020) emphasize that most of the immigration literature rests on the assumption of perfectly competitive labor markets. They argue that this assumption is problematic because markdowns on wages in a setting with monopsony power are likely to be endogenous to immigration since labor supply of immi-

[61] Corporations account for 60% of total net income from business. We calculate τ_p as .6 times federal and average state corporate tax rate plus .4 times the business income weighted average effective tax rate arising from income taxes and transfers using our ACS data. In 2017, the federal corporate tax rate plus the average of the state income tax rates was 38.9%. Source: `https://taxfoundation.org/us-corporate-income-tax-more-competitive/` . We find a business income weighted effective tax rate of 33.9%.

[62] Burnside (1996) estimates a weighted average of industry specific returns to scale of .9.

[63] As we show in Appendix B.7, the own-wage elasticity with decreasing returns to scale is given by $\gamma_{u,own} = (\lambda - 1)\,\kappa_u - \frac{1}{\sigma}\kappa_s$. Therefore, the own-wage elasticity holding labor income constant is simply given by $\tilde{\gamma}_{u,own} = -\frac{1}{\sigma}\kappa_s$.

[64] It's worth noting that corporate tax rates dropped substantially in 2018 to a weighted average of 25.7%. Performing this calculating with 2018 corporate tax rates implies an indirect fiscal effect of \$561.

[65] Colas, Findeisen, and Sachs (2021) estimate average lifetime fiscal externalities of attending college ranging roughly \$60,000 to \$90,000, conditional on parental income.

grants tends to be relatively inelastic.[66] In this case, low-skilled immigration would not only imply redistribution from low- to high-skilled workers but also from workers to firms, similar to the decreasing-returns to scale extension in Appendix A.5. An important difference to Appendix A.5 is that immigrants are not paid their marginal product in such a setting. This implies that the economic pie accruing to residents would increase and thereby reinforce the indirect fiscal benefit.

Search Frictions We have abstracted from search frictions in the labor market. As has been pointed out by Battisti, Felbermayr, Peri, and Poutvaara (2018), immigration can attenuate search frictions on the labor market, which also implies indirect fiscal benefits.

Resident Migration Responses Low-skilled immigrant inflows into a given city can induce migration responses by residents (Borjas, Freeman, and Katz, 1997; Piyapromdee, 2020; Monras, 2020). These resident migration responses, either in the form of outflows of low-skilled or inflows of high-skilled residents, would mitigate the effect of immigration on local wage inequality and therefore reduce the indirect fiscal effect generated locally, but would increase wage inequality and therefore generate indirect fiscal effects in other cities. Concretely, if the economy consists of J cities with different population sizes but that are otherwise identical, the total indirect fiscal effect generated across all cities would be independent of the distribution of the low-skilled immigrants across cities and of any resident migration responses.[67] However, if cities differ in their wage levels, residents' incomes and tax payments will depend on their location and therefore resident migration will imply a fiscal externality. These effects could be jointly analyzed using a spatial equilibrium model with taxes, such as in Colas and Hutchinson (2021).

A.7 Further Issues

Steady State versus Dynamics In all our specifications, we have focused on a steady state interpretation and have abstracted from the fact that it may take some time until the economy reaches the new steady state after the arrival of the immigrants.[68] It would certainly be possible to extend our approach numerically to such more dynamic settings and discuss how the indirect fiscal effects differ in the short run. One can, however, interpret our results with exogenous labor supply as fiscal effects that apply in the short run and the results with endogenous labor supply as the fiscal effects that apply in the long run. As can be see in Table 2, short and long-run effects are rather similar.

[66] For the US, the authors show that the assumption that markdowns are exogenous is rejected by the data.

[67] This is because the indirect fiscal effect is independent of the size of the resident population. See also the discussion in Foonote 20.

[68] See, for example, Card (1990), Cohen-Goldner and Paserman (2011), Llull (2017), Monras (2020), Borjas (2015) and Edo (2017) for reduced-form evidence comparing the short- and long-run wage impacts.

More structural approaches have been taken in the literature more recently, e.g. by Llull (2018) who considers endogenous responses of workers along the occupation and education margin, by Bound, Braga, Golden, and Khanna (2015) who consider major and occupation choice responses of skilled natives, by Monras (2020) who considers a dynamic spatial equilibrium model, and by Colas (2019) who also considers sectoral choices of residents.

Documented versus Undocumented Immigration In our analysis we have not explicitly made the distinction between authorized and undocumented immigrants. This distinction would matter for the calculation of the indirect fiscal effect because undocumented immigrants differ in their eligibility status for welfare programs and their likelihood to pay income or payroll taxes.[69] However, we focus on the indirect fiscal effect, which operates through a low-skilled immigrant's effect on resident wages, independent of the taxes paid and benefits received by the immigrant themselves. As such, an immigrant's documentation status is unlikely to have a first-order effect on their indirect fiscal effect conditional on their income level y_i.[70]

Other Indirect Effects Immigrants may have indirect fiscal effects on top of those described in this paper. We have focused on a single consumption good and therefore abstracted from how immigrants may affect tax revenue by changing relative consumption prices. For example, it has been shown that low-skilled immigration lowers prices for low-skilled services such as gardening or housekeeping (Cortes, 2008). Such effects would only matter if the goods or services whose relative prices increase is taxed at a different rate then the goods for which the relative prices decrease. An effect that probably matters more is the interaction between the prices for these services and resident labor supply. Cortes and Tessada (2011) show that high-skilled female native labor supply increased due low-skilled immigration and, consistently with that, these women have reduced their time spent on household work. Additionally, immigration may increase local housing prices and rents (Saiz, 2003, 2007) and therefore lead to additional fiscal effects arising from property taxes and taxes on rental income.

Local Taxes versus Federal Taxes We have accounted in detail for how taxes paid and transfers received vary with income to obtain reliable estimates for income-weighted averages of marginal tax rates for the different income groups. We have not accounted for the fact that some taxes are raised at the state level and some at the federal level. Similarly, some transfers are paid by the states and some by the federal government. We have therefore taken a national

[69] The National Academy of Sciences (2017) summarize the literature on the fiscal effects of undocumented immigrants as finding that undocumented immigrants tend to have a more positive impact than documented immigrants, largely due to the fact that undocumented immigrants tend to be younger. Undocumented immigrants are also ineligible for medical coverage under the Affordable Care Act and are ineligible for the Earned Income Tax Credit, among other programs.

[70] As undocumented immigrants on average have lower income than authorized immigrants, they will have on average a lower indirect fiscal effect because the indirect fiscal effect is increasing in the immigrant's income.

perspective on public finances. We leave the issue of how the fiscal effect is distributed between different levels of government for future research.

Larger Immigrant Inflows We have focused on small inflows of immigrants and therefore considered first-order approximations throughout, thus allowing for a transparent analytical approach. For larger inflows of immigrants, these first-order approximations would become less appropriate. It would be straightforward to consider larger immigration inflows numerically and thereby go beyond first-order approximations.

B Theoretical Appendix

B.1 Relation between Own-Wage Elasticity and Elasticity of Substitution

To understand the relationship $\gamma_{u,own} = -\frac{\frac{\mathscr{L}_s w_s}{\mathscr{L}_s w_u + \mathscr{L}_s w_s}}{\sigma}$, first recall the definition of the elasticity of substitution

$$\sigma = -\frac{\frac{\partial \mathscr{L}_u}{\partial \mathscr{L}_s} / \frac{\mathscr{L}_u}{\mathscr{L}_s}}{\frac{\partial w_u}{\partial w_s} / \frac{w_u}{w_s}}.$$

Now consider an increase of low skilled labor by 1%. This increases the ratio of low-skilled over high-skilled labor by 1% (since the high skilled labor stays constant). This directly implies that the relative wage ratio $\frac{\partial w_u}{\partial w_s} / \frac{w_u}{w_s}$ decreases by $\frac{1}{\sigma}$.

Next, derive the percentage change of $\frac{w_u}{w_s}$ by using the cross- and own-wage elasticity. The numerator changes by $\gamma_{u,own}$%. The denominator changes by $\gamma_{s,cross}$%. Hence, $\frac{\partial w_u}{\partial w_s} / \frac{w_u}{w_s} = \gamma_{u,own} - \gamma_{s,cross}$. Using Lemma 1, this can be written as: $\gamma_{u,own} + \gamma_{u,own} \frac{w_u \mathscr{L}_u}{w_s \mathscr{L}_s}$.

As a consequence, we have to have

$$-\frac{1}{\sigma} = \gamma_{u,own} + \gamma_{u,own} \frac{w_u \mathscr{L}_u}{w_s \mathscr{L}_s}$$

which yields the result: $\gamma_{u,own} = -\frac{\frac{\mathscr{L}_s w_s}{\mathscr{L}_s w_u + \mathscr{L}_s w_s}}{\sigma}$.

B.2 Baseline Model with Labor Supply

B.2.1 Proof of Proposition 1

Note that tax revenue in this economy provided by residents is given by:

$$\mathscr{R} = \int_{\mathcal{I}_u} T(y_i, i) m_i di + \int_{\mathcal{I}_s} T(y_i, i) m_i di.$$

The indirect fiscal effect associated with an immigrant with productivity ω_j and hours h_j is given by the effect of an immigrant on tax revenue derived from residents

$$d\mathscr{R}^{ex}_{ind}(j) = \frac{d\mathscr{R}}{d\mathscr{L}_u}\omega_j h_j.$$

Taking derivatives yields

$$d\mathscr{R}^{ex}_{ind}(j) = \frac{\partial w_u}{\partial \mathscr{L}_u}\omega_j h_j \int_{\mathcal{I}_u} \frac{\partial T(y_i,i)}{\partial y_i} h_i \omega_i m_i di + \frac{\partial w_s}{\partial \mathscr{L}_u}\omega_j h_j \int_{\mathcal{I}_s} \frac{\partial T(y_i,i)}{\partial y_i} h_i \omega_i m_i di.$$

Next, we can use the definitions of own- and cross-wage elasticities to write

$$d\mathscr{R}^{ex}_{ind}(j) = \gamma_{u,own}\frac{\omega_j h_j}{\mathscr{L}_u} \int_{\mathcal{I}_u} \frac{\partial T(y_i,i)}{\partial y_i} h_i \omega_i w_u m_i di + \gamma_{s,cross}\frac{\omega_j h_j}{\mathscr{L}_u} \int_{\mathcal{I}_s} \frac{\partial T(y_i,i)}{\partial y_i} h_i \omega_i w_s m_i di.$$

Applying the relationship between cross- and own-wage elasticities in Lemma 1 yields

$$d\mathscr{R}^{ex}_{ind}(j) = |\gamma_{u,own}| \left(-\frac{\omega_j h_j w_u}{\mathscr{L}_u w_u} \int_{\mathcal{I}_u} \frac{\partial T(y_i,i)}{\partial y_i} h_i \omega_i w_u m_i di + \frac{w_u \mathscr{L}_u}{w_s \mathscr{L}_s}\frac{\omega_j h_j}{\mathscr{L}_u} \int_{\mathcal{I}_s} \frac{\partial T(y_i,i)}{\partial y_i} h_i \omega_i w_s m_i di \right).$$

Defining income-weighted marginal tax rates as $\bar{T'}_e = \frac{\int_{i\in\mathcal{I}_e} \frac{\partial T(y_i,i)}{\partial y_i} y_i m_i di}{Y_e}$, we can rewrite the above equation as

$$d\mathscr{R}^{ex}_{ind}(j) = |\gamma_{u,own}| \times y_j \times \left(\bar{T'}_s - \bar{T'}_u\right).$$

Finally, using Lemma 2 yields

$$d\mathscr{R}^{ex}_{ind}(j) = \frac{\kappa_s}{\sigma} \times y_j \times \left(\bar{T'}_s - \bar{T'}_u\right).$$

B.2.2 Proof of Lemma 3

Tax revenue is given by

$$\mathscr{R} = \int_{\mathcal{I}_u} \left(T(y_i,i)\nu_i + T(0,i)(1-\nu_i)\right) m_i di + \int_{\mathcal{I}_s} \left(T(y_i,i)\nu_i + T(0,i)(1-\nu_i)\right) m_i di.$$

Denote by $\frac{dw_u}{w_u}$ and $\frac{dw_s}{w_s}$ the equilibrium changes in wages that occur due to the immigrant and the implied endogenous responses of the residents along both the intensive and the extensive margins. Then, it follows from the definitions of the labor supply elasticities that tax revenue changes according to:

$$\begin{aligned} d\mathscr{R}_{ind} = &\int_{\mathcal{I}_u} T'(y_i,i) y_i \frac{dw_u}{w_u}(1+\varepsilon_i)\nu_i m_i di + \int_{\mathcal{I}_s} T'(y_i,i) y_i \frac{dw_s}{w_s}(1+\varepsilon_i)\nu_i m_i di \\ &+ \int_{\mathcal{I}_u} T_{part}(y_i,i) y_i \frac{dw_u}{w_u}\eta_i \nu_i m_i di + \int_{\mathcal{I}_s} T_{part}(y_i,i) y_i \frac{dw_s}{w_s}\eta_i \nu_i m_i di. \end{aligned} \tag{19}$$

B.2.3 Proof of Lemma 4

The set of integral equations is given by

$$\forall i \in \mathcal{I}_u : \frac{dL_i}{L_i} = \xi_i \left(\gamma_{u,own} \frac{L^{Im}}{\mathscr{L}_u} + \gamma_{u,own} \int_{\mathcal{I}_u} \frac{dL_j}{L_j} \frac{L_j \omega_j}{\mathscr{L}_u} dj + \gamma_{u,cross} \int_{\mathcal{I}_s} \frac{dL_j}{L_j} \frac{L_j \omega_j}{\mathscr{L}_s} dj \right)$$

and

$$\forall i \in \mathcal{I}_s : \frac{dL_i}{L_i} = \xi_i \left(\gamma_{s,cross} \frac{L^{Im}}{\mathscr{L}_u} + \gamma_{s,cross} \int_{\mathcal{I}_u} \frac{dL_j}{L_j} \frac{L_j \omega_j}{\mathscr{L}_u} dj + \gamma_{s,own} \int_{\mathcal{I}_s} \frac{dL_j}{L_j} \frac{L_j \omega_j}{\mathscr{L}_s} dj \right).$$

This is a system of integral equations with a simple solution because the kernels of the integral equations are separable. Let's first consider the integral equation for low-skilled workers. Multiplying both sides by $\frac{\omega_i L_i}{\mathscr{L}_u}$ and integrating over $\mathcal{I}_u$ gives

$$\int_{\mathcal{I}_u} \frac{dL_i}{L_i} \frac{\omega_i L_i}{\mathscr{L}_u} di = \int_{\mathcal{I}_u} \xi_i \Bigg(\gamma_{u,own} \frac{L^{Im}}{\mathscr{L}_u} + \gamma_{u,own} \int_{\mathcal{I}_u} \frac{dL_j}{L_j} \frac{L_j \omega_j}{\mathscr{L}_u} dj + \gamma_{u,cross} \int_{\mathcal{I}_s} \frac{dL_j}{L_j} \frac{L_j \omega_j}{\mathscr{L}_s} dj \Bigg) \frac{\omega_i L_i}{\mathscr{L}_u} m_i di$$

which can be written as

$$\frac{d\mathscr{L}_u}{\mathscr{L}_u} = \bar{\xi}^u \gamma_{u,own} \frac{L^{Im}}{\mathscr{L}_u} + \bar{\xi}^u \gamma_{u,own} \frac{d\mathscr{L}_u}{\mathscr{L}_u} + \bar{\xi}^u \gamma_{u,cross} \frac{d\mathscr{L}_s}{\mathscr{L}_s},$$

where $d\mathscr{L}_u = \int_{\mathcal{I}_u} dL_i \omega_i di$ and $\bar{\xi}^u = \frac{\int_{\mathcal{I}_i} \xi_i \omega_i L_i di}{\mathscr{L}_u} = \frac{\int_{\mathcal{I}_u} \xi_i y_i m_i \nu_i di}{Y_u}$ is the income-weighted average of the total hours elasticity of low-skilled labor.

Equivalently, we obtain

$$\frac{d\mathscr{L}_s}{\mathscr{L}_s} = \bar{\xi}^s \gamma_{s,cross} \frac{L^{Im}}{\mathscr{L}_u} + \bar{\xi}^s \gamma_{s,cross} \frac{d\mathscr{L}_u}{\mathscr{L}_u} + \bar{\xi}^s \gamma_{s,own} \frac{d\mathscr{L}_s}{\mathscr{L}_s}.$$

This is just a simple system of two linear equations and it is easy to show that it has the following solution:

$$\frac{d\mathscr{L}_u}{\mathscr{L}_u} = \frac{\bar{\xi}^u \gamma_{u,own}}{1 - \bar{\xi}^u \gamma_{u,own} - \bar{\xi}^s \gamma_{s,own}} \frac{L^{Im}}{\mathscr{L}_u}$$

and

$$\frac{d\mathscr{L}_s}{\mathscr{L}_s} = \frac{\bar{\xi}^s \gamma_{s,cross}}{1 - \bar{\xi}^u \gamma_{u,own} - \bar{\xi}^s \gamma_{s,own}} \frac{L^{Im}}{\mathscr{L}_u}.$$

Next, we obtain the wage changes for $e = s, u$. We can rewrite the definition of the total hours elasticity as

$$\frac{dL_i}{L_i} = \xi_i \frac{dw_e}{w_e}.$$

Again multiplying both sides by $\frac{\omega_i L_i}{\mathscr{L}_e}$ and integrating over $\mathcal{I}_e$ yields

$$\int_{\mathcal{I}_e} \frac{dL_i}{L_i} \frac{\omega_i L_i}{\mathscr{L}_e} di = \frac{dw_e}{w_e} \int_{\mathcal{I}_e} \xi_i \frac{\omega_i L_i}{\mathscr{L}_e} di.$$

Using $d\mathscr{L}_e = \int_{\mathcal{I}_e} dL_i \omega_i di$ and $\bar{\xi}^e = \frac{\int_{\mathcal{I}_i} \xi_i \omega_i L_i di}{\mathscr{L}_e}$ gives us

$$\frac{dw_e}{w_e} = \frac{d\mathscr{L}_e}{\mathscr{L}_e} \frac{1}{\bar{\xi}^e}.$$

Therefore, we have

$$\frac{dw_u}{w_u} = \frac{\gamma_{u,own}}{1 + \bar{\xi}^u |\gamma_{u,own}| + \bar{\xi}^s |\gamma_{s,own}|} \frac{L^{Im}}{\mathscr{L}_u}$$

$$\frac{dw_s}{w_s} = \frac{\gamma_{s,cross}}{1 + \bar{\xi}^u |\gamma_{u,own}| + \bar{\xi}^s |\gamma_{s,own}|} \frac{L^{Im}}{\mathscr{L}_u}.$$

B.2.4 Proof of Proposition 2

Now we have described the equilibrium changes of labor supply. We can now turn to the indirect fiscal effect, which is given by:

$$d\mathscr{R}_{ind} = \int_{\mathcal{I}_u} T'(y_i, i) y_i \frac{dw_u}{w_u} (1 + \varepsilon_i) \nu_i m_i di + \int_{\mathcal{I}_s} T'(y_i, i) y_i \frac{dw_s}{w_s} (1 + \varepsilon_i) \nu_i m_i di$$
$$+ \int_{\mathcal{I}_u} T_{part}(y_i, i) y_i \frac{dw_u}{w_u} \eta_i \nu_i m_i di + \int_{\mathcal{I}_s} T_{part}(y_i, i) y_i \frac{dw_s}{w_s} \eta_i \nu_i m_i di.$$

Now using the equilibrium wage changes:

$$\frac{dw_u}{w_u} = \frac{\gamma_{u,own}}{1 - \bar{\xi}^u \gamma_{u,own} - \bar{\xi}^s \gamma_{s,own}} \frac{L^{Im}}{\mathscr{L}_u}$$

and

$$\frac{dw_s}{w_s} = \frac{\gamma_{s,cross}}{1 - \bar{\xi}^u \gamma_{u,own} - \bar{\xi}^s \gamma_{s,own}} \frac{L^{Im}}{\mathscr{L}_u}$$

as well as

$$\gamma_{s,cross} = |\gamma_{u,own}| \times \frac{w_u \mathscr{L}_u}{w_s \mathscr{L}_s}$$

implies the following:

$$d\mathscr{R}_{ind} = \frac{\frac{L^{Im}}{\mathscr{L}_u} |\gamma_{u,own}| Y_u}{1 - \bar{\xi}^u \gamma_{u,own} - \bar{\xi}^s \gamma_{s,own}} \Bigg(- \frac{\int_{\mathcal{I}_u} T'(y_i, i) y_i (1 + \varepsilon_i) \nu_i m_i di}{Y_u} + \frac{\int_{\mathcal{I}_s} T'(y_i, i) y_i (1 + \varepsilon_i) \nu_i m_i di}{Y_s}$$
$$- \frac{\int_{\mathcal{I}_u} T_{part}(y_i, i) y_i \eta_i \nu_i m_i di}{Y_u} + \frac{\int_{\mathcal{I}_s} T_{part}(y_i, i) y_i \eta_i \nu_i m_i di}{Y_s} \Bigg) \tag{20}$$

and hence

$$d\mathscr{R}_{ind}(i) = \frac{y_i|\gamma_{u,own}|}{1+\bar{\xi}^u|\gamma_{u,own}|+\bar{\xi}^s|\gamma_{s,own}|}\left(\bar{T}'_s - \bar{T}'_u + \overline{\varepsilon_s T'_s} - \overline{\varepsilon_u T'_u} + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}}\right). \quad (21)$$

Finally, using Lemma 2 for both $\gamma_{u,own}$ and $\gamma_{s,own}$ yields

$$d\mathscr{R}_{ind}(i) = \frac{y_i\frac{\kappa_s}{\sigma}}{1+\bar{\xi}^u\frac{\kappa_s}{\sigma}+\bar{\xi}^s\frac{\kappa_u}{\sigma}}\left(\bar{T}'_s - \bar{T}'_u + \overline{\varepsilon_s T'_s} - \overline{\varepsilon_u T'_u} + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}}\right). \quad (22)$$

B.3 Theory: Welfare and Distributional Effects

Characterizing the welfare effects of immigration is difficult, as low-skilled immigration leads to winners and losers. The welfare effects therefore depend crucially on how the social planner weighs the utility of different income groups, foreign-born versus domestic-born workers, and, perhaps more difficultly, on potential immigrants versus individuals in the United States. The welfare gains of low-skilled immigrants are likely to be very large, given that low-skilled immigrants experience massive income gains after moving to the United States (Hendricks and Schoellman, 2018). In what follows, the welfare calculation do not account for the welfare gains of the immigrants themselves.

Concretely, let $g(i)$ denote the welfare weight of individual i, such that $g(i)$ gives the increase in social welfare – measured in units of public funds – associated with a one unit increase in income for individual i. These weights are normalized such that on average they are equal to one and one is the weight on government revenue (Saez and Stantcheva, 2016). The welfare surplus associated with one low-skilled immigrant is given by the following Proposition.

Proposition 3. *The weighted surplus accruing to residents for one low-skilled immigrant is given by:*

$$Surplus(i) = d\mathscr{R}_{dir}(i) + \text{FiscExternalities}(i) + \text{Distributional}(i) + \text{TaxMitigation}(i),$$

where

$$\text{FiscExternalities}(i) = \frac{y_i \times |\gamma_{u,own}|}{1+\bar{\xi}^u|\gamma_{u,own}|+\bar{\xi}^s|\gamma_{s,own}|}\left(\overline{\varepsilon_s T'_s} - \overline{\varepsilon_u T'_u} + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}}\right), \quad (23)$$

$$\text{Distributional}(i) = \frac{y_i \times |\gamma_{u,own}|}{1+\bar{\xi}^u|\gamma_{u,own}|+\bar{\xi}^s|\gamma_{s,own}|} \times \left(\overline{g_s} - \overline{g_u}\right),$$

$$\text{TaxMitigation}(i) = \frac{y_i \times |\gamma_{u,own}|}{1+\bar{\xi}^u|\gamma_{u,own}|+\bar{\xi}^s|\gamma_{s,own}|} \times \left(\left(\bar{T}'_s - \overline{g_s\,(T'_s)}\right) - \left(\bar{T}'_u - \overline{g_u\,(T'_u)}\right)\right),$$

and where $d\mathscr{R}_{dir}(i)$ is the direct fiscal effect, $\overline{g_e}$ is the income-weighted average of the welfare weights conditional on skill e and $\overline{g_e\left(T_e'\right)}$ is the income-weighted average of the product of the welfare weights and marginal tax rates conditional on skill e.

Proof. See Appendix B.3.1. □

The fiscal externality (23) is the additional tax revenue generated by resident labor supply responses. Note that the fiscal externality term would be zero if (i) labor supply of residents were exogenous or (ii) the tax system were proportional and labor supply elasticities were common between low- and high-skilled workers. The endogeneity of labor supply combined with the progressivity of the tax system jointly imply a welfare surplus: while the labor supply responses do not directly affect resident welfare due to the envelope theorem, they affect resident welfare through their implied indirect fiscal effects (Hendren, 2015).

The term Distributional(i) captures the mechanical distributional effects between high-skilled and low-skilled residents resulting from the change in relative wages. These distributional effects are partially mitigated by the tax system, as captured by the term TaxMitigation(i). In particular, the term $\left(\bar{T}_e' - \overline{g_e\left(T_e'\right)}\right)$ captures that an increase (decrease) in wages for high-skilled (low-skilled) is partially offset by the tax code. We now discuss two special cases for the welfare weights and thereby relate modern approaches in public economics to the approaches in the immigration literature.

Kaldor-Hicks Immigration Surplus. The "immigration surplus", an application of the Kaldor-Hicks compensation test (Kaldor, 1939; Hicks, 1939, 1940), is a leading approach to study welfare in the immigration literature (see e.g. Borjas (2014)). The immigration surplus measures whether the residents hurt by immigration could hypothetically be compensated by those who benefit and is given by the sum of government revenue and the monetized gains and losses of all the residents. Note that the immigration surplus is simply a special case of the welfare effect in Proposition 3 with $g(i) = 1$ for all i. In this case, the welfare effect is simply given by the direct fiscal effects plus the fiscal externality. Both the distributional effects and tax mitigation effects are equal to zero because each dollar would be valued equally regardless of whether it accrues to high-skilled residents or low-skilled residents or to the government. The fact that this surplus is non-zero beyond the direct fiscal effect is novel.

Inverse-Optimum Weights. In our quantification of these welfare effects in Appendix D.1, we calculate the welfare effects of immigration using the so-called inverse optimum weights as in Hendren (2020). These are the welfare weights for which the current U.S. tax-transfers system is optimal according to optimality conditions from the optimal income tax literature. Hendren (2020) shows that by using these weights, one can extend the Kaldor-Hicks surplus to account for distortionary costs of compensation.[71] If the welfare effect is positive with such weights, then a Pareto improvement can be achieved because the losers can be compensated.[72]

For the U.S., Hendren (2020) calibrates a weight function which is generally decreasing in income and thus gives higher weight to low-skilled than high-skilled individuals. For such weights, low-skilled immigration will lead to negative distributional effects because the income losses of low-skilled receive a higher weight than the income gains of high-skilled.

We also consider an extension, in which the utility of previous immigrants are not weighted in welfare calculations.[73] As will become clear in the quantification of these welfare effects in Appendix D.1, whether previous immigrants are taken into account or not in the welfare analysis plays an important role for the welfare effects of further immigration.

B.3.1 Kaldor-Hicks Surplus

To obtain the Kaldor-Hicks surplus, one has to add up the monetized gains and losses of all citizens and the fiscal effects. Denote the direct fiscal effect by $d\mathscr{R}_{dir}$. The indirect fiscal effect is given by (see Proposition 2):

$$d\mathscr{R}_{ind}(i) = \frac{y_i|\gamma_{u,own}|}{1+\bar{\xi}^u|\gamma_{u,own}|+\bar{\xi}^s|\gamma_{s,own}|}\left(\bar{T}'_s - \bar{T}'_u + \overline{\varepsilon_s T'_s} - \overline{\varepsilon_u T'_u} + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}}\right).$$

The monetized utility effect of resident individuals is simply given by the change in income that arises due to the change in wages. The changes in income due to changes in labor supply do not matter for utility due to the envelope theorem. Hence, an individual of type i with $e_i = e$ has a utility change of

$$(1 - T'(y_i, i))y_i \frac{dw_e}{w_e},$$

where $\frac{dw_e}{w_e}$ is given in Lemma 4. Integrating over all residents and adding the monetized gains and losses to the tax revenue effects gives the immigration surplus:

$$Surplus_{Kaldor-Hicks}(i) = d\mathscr{R}_{dir} + \frac{y_i|\gamma_{u,own}|}{1+\bar{\xi}^u|\gamma_{u,own}|+\bar{\xi}^s|\gamma_{s,own}|}\left(\overline{\varepsilon_s T'_s} - \overline{\varepsilon_u T'_u} + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}}\right).$$

[71] Going one step further, Schulz et al. (2022) generalize the compensation principle to a setting where distortive taxes also imply general equilibrium effects on wages, which creates a complicated fixed-point problem. The authors analytically describe the tax reform that achieves compensation in such a setting.

[72] One underlying assumption that this can be achieved with a standard tax schedule, is that for a given income level, all individuals are affected in the same way. This assumption is apparently violated in our model where at a certain income level, both low and high-skilled individuals are present and hence compensating policies would need to condition on skill.

[73] This could e.g. be motivated by Alesina, Miano, and Stantcheva (2018, Figure 13), who find that less than 40% of Americans agree to the following statement "The government should care equally about everyone living in the country whether born there or not".

The indirect fiscal effects that were not caused by fiscal externalities and the monetized gains and losses from residents add up to zero. What the government gains is what resident taxpayers in aggregate lose.

Note that this only holds because all gains and losses are given equal weight. If we follow Hendren (2020) and weight the monetized utility gains and losses by the inverse optimum weights $g(y)$, then we obtain:

$$Surplus_{weighted}(i) = d\mathscr{R}_{dir} + \frac{y_i|\gamma_{u,own}|}{1+\bar{\xi}^u|\gamma_{u,own}|+\bar{\xi}^s|\gamma_{s,own}|} \times \left(\overline{g_s\left(1-T_s'\right)} - \overline{g_u\left(1-T_u'\right)} + \bar{T}_s' - \bar{T}_u' + \overline{\varepsilon_s T'_s} - \overline{\varepsilon_u T'_u} + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}}\right).$$

We provide a quantitative evaluation for the inverse-optimum approach in Appendix D.1.

B.4 Indirect Fiscal Effect with Four Education Groups and Imperfectly Substitutable Experience Groups

We consider an immigrant i with experience a and education e. The indirect fiscal effect is given by:

$$d\mathscr{R}_{ind}\left(a,e,i\right) = h_i\omega_i\left[\sum_{e'\neq e}\sum_{a'}\left(\bar{T}'_{a'e'}\mathscr{L}_{a'e'}\frac{\partial w_{a'e'}}{\partial\mathscr{L}_{ae}}\right) + \sum_{a'\neq a}\left(\bar{T}'_{a'e}\mathscr{L}_{a'e}\frac{\partial w_{a'e}}{\partial\mathscr{L}_{ae}}\right) + \left(\bar{T}'_{ae}\mathscr{L}_{ae}\frac{\partial w_{ae}}{\partial\mathscr{L}_{ae}}\right)\right],$$

The first term captures the wage changes of individuals with different education levels, whose wage unambiguously increases. The second term captures the wage change of those with the same education but different experience, whose wage may increase or decrease. The third term captures the wage change of those with the same education and experience, whose wage unambiguously decreases.

Now we rewrite it in terms of elasticities

$$d\mathscr{R}_{ind}\left(a,e,i\right) = h_i\omega_i\left[\sum_{e'\neq e}\sum_{a'}\left(\bar{T}'_{a'e'}\frac{\mathscr{L}_{a'e'}w_{a'e'}}{\mathscr{L}_{ae}}\gamma_{a'e',ae}\right) + \sum_{a'\neq a}\left(\bar{T}'_{a'e}\frac{\mathscr{L}_{a'e}w_{a'e}}{\mathscr{L}_{ae}}\gamma_{a'e,ae}\right) + \left(\bar{T}'_{ae}w_{ae}\gamma_{ae,ae}\right)\right].$$

Let $Y_{ae} = w_{ae}\mathscr{L}_{ae}$ give aggregate income for a given education-experience group and let $Y_e = \sum_a Y_{ae}$ give aggregate income of a given education group. Further, let $\kappa_e = \frac{Y_e}{Y}$ give the income share of education group e and let $\kappa_{a,e} = \frac{Y_{ae}}{Y_e}$ give the income share of experience group a within education group e. Some standard algebra shows, that the wage elasticities read as follows for this nested CES production function:

$$\gamma_{e,e} = -\frac{1-\kappa_e}{\sigma_E}$$

and

$$\gamma_{e',e} = \frac{\kappa_e}{\sigma_E}.$$

Further, for $e' \neq e$, we have:

$$\gamma_{a'e',ae} = \frac{\kappa_e}{\sigma_E}\kappa_{a,e} = \gamma_{e',e}\kappa_{a,e}.$$

For $e' = e$, this becomes:

$$\gamma_{a'e,ae} = -\frac{1-\kappa_e}{\sigma_E}\kappa_{a,e} + \underbrace{\frac{\kappa_{a,e}}{\sigma_X}}_{:=\tilde{\gamma}_{a'e,ae}} = \gamma_{e,e}\kappa_{a,e} + \tilde{\gamma}_{a'e,ae}.$$

Finally, for $e' = e$ and $a' = a$, this becomes

$$\gamma_{ae,ae} = -\frac{1-\kappa_e}{\sigma_E}\kappa_{a,e} \underbrace{-\frac{1-\kappa_{a,e}}{\sigma_X}}_{:=\tilde{\gamma}_{ae,ae}} = \gamma_{e,e}\kappa_{a,e} + \tilde{\gamma}_{ae,ae}.$$

Plugging this into the indirect fiscal effect formulas gives:

$$\begin{aligned} d\mathscr{R}_{ind}^{\text{Borjas}}(a,e,i) =& h_i\omega_i \Bigg[\frac{\kappa_{a,e}}{\mathscr{L}_{ae}\sigma_E} \Bigg(\kappa_e \sum_{e'\neq e}\sum_{a'} \left(\bar{T}'_{a'e'}\mathscr{L}_{a'e'}w_{a'e'}\right) \\ &- (1-\kappa_e)\Bigg(\sum_{a'} \bar{T}'_{a'e}\mathscr{L}_{a'e}w_{a'e}\Bigg)\Bigg) \\ &+ \frac{1}{\mathscr{L}_{ae}\sigma_X}\Bigg(\kappa_{a,e}\sum_{a'\neq a}\left(\bar{T}'_{a'e}\mathscr{L}_{a'e}w_{a'e}\right) - (1-\kappa_{a,e})\left(\bar{T}'_{ae}\mathscr{L}_{ae}w_{ae}\right)\Bigg)\Bigg]. \end{aligned}$$

This can be rewritten as

$$\begin{aligned} d\mathscr{R}_{ind}^{\text{Borjas}}(a,e,i) =& \underbrace{h_i\omega_i w_{ae}}_{y_i} \Bigg[\frac{\kappa_{a,e}}{Y_{ae}\sigma_E}\Bigg(\kappa_e \sum_{e'\neq e}(Y'_e) \times \bar{T}'_{e'\neq e} - (1-\kappa_e)\,Y_e\bar{T}'_e\Bigg) \\ &+ \frac{1}{Y_{ae}\sigma_X}\Bigg(\kappa_{a,e}\sum_{a'\neq a}(Y_{a'e}) \times \bar{T}'_{a'\neq a,e}. - (1-\kappa_{a,e})Y_{ae}\bar{T}'_{ae}\Bigg)\Bigg]. \end{aligned}$$

Now use the definition of the income shares to write this as:

$$\begin{aligned} d\mathscr{R}_{ind}^{\text{Borjas}}(a,e,i) =& y_i \Bigg[\frac{\kappa_{a,e}(1-\kappa_e)\,Y_e}{Y_{ae}\sigma_E}\Bigg(\bar{T}'_{e'\neq e} - \bar{T}'_e\Bigg) \\ &+ \frac{(1-\kappa_{a,e})\,Y_{ae}}{Y_{ae}\sigma_X}\left(\,\bar{T}'_{a'\neq a,e} - \bar{T}'_{ae}\right)\Bigg]. \end{aligned}$$

and hence

$$d\mathscr{R}_{ind}^{\text{Borjas}}(a,e,i) = y_i\left[\left(\bar{T}'_{a'\neq a,e} - \bar{T}'_{ae}\right)|\tilde{\gamma}_{ae,own}| + \left(\bar{T}'_{e'\neq e} - \bar{T}'_e\right)|\gamma_{e,own}|\right].$$

B.5 Indirect Fiscal Effects in Dustmann, Frattini, and Preston (2013)

The indirect fiscal effect for an immigrant of skill group j is given by

$$d\mathscr{R}_{ind}(j,i) = h_i\omega_i \sum_k \int_{\mathcal{I}_k} T'(y_i(\omega')) L_i \frac{\partial w_j}{\partial \mathscr{L}_i} di = h_i\omega_i \sum_k \bar{T}'_k \mathscr{L}_j \frac{\partial w_k}{\partial \mathscr{L}_j}.$$

Since the production function is CRS, we know by Euler's equation that

$$\mathscr{L}_j \frac{\partial w_j}{\partial L_j} = -\sum_{k \neq j} \mathscr{L}_k \frac{\partial w_k}{\partial \mathscr{L}_j}.$$

Plugging this into the indirect fiscal effect and rearranging yields:

$$d\mathscr{R}_{ind}(j,i) = h_i\omega_i \sum_{k \neq j} \left(\bar{T}'_k - \bar{T}'_j\right) \mathscr{L}_k \frac{\partial w_k}{\partial \mathscr{L}_j}$$

which can be rewritten in terms of elasticities as

$$d\mathscr{R}_{ind}(j,i) = h_i\omega_i \sum_{k \neq j} \left(\bar{T}'_k - \bar{T}'_j\right) \frac{w_k \mathscr{L}_k}{\mathscr{L}_j} \gamma_{k,j}$$

where $\gamma_{k,j} = \frac{\partial w_k}{\partial \mathscr{L}_j} \frac{\mathscr{L}_j}{w_k}$ gives the cross-wage elasticity of k's wages with respect to $\mathscr{L}_j$.

Given the CES production function, these cross-wage elasticities are all given by $\gamma_{k,j} = \frac{1}{\sigma}\kappa_j$, where $\kappa_j = \frac{w_j L_j}{Y}$. Plugging in and rearranging yields

$$d\mathscr{R}_{ind}(j,i) = \frac{y_i}{\sigma} \left[\left(\sum_{k \neq j} \left(\bar{T}'_k \kappa_k\right) \right) - \bar{T}'_j \sum_{k \neq j} \kappa_k \right].$$

Dividing and multiplying by $\sum_{k \neq j} \kappa_k = 1 - \kappa_j$ yields

$$d\mathscr{R}_{ind}(j,i) = \frac{y_i}{\sigma} \left[\bar{T}'_{k \neq j} - \bar{T}'_j\right] (1 - \kappa_j)$$

where $\bar{T}'_{k \neq j} = \frac{\sum_{k \neq j} T'(y_k)\omega_k}{\sum_{k \neq j} \omega_k}$ is the income weighted tax of all other group $k \neq j$.

$$d\mathscr{R}^{DFP}_{ind}(j,i) = y_i \times \left(\bar{T}'_{k \neq j} - \bar{T}_j\right) \times |\gamma_{j,own}| = y_i \times \left(\bar{T}'_{k \neq j} - \bar{T}_j\right) \frac{1 - \kappa_j}{\sigma},$$

where we used $\frac{1-\kappa_j}{\sigma} = |\gamma_{j,own}|$.

B.6 Indirect Fiscal Effect in Peri and Sparber (2009)

The starting point is equation (17)

$$d\mathscr{R}^{PS}_{ind} = T'_s N_s \frac{dy_s}{dN_f} dN_f + T'_f N_f \frac{dy_f}{dN_f} dN_f + T'_d N_d \frac{dy_d}{dN_f} dN_f.$$

We now show how this can be decomposed into three terms:

$$d\mathscr{R}_{ind} = \underbrace{d\mathscr{R}_{ind}^{SR}}_{\text{short run effect}} + \underbrace{d\mathscr{R}_{ind}^{SORT}}_{\text{sorting effect}} + \underbrace{d\mathscr{R}_{ind}^{PR}.}_{\text{secondary price effect}} \tag{24}$$

The first term captures the indirect fiscal effect that would arise if task choices were exogenous. The second term gives the change in tax revenue that is due to the change in task supplies – holding task wages constant. The third term is similar to the first term again in that it captures changes in wages for given task supplies. It captures the changes in tax payment due to wage changes that are due to the changes in task supply of low-skilled domestic-born workers and low-skilled foreign-born workers.

To arrive at this decomposition, first note that the effect of immigration N_f on task supplies can be written (note that cognitive task supply is by assumption exogenous):

$$\frac{dM}{dN_f} = m_f + N_d \frac{dm_d}{dN_f} + N_f \frac{dm_f}{dN_f} = m_f + \left(\frac{dM}{dN_f}\right)_{ind}$$

and

$$\frac{dC}{dN_f} = c_f + N_d \frac{dc_d}{dN_f} + N_f \frac{dc_f}{dN_f} = c_f + \left(\frac{dC}{dN_f}\right)_{ind},$$

where $(\cdot)_{ind}$ captures the indirect effect through changes in task supply. These indirect effect are given by

$$\left(\frac{dC}{dN_f}\right)_{ind} = c_d \eta_d^c (1-f)^2 + c_f \eta_c^f f^2$$

and

$$\left(\frac{dM}{dN_f}\right)_{ind} = m_d \eta_d^m (1-f)^2 + m_f \eta_f^m f^2$$

where

$$\eta_j^c = \frac{dc^j}{df}\frac{1}{c^j} \text{ and } \eta_j^m = \frac{dm^j}{df}\frac{1}{m^j}\ \forall\, j = f, d \text{ and } f = \frac{N_f}{N_f + N_d}.$$

Note that η_j and η_j^m are general equilibrium elasticities that captures all adjustments and higher order wage effects. The reason why we express – in contrast to our analysis in the main model – the formula in terms of such general equilibrium elasticities is that Peri and Sparber (2009) provide estimates for these general equilibrium elasticities.

As a next step, note that the wage changes of high-skilled, foreign and domestic low-skilled workers can be written as (recall that for high skilled we have $y_s = w_s$ – wage equals income since the high-skilled exogenously supply one unit of cognitive taks):

$$\frac{dy_s}{dN_f} = \frac{\partial y_s}{\partial M}\frac{dM}{dN_f} + \frac{\partial y_s}{\partial C}\frac{dC}{dN_f}$$

$$= \underbrace{\frac{\partial y_s}{\partial M} m_f + \frac{\partial y_s}{\partial C} c_f}_{\text{direct effect}} + \underbrace{\frac{\partial y_s}{\partial M}\left(\frac{dM}{dN_f}\right)_{ind} + \frac{\partial y_s}{\partial C}\left(\frac{dC}{dN_f}\right)_{ind}}_{\text{indirect price effect}},$$

for high skilled residents,

$$\frac{dy_f}{dN_f} = \frac{dw_m}{dN_f} m_f + \frac{dw_c}{dN_f} c_f + \underbrace{w_m \frac{dm_f}{dN_f} + w_c \frac{dc_f}{dN_f}}_{\text{sorting effect}},$$

for low-skilled foreigners and

$$\frac{dy_d}{dN_f} = \frac{dw_m}{dN_f} m_d + \frac{dw_c}{dN_f} c_d + \underbrace{w_m \frac{dm_d}{dN_f} + w_c \frac{dc_d}{dN_f}}_{\text{sorting effect}},$$

for low-skilled domestic-born workers. For the latter two, the changes in wages of the manual and communication tasks can be written as:

$$\frac{dw_m}{dN_f} = \underbrace{\frac{\partial w_m}{\partial M} m_f + \frac{\partial w_m}{\partial C} c_f}_{\text{direct effect}} + \underbrace{\frac{\partial w_m}{\partial M} \left(\frac{dM}{dN_f} \right)_{ind} + \frac{\partial w_m}{\partial C} \left(\frac{dC}{dN_f} \right)_{ind}}_{\text{indirect price effect}},$$

and

$$\frac{dw_c}{dN_f} = \underbrace{\frac{\partial w_c}{\partial M} m_f + \frac{\partial w_c}{\partial C} c_f}_{\text{direct effect}} + \underbrace{\frac{\partial w_c}{\partial M} \left(\frac{dM}{dN_f} \right)_{ind} + \frac{\partial w_c}{\partial C} \left(\frac{dC}{dN_f} \right)_{ind}}_{\text{indirect price effect}}.$$

Rearranging terms, we can now obtain (24). We describe the three terms one after another. All the terms are expressed in terms of empirical objects. For the quantification, see Appendix C.6.

Short Run Effect: Collecting the terms that do not involve endogenous task responses yields:

$$d\mathscr{R}_{ind}^{SR} = T_s' N_s \frac{dy_s}{dN_f}|_{dc_j = dm_j = 0} dN_f +$$
$$T_f' N_f \frac{dy_f}{dN_f}|_{dc_j = dm_j = 0} dN_f + T_d' N_d \frac{dy_d}{dN_f}|_{dc_j = dm_j = 0} dN_f,$$

where

$$\frac{dy_s}{dN_f}|_{dc_j = dm_j = 0} = \frac{\partial y_s}{\partial M} m_f + \frac{\partial y_s}{\partial C} c_f$$

$$\frac{dy_f}{dN_f}|_{dc_j = dm_j = 0} = m_f \left(\frac{\partial w_m}{\partial M} m_f + \frac{\partial w_m}{\partial C} c_f \right) + c_f \left(\frac{\partial w_c}{\partial M} m_f + \frac{\partial w_c}{\partial C} c_f \right),$$

and

$$\frac{dy_d}{dN_f}|_{dc_j = dm_j = 0} = m_d \left(\frac{\partial w_m}{\partial M} m_f + \frac{\partial w_m}{\partial C} c_f \right) + c_d \left(\frac{\partial w_c}{\partial M} m_f + \frac{\partial w_c}{\partial C} c_f \right)$$

give the income elasticities of the three worker groups, holding all task supplies of a given worker constant.

Holding task supplies constant, the production function exhibits constant returns to scale in labor from the three worker types. Therefore, using Euler's theorem, we know that

$$\frac{dy_d}{dN_f}|_{dc_j=dm_j=0} + \frac{dy_s}{dN_f}|_{dc_j=dm_j=0} = -\frac{dy_f}{dN_f}|_{dc_j=dm_j=0}.$$

Plugging this in and writing in terms of elasticities yields:

$$\begin{aligned}\mathscr{R}^{SR}_{ind} =& \frac{N_d}{N_f}\left(T'_d - T'_f\right) y_d \times \gamma_{y_d,M}\Big|_{dc_j=dm_j=0} m_f dN_f \\ &+ \frac{N_d}{N_f}\left(T'_d - T'_f\right) y_d \times \gamma_{y_d,C}\Big|_{dc_j=dm_j=0} c_f dN_f \\ &+ \frac{N_s}{N_f}\left(T'_s - T'_f\right) y_s \times \gamma_{y_s,M}\Big|_{dc_j=dm_j=0} m_f dN_f \\ &+ \frac{N_s}{N_f}\left(T'_s - T'_f\right) y_s \times \gamma_{y_s,C}\Big|_{dc_j=dm_j=0} c_f dN_f.\end{aligned}$$

where $\gamma_{y_d,M}\Big|_{dc_j=dm_j=0}$, $\gamma_{y_d,C}\Big|_{dc_j=dm_j=0}$, $\gamma_{y_s,M}\Big|_{dc_j=dm_j=0}$, and $\gamma_{y_s,C}\Big|_{dc_j=dm_j=0}$ are 'short run' elasticities that capture how the incomes of low- and high-skilled residents change in response to changes in task supplies under the assumption that low-skilled foreign-born and domestic-born residents do not react. $\gamma_{y_d,M}\Big|_{dc_j=dm_j=0}$ and $\gamma_{y_d,C}\Big|_{dc_j=dm_j=0}$ can be written in terms of resident task elasticities as

$$\gamma_{y_d,C}\Big|_{dc_j=dm_j=0} = \gamma_{w_c,C}\frac{w_c c_d}{y_d} + \gamma_{w_m,C}\frac{w_m m_d}{y_d}$$

and

$$\gamma_{y_d,M}\Big|_{dc_j=dm_j=0} = \gamma_{w_c,M}\frac{w_c c_d}{y_d} + \gamma_{w_m,M}\frac{w_m m_d}{y_d}.$$

Finally, the task price elasticities can be solved for via CES algebra as

$$\gamma_{y_s,M}\Big|_{dc_j=dm_j=0} = \gamma_{w_s,M} = \frac{\kappa_m}{\sigma},$$

$$\gamma_{y_s,C}\Big|_{dc_j=dm_j=0} = \gamma_{w_s,C} = \frac{\kappa_c}{\sigma},$$

$$\gamma_{w_c,C} = \left(\frac{1}{\sigma}\right)\kappa_c + \left(\frac{1}{\sigma_u} - \frac{1}{\sigma}\right)\kappa^u_c - \frac{1}{\sigma_u},$$

$$\gamma_{w_m,M} = \left(\frac{1}{\sigma}\right)\kappa_m + \left(\frac{1}{\sigma_u} - \frac{1}{\sigma}\right)\kappa^u_m - \frac{1}{\sigma_u},$$

$$\gamma_{w_c,M} = \left(\frac{1}{\sigma}\right)\kappa_m + \left(\frac{1}{\sigma_u} - \frac{1}{\sigma}\right)\kappa^u_m,$$

and

$$\gamma_{w_m,C} = \left(\frac{1}{\sigma}\right)\kappa_c + \left(\frac{1}{\sigma_u} - \frac{1}{\sigma}\right)\kappa^u_c,$$

where κ_j for $j \in \{c, m\}$ is the fraction of total income paid to factor j, and κ_j^u is the fraction of total low-skilled income paid to factor j.

Sorting Effect: The fiscal effect of sorting is given by

$$\underbrace{T_f' N_f \left(w_m \frac{dm_f}{dN_f} + w_c \frac{dc_f}{dN_f} \right) dN_f}_{\text{Foreign-Born Sorting Effect}} + \underbrace{T_d' N_d \left(w_m \frac{dm_d}{dN_f} + w_c \frac{dc_d}{dN_f} \right) dN_f}_{\text{Domestic-Born Sorting Effect}}.$$

The terms in brackets multiplied by dN_f give the change in income per foreign-born and domestic-born worker. Multiplying this with their amount and the marginal tax rate gives the implied tax effects.

We can rewrite this formula in terms of task supply elasticities η_j^c and η_j^m, for $j = f, d$ as

$$\underbrace{T_f' N_f \left(w_m m_f \eta_f^m \frac{df}{dN_f} + w_c c_f \eta_f^c \frac{df}{dN_f} \right) dN_f}_{\text{Foreign-Born Sorting Effect}} + \underbrace{T_d' N_d \left(w_m m_d \eta_d^m \frac{df}{dN_f} + w_c c_d \eta_d^c \frac{df}{dN_f} \right) dN_f}_{\text{Domestic-Born Sorting Effect}}.$$

Using $\frac{df}{dN_f} = \frac{N_d}{\left(N_d + N_f\right)^2}$, we can rewrite this term again solely in terms of shares and independent of population size:

$$d\mathscr{R}_{ind}^{SORT} = \underbrace{T_f' f(1-f) \left(w_m m_f \eta_f^m + w_c c_f \eta_f^c \right) dN_f}_{\text{Foreign-Born Sorting Effect}} + \underbrace{T_d' (1-f)^2 \left(w_m m_d \eta_d^m + w_c c_d \eta_d^c \right) dN_f}_{\text{Domestic-Born Sorting Effect}}.$$

Secondary Price Effect: Collecting the remaining terms yields the indirect price effect:

$$\begin{aligned}
&d\mathscr{R}_{ind}^{PR} = \\
&T_s' N_s \left[\frac{\partial y_s}{\partial M} \left(\frac{dM}{dN_f} \right)_{ind} + \frac{\partial y_s}{\partial C} \left(\frac{dC}{dN_f} \right)_{ind} \right] + \\
&T_f' N_f \left[m_f \left(\frac{\partial w_m}{\partial M} \left(\frac{dM}{dN_f} \right)_{ind} + \frac{\partial w_m}{\partial C} \left(\frac{dC}{dN_f} \right)_{ind} \right) + c_f \left(\frac{\partial w_c}{\partial M} \left(\frac{dM}{dN_f} \right)_{ind} + \frac{\partial w_c}{\partial C} \left(\frac{dC}{dN_f} \right)_{ind} \right) \right] + \\
&T_d' N_d \left[m_d \left(\frac{\partial w_m}{\partial M} \left(\frac{dM}{dN_f} \right)_{ind} + \frac{\partial w_m}{\partial C} \left(\frac{dC}{dN_f} \right)_{ind} \right) + c_d \left(\frac{\partial w_c}{\partial M} \left(\frac{dM}{dN_f} \right)_{ind} + \frac{\partial w_c}{\partial C} \left(\frac{dC}{dN_f} \right)_{ind} \right) \right].
\end{aligned} \tag{25}$$

We can rearrange this to yield

$$\begin{aligned}
&d\mathscr{R}_{ind}^{PR} = \\
&\left(\frac{dM}{dN_f} \right)_{ind} \left[T_s' N_s \frac{\partial y_s}{\partial M} + T_f' N_f \frac{\partial y_f}{\partial M} + T_d' N_d \frac{\partial y_d}{\partial M} \right] + \\
&\left(\frac{dC}{dN_f} \right)_{ind} \left[\bar{T}_s' N_s \frac{\partial y_s}{\partial C} + T_f' N_f \frac{\partial y_f}{\partial C} + T_d' N_d \frac{\partial y_d}{\partial C} \right].
\end{aligned} \tag{26}$$

Using again Euler's theorem again, this yields:

$$\begin{aligned}\mathscr{R}_{ind}^{PR} =&\frac{N_d}{N_f}\left(T_d'-T_f'\right)y_d\times\gamma_{y_d,M}\Big|_{dc_j=dm_j=0}\left(\frac{dM}{dN_f}\right)_{ind}dN_f\\&+\frac{N_d}{N_f}\left(T_d'-T_f'\right)y_d\times\gamma_{y_d,C}\Big|_{dc_j=dm_j=0}\left(\frac{dC}{dN_f}\right)_{ind}dN_f\\&+\frac{N_s}{N_f}\left(T_s'-T_f'\right)y_s\times\gamma_{y_s,M}\Big|_{dc_j=dm_j=0}\left(\frac{dM}{dN_f}\right)_{ind}dN_f\\&+\frac{N_s}{N_f}\left(T_s'-T_f'\right)y_s\times\gamma_{y_s,C}\Big|_{dc_j=dm_j=0}\left(\frac{dC}{dN_f}\right)_{ind}dN_f.\end{aligned}$$

B.7 Indirect Fiscal Effect with Decreasing Returns to Scale

The indirect fiscal effect associated with an immigrant of type i is

$$d\mathscr{R}_{ind}^{\mathrm{DRS}}(i)=h_i\omega_i\left[\tau_p\frac{\partial\pi}{\partial\mathscr{L}_u}+\int_{\mathcal{I}_s}T'(y_i,i)\frac{\partial w_s}{\partial\mathscr{L}_u}h_i\omega_i m_i di+\int_{\mathcal{I}_u}T'(y_i,i)\frac{\partial w_u}{\partial\mathscr{L}_u}h_i\omega_i m_i di\right].$$

We can rewrite this as

$$d\mathscr{R}_{ind}^{\mathrm{DRS}}(i)=h_i\omega_i\left[\tau_p\frac{\partial\pi}{\partial\mathscr{L}_u}+\bar{T}_s'\mathscr{L}_s\frac{\partial w_s}{\partial\mathscr{L}_u}+\bar{T}_u'\mathscr{L}_u\frac{\partial w_u}{\partial\mathscr{L}_u}\right].$$

where $\bar{T}_u'$ and $\bar{T}_s'$ are the income-weighted marginal tax rates of low and high skilled labor and τ_p is the tax on profits. First, we derive a relation between a change in profits and the change in labor income. Consider the effect of the inflow on profits:

$$\frac{\partial\pi}{\partial\mathscr{L}_u}=\left(\frac{\partial\pi}{\partial w_s}\frac{\partial w_s}{\partial\mathscr{L}_u}+\frac{\partial\pi}{\partial w_u}\frac{\partial w_u}{\partial\mathscr{L}_u}\right).$$

By Hotelling's lemma $\frac{\partial\pi}{\partial w_s}=-\mathscr{L}_s$ and same for low-skilled labor. Therefore we can write:

$$\frac{\partial\pi}{\partial\mathscr{L}_u}=-\left(\mathscr{L}_s\frac{\partial w_s}{\partial\mathscr{L}_u}+\mathscr{L}_u\frac{\partial w_u}{\partial\mathscr{L}_u}\right).$$

Denote by I aggregate labor income. Then we of course have

$$\frac{\partial I}{\partial\mathscr{L}_u}=\mathscr{L}_s\frac{\partial w_s}{\partial\mathscr{L}_u}+\mathscr{L}_u\frac{\partial w_u}{\partial\mathscr{L}_u}$$

and we can write

$$\frac{\partial\pi}{\partial\mathscr{L}_u}=-\frac{\partial I}{\partial\mathscr{L}_u}.$$

With constant returns to scale, we of course have that both sides are equal to zero. With decreasing returns, profits increase and labor income decreases. Aggregate resident income (sum of profits and labor income) is not affected, however. We can therefore write the indirect fiscal effect as:

$$d\mathscr{R}_{ind}^{\text{DRS}}(i) = h_i\omega_i\left[-\tau_p\frac{\partial I}{\partial \mathscr{L}_u} + \bar{T}_s'\mathscr{L}_s\frac{\partial w_s}{\partial \mathscr{L}_u} + \bar{T}_u'\mathscr{L}_u\frac{\partial w_u}{\partial \mathscr{L}_u}\right],$$

Let $\kappa_s = \frac{\mathscr{L}_s w_s}{\mathscr{L}_s w_s + \mathscr{L}_u w_u}$ be the high-skilled fraction of labor income. Adding and subtracting $\left(\bar{T}_s'\kappa_s + \bar{T}_u'\kappa_u\right)\frac{\partial I}{\partial \mathscr{L}_u}$:

$$\begin{aligned} d\mathscr{R}_{ind}^{\text{DRS}}(i) =& h_i\omega_i\Big[-\tau_p\frac{\partial I}{\partial \mathscr{L}_u} + \bar{T}_s'\left(\mathscr{L}_s\frac{\partial w_s}{\partial \mathscr{L}_u} - \kappa_s\frac{\partial I}{\partial \mathscr{L}_u}\right) + \bar{T}_u'\left(\mathscr{L}_u\frac{\partial w_u}{\partial \mathscr{L}_u} - \kappa_u\frac{\partial I}{\partial \mathscr{L}_u}\right) + \\ & \left(\bar{T}_s'\kappa_s + \bar{T}_u'\kappa_u\right)\frac{\partial I}{\partial \mathscr{L}_u}\Big]. \end{aligned}$$

Rearranging the above equation yields

$$d\mathscr{R}_{ind}^{\text{DRS}}(i) = h_i\omega_i\left[\left(\bar{T}_I' - \tau_p\right)\frac{\partial I}{\partial \mathscr{L}_u} + \bar{T}_s'\left(\mathscr{L}_s\frac{\partial w_s}{\partial \mathscr{L}_u} - \kappa_s\frac{\partial I}{\partial \mathscr{L}_u}\right) + \bar{T}_u'\left(\mathscr{L}_u\frac{\partial w_u}{\partial \mathscr{L}_u} - \kappa_u\frac{\partial I}{\partial \mathscr{L}_u}\right)\right],$$

where $\bar{T}_I' = \bar{T}_s'\kappa_s + \bar{T}_u'\kappa_u$ is income weighted average income tax. Note that

$$\mathscr{L}_s\frac{\partial w_s}{\partial \mathscr{L}_u} + \mathscr{L}_u\frac{\partial w_u}{\partial \mathscr{L}_u} = \kappa_u\frac{\partial I}{\partial \mathscr{L}_u} + \kappa_s\frac{\partial I}{\partial \mathscr{L}_u}$$

So we can plug in $\mathscr{L}_s\frac{\partial w_s}{\partial \mathscr{L}_u} - \kappa_s\frac{\partial I}{\partial \mathscr{L}_u} = -\left(\mathscr{L}_u\frac{\partial w_u}{\partial \mathscr{L}_u} - \kappa_u\frac{\partial I}{\partial \mathscr{L}_u}\right)$ which yields

$$d\mathscr{R}_{ind}^{\text{DRS}}(i) = h_i\omega_i\left[\left(\bar{T}_I' - \tau_p\right)\frac{\partial I}{\partial \mathscr{L}_u} + \left(\bar{T}_u' - \bar{T}_s'\right)\left(\mathscr{L}_u\frac{\partial w_u}{\partial \mathscr{L}_u} - \kappa_u\frac{\partial I}{\partial \mathscr{L}_u}\right)\right].$$

The term $\kappa_u\frac{\partial I}{\partial \mathscr{L}_u}$ is the effect of immigration on low-skilled income that occurs through the scale effect that arises from changing the total income but keeping share going to low-skilled workers constant. Therefore, we can think of the whole term $N_u h_u\frac{\partial w_u}{\partial \mathscr{L}_u} - \kappa_u\frac{\partial I}{\partial \mathscr{L}_u}$ as the total change in low-skilled income from immigration minus the scale effect. Therefore, this whole term captures the effect of immigration on wages, holding total labor income constant. Define $\frac{\partial \tilde{w}_u}{\partial \mathscr{L}_u} = N_u h_u\frac{\partial w_u}{\partial \mathscr{L}_u} - \kappa_u\frac{\partial I}{\partial \mathscr{L}_u}$ as the effect of immigration on wages, holding total labor income constant. Let's further assume that the production function is homogenous of degree λ, where $\lambda < 1$ if we have decreasing returns to scale. Hence, $F(t\mathscr{L}_u, t\mathscr{L}_s) = t^\lambda F(\mathscr{L}_u, \mathscr{L}_s)$. Taking derivatives w.r.t. to t and normalizing $t = 1$ yields :

$$\mathscr{L}_u w_u + \mathscr{L}_s w_s = \lambda F,$$

Now taking derivatives of both sides w.r.t. $\mathscr{L}_u$ yields:

$$w_u + \mathscr{L}_u\frac{\partial w_u}{\partial \mathscr{L}_u} + \mathscr{L}_s\frac{\partial w_s}{\partial \mathscr{L}_u} = \lambda w_u.$$

Therefore (recall $\frac{\partial I}{\partial \mathscr{L}_u} = \mathscr{L}_u \frac{\partial w_u}{\partial \mathscr{L}_u} + \mathscr{L}_s \frac{\partial w_s}{\partial \mathscr{L}_u}$)

$$\frac{\partial I}{\partial \mathscr{L}_u} = (\lambda - 1) w_u.$$

Inserting this into the indirect fiscal effect yields

$$d\mathscr{R}_{ind}^{\text{DRS}}(i) = h_i \omega_i w_u \left[\left(\tau_p - \bar{T}_I'\right)(1-\lambda) + \left(\bar{T}_s' - \bar{T}_u'\right)\left(|\gamma_{u,own} + \kappa_u (1-\lambda)|\right)\right],$$

which yields

$$d\mathscr{R}_{ind}^{\text{DRS}}(i) = y_i \left[\left(\tau_p - \bar{T}_I'\right)(1-\lambda) + \left(\bar{T}_s' - \bar{T}_u'\right)\left(|\tilde{\gamma}_{u,own}|\right)\right],$$

where $\tilde{\gamma}_{u,own} = \gamma_{u,own} + \kappa_u (1-\lambda)$ is own-wage elasticity, holding total labor income constant.

To solve for $\tilde{\gamma}_{u,own}$ as a function of the elasticity of substitution, note that as shown in Appendix B.1, we can use the definition of the elasticity of subsitution to write:

$$-\frac{1}{\sigma} = \gamma_{u,own} - \gamma_{s,cross}. \tag{27}$$

From Euler's homogenous function theorem we know that

$$w_u \mathscr{L}_u + w_s \mathscr{L}_s = \lambda Y.$$

Taking derivatives with respect to $\mathscr{L}_u$ and rearranging yields

$$\gamma_{s,cross} = -\gamma_{u,own} \frac{w_u \mathscr{L}_u}{w_s \mathscr{L}_s} + (\lambda - 1) \frac{w_u \mathscr{L}_u}{w_s \mathscr{L}_s}.$$

Plugging this into (27) yields

$$-\frac{1}{\sigma} = \gamma_{u,own} \underbrace{\left(1 + \frac{w_u \mathscr{L}_u}{w_s \mathscr{L}_s}\right)}_{= \frac{\lambda Y}{w_s \mathscr{L}_s}} - \frac{w_u \mathscr{L}_u}{w_s \mathscr{L}_s}(\lambda - 1).$$

Solving for $\gamma_{u,own}$ yields

$$\gamma_{u,own} = (\lambda - 1) \frac{w_u \mathscr{L}_u}{\lambda Y} - \frac{1}{\sigma} \frac{w_s \mathscr{L}_s}{\lambda Y}.$$

Using $\frac{w_u \mathscr{L}_u}{\lambda Y} = \kappa_u$ and $\frac{w_s \mathscr{L}_s}{\lambda Y} = \kappa_s$ by Euler's homogenous function theorem yields

$$\gamma_{u,own} = (\lambda - 1)\kappa_u - \frac{1}{\sigma}\kappa_s.$$

Therefore, we can write

$$\tilde{\gamma}_{u,own} = -\frac{1}{\sigma}\kappa_s.$$

B.8 Indirect Fiscal Effect with Capital

We show the proof for the more general CES production function. Let production Y be given by

$$Y = \left(\theta_k K^\rho + \theta_l G\left(\mathscr{L}_u, \mathscr{L}_s\right)^\rho\right)^{1/\rho}.$$

We begin by solving for the relationship of factor price elasticities when capital supply is elastic and capital supply is inelastic. For this, first consider the case when capital supply is perfectly elastic. In this case, the capital labor ratio is constant. In this case, we can write $K = CG\left(\mathscr{L}_u, \mathscr{L}_s\right)$ where C is the constant capital labor ratio. The production function can be written as

$$Y = \bar{A}G\left(\mathscr{L}_u, \mathscr{L}_s\right),$$

where $\bar{A}$ is a constant.[74] The elasticities of wages with respect to low-skilled labor with perfectly elastic capital supply are given by

$$\gamma_{s,cross}^{elast} = \frac{\partial \log \frac{\partial G}{\partial \mathscr{L}_s}}{\partial \log \mathscr{L}_u}$$

and

$$\gamma_{u,own}^{elast} = \frac{\partial \log \frac{\partial G}{\partial \mathscr{L}_u}}{\partial \log \mathscr{L}_u}.$$

Following the arguments in Appendix B.1, we can write these as $\gamma_{s,cross}^{elast} = \frac{1}{\sigma}\kappa_u$ and $\gamma_{u,own}^{elast} = -\frac{1}{\sigma}\left(1-\kappa_u\right)$, where $\kappa_u = \frac{w_u \mathscr{L}_u}{w_u \mathscr{L}_u + w_s \mathscr{L}_s}$ is the share of wage payments that go to low-skilled labor.

Next, consider the case in which capital supply is perfectly inelastic. Let $\kappa_L = \frac{w_u \mathscr{L}_u + w_s \mathscr{L}_s}{Y}$ be the share of factor payments that go to labor, let $\kappa_K = 1 - \kappa_L$, and let r give the price of capital. Standard CES algebra yields the capital price elasticity

$$\gamma_{r,u} = \frac{\kappa_L}{\sigma}\kappa_u.$$

Further, note that log wages for each skill group are given by

$$\log w_u = \log \frac{\partial Y}{\partial G} + \log \frac{\partial G}{\partial \mathscr{L}_u}$$

and

$$\log w_s = \log \frac{\partial Y}{\partial G} + \log \frac{\partial G}{\partial \mathscr{L}_s}.$$

Taking derivatives of these log wage functions with respect to $\log \mathscr{L}_u$ yields

$$\gamma_{s,cross} = \underbrace{\frac{\partial \log \frac{\partial Y}{\partial G}}{\partial \log \mathscr{L}_u}}_{=-\frac{\kappa_K}{\sigma}\kappa_u} + \underbrace{\frac{\partial \log \frac{\partial G}{\partial \mathscr{L}_s}}{\partial \log \mathscr{L}_u}}_{\gamma_{s,cross}^{elast}}$$

[74] Concretely, note that $Y = \left(\theta_k \left(CG\right)^\rho + \theta_l G^\rho\right)^{1/\rho}$ and hence $Y = \left(\theta_k C^\rho + \theta_l\right)^{\frac{1}{\rho}} G$. Hence, the constant is given by $\bar{A} = \left(\theta_k C^\rho + \theta_l\right)^{\frac{1}{\rho}}$.

and

$$\gamma_{u,own} = \underbrace{\frac{\partial \log \frac{\partial Y}{\partial G}}{\partial \log \mathscr{L}_u}}_{=-\frac{\kappa_K}{\sigma}\kappa_u} + \underbrace{\frac{\partial \log \frac{\partial G}{\partial \mathscr{L}_u}}{\partial \log \mathscr{L}_u}}_{\gamma^{elast}_{u,own}},$$

which give the relationship between own wage elasticity with elastically supplied and inelastically supplied capital.

Now, consider the indirect fiscal effect with inelastically supply supplied capital:

$$d\mathscr{R}_{ind}(i) = h_i\omega_i \left[\tau_k K \frac{\partial r}{\partial \mathscr{L}_u} + \bar{T}'_s \mathscr{L}_s \frac{\partial w_s}{\partial \mathscr{L}_u} + \bar{T}'_u \mathscr{L}_u \frac{\partial w_u}{\partial \mathscr{L}_u}\right].$$

We can rewrite this as

$$d\mathscr{R}_{ind}(i) = h_i\omega_i \left[\tau_k \frac{rK}{\mathscr{L}_u}\gamma_{r,u} + \bar{T}'_s \frac{\mathscr{L}_s w_s}{\mathscr{L}_u}\gamma_{s,cross} + \bar{T}'_u w_u \gamma_{u,own}\right].$$

Plugging in the factor price elasticities from above yields

$$\begin{aligned} d\mathscr{R}_{ind}(i) =& h_i\omega_i \Bigg[\frac{\kappa_u}{\mathscr{L}_u\sigma}\left(\tau_k rK \frac{w_u\mathscr{L}_u + w_s\mathscr{L}_s}{Y} - \bar{T}'_s\mathscr{L}_s w_s \frac{rK}{Y} - \bar{T}'_u \mathscr{L}_u w_u \frac{rK}{Y}\right) + \\ & \bar{T}'_s \frac{\mathscr{L}_s w_s}{\mathscr{L}_u}\gamma^{elast}_{s,cross} + \bar{T}'_u w_u \gamma^{elast}_{u,own}\Bigg]. \end{aligned}$$

Factorizing $\kappa_K = \frac{rK}{Y}$ in the first line yields

$$\begin{aligned} d\mathscr{R}_{ind}(i) =& h_i\omega_i \Bigg[\kappa_K \frac{\kappa_u}{\mathscr{L}_u\sigma}\left(\tau_k (w_u\mathscr{L}_u + w_s\mathscr{L}_s) - \bar{T}'_s\mathscr{L}_s w_s - \bar{T}'_u \mathscr{L}_u w_u\right) + \\ & \bar{T}'_s \frac{\mathscr{L}_s w_s}{\mathscr{L}_u}\gamma^{elast}_{s,cross} + \bar{T}'_u w_u \gamma^{elast}_{u,own}\Bigg]. \end{aligned}$$

Letting $\bar{T}'_I = \frac{\bar{T}'_s\mathscr{L}_s w_s + \bar{T}'_u \mathscr{L}_u w_u}{w_u\mathscr{L}_u + w_s\mathscr{L}_s}$, we can rewrite this as:

$$d\mathscr{R}_{ind}(i) = h_i\omega_i \left[(w_u\mathscr{L}_u + w_s\mathscr{L}_s)\kappa_K \frac{\kappa_u}{\mathscr{L}_u\sigma}\left(\tau_k - \bar{T}'_I\right) + \bar{T}'_s \frac{\mathscr{L}_s w_s}{\mathscr{L}_u}\gamma^{elast}_{s,cross} + \bar{T}'_u w_u \gamma^{elast}_{u,own},\right]$$

which can be simplified to

$$d\mathscr{R}_{ind}(i) = h_i\omega_i \left[w_u \frac{\kappa_K}{\sigma}\left(\tau_k - \bar{T}'_I\right) + \bar{T}'_s \frac{\mathscr{L}_s w_s}{\mathscr{L}_u}\gamma^{elast}_{s,cross} + \bar{T}'_u w_u \gamma^{elast}_{u,own}.\right]$$

Further, we know that F is constant returns to scale, which implies that $w_u \gamma_{u,own}^{elast} = -\frac{\mathscr{L}_s w_s}{\mathscr{L}_u} \gamma_{s,cross}^{elast}$ (recall Lemma 1). We can therefore write

$$d\mathscr{R}_{ind}(i) = h_i \omega_i \left[w_u \frac{\kappa_K}{\sigma} \left(\tau_k - \bar{T}_I'\right) + \left(\bar{T}_s' - \bar{T}_u'\right) w_u |\gamma_{u,own}^{elast}| \right].$$

Rearranging this equation yields

$$d\mathscr{R}_{ind}(i) = y_i \left[\left(\bar{T}_s' - \bar{T}_u'\right) |\gamma_{u,own}^{elast}| + \frac{\kappa_K}{\sigma} \left(\tau_k - \bar{T}_I'\right) \right]. \quad (28)$$

If the production function is Cobb-Douglas in capital and the labor aggregate, then $\frac{\kappa_K}{\sigma} = \alpha$.

C Empirical Appendix

C.1 Data Cleaning in the ACS and Calculation of Tax Rates

We use data from the 2017 ACS. We limit the sample to individuals between ages 18 and 65 who do not live in group quarters. We limit our sample to household heads and their spouses, as tax filling status is less clear for other individuals. This leaves us with a sample of over 1.2 million individuals.

When calculating taxes, we account for an individual's wage income and business income as sources of taxable income. All income weighted averages are weighted by wage incomes and sample weights. When calculating the income-weighted pass-through tax rate in Section A.5, we weight by business income.

To calculate marginal income and payroll tax rates, we begin by calculating the total income for each household head and their spouse for all households in the ACS. We then use TAXSIM to calculate the marginal income and payroll taxes for each individual, taking into account the individual's marital status (which determines filing status), number of children (a determinant in personal exemptions), age of children (a determinant in eligibility of the Dependent Care Credit, the Child Credit, and the Earned Income Tax Credit), location (which determines state income tax schedules), and age of the household head and spouse (which determine eligibility for various deductions and exemptions).

C.2 Calculation of Marginal Phase-Out Rates and TANF and SNAP

We begin by calculating total monthly SNAP benefits and TANF benefits for each household in the SIPP. One issue is that benefit receipts are generally underreported in household surveys, including the SIPP (Meyer, Mok, and Sullivan, 2015). To deal with this, we utilize data from the U.S. Bureau of Economic Analysis' National Income and Product Accounts (NIPA) tables, which report annual government spending on various U.S. programs. We multiply benefit receipt amounts in the SIPP by a multiplicative constant such that the total population-weighted benefit receipts in the SIPP are consistent with the aggregates from the NIPA tables. Specifically, we utilize data from NIPA Table 3.12. We multiply SNAP benefits in the SIPP by a constant such they are consistent with SNAP benefits from this table and multiple TANF benefits in the SIPP by a constant such they are consistent with "Family assistance" benefits from this table multiplied by the fraction of TANF benefits which are spend on basic assistance.

Next, we divide households by household size and estimate monthly TANF and SNAP benefits as a linear spline in household income. We estimate a separate spline for each household size. Next, using these function of benefits as a function of income, we can calculate the *marginal* average monthly benefits as a function of monthly income and household size. We aggregate these monthly estimates to yearly estimates by taking the income-weighted average across months for each household in the SIPP.

C.3 Calculation of Government Medicaid Costs

First, we calculate the number and age of all household members who are on Medicaid for each month for each household in the SIPP. To calculate the government cost associated with each household member on Medicaid, we use estimates of the average government cost for adults and for children from the Kaiser Family Foundation.[75] Specifically, we assign the national average costs for adults and children for each medically enrolled adult and child in our data.

Next, as with our calculation of TANF and SIPP phase-out rates, we divide households by household size and estimate monthly Medicaid costs as a linear spline in household income, using a separate spline for each household size. We can then calculate the marginal average monthly government cost as a function of monthly income and household size by using these functions of cost as a function of income. We then take the income-weighted average across months for each household to aggregate these monthly estimates to yearly estimates.

C.4 Calculation of Marginal Replacement Rates of Social Security Benefits

An individual's social security benefits are calculated as a function of their average indexed monthly earnings (AIME). If the current year's income is one of the 35 highest earning years, a \$1 increase in current year income will increase an individual's AIME by \$1/35. If the current year's income is not one of the 35 highest earning years, a marginal increase in current year income will have no effect on social security benefits. Further, if current year's income is above the maximum taxable earnings threshold, an increase in current income has no effect on social security benefits.

[75] https://www.kff.org/medicaid/state-indicator/medicaid-spending-per-enrollee/

We assume an individual receives social security from age 66 until their death. Let $MRR(AIME_i)$ denote the marginal increase in yearly social security benefits as a function of an individual's AIME and let T_i represent an individual's life expectancy. The discounted marginal replacement rate associate with current earnings of an individual of age age_i is given by:

$$DRR_i = MRR(AIME_i)\frac{1}{35}\left(\frac{1+g}{1+r}\right)^{65-age_i}\sum_{t=66}^{T_i}\left(\frac{1}{1+r}\right)^{t-65} \tag{29}$$

if current year income is one of the individual's 35 highest earning years and income is below the maximum taxable earnings threshold, and 0 otherwise, where g is the aggregate growth rate and r is the interest rate. This gives the increase in yearly social security benefits associated with a $1 increase in AIME. An increase in the current year's income increase the average career income by 1/35, which in turn increases yearly future social security benefits from the agents retirement until death.

We estimate an individual's AIME and 35th highest year of earning as a function of current income and household characteristics using data from the NLSY79. The NLSY79 is a nationally representative panel dataset which provides data on respondents from 1979 until 2016. There are a few issues with missing data that we need to resolve. First, starting in 1994, individuals are only interviewed in even numbered years. We therefore assume that data in odd numbered years post 1994 is the same as in the previous year. Further, in 2016, the last year from which data are available, respondents are between age 53 and 60. We therefore do not have income information for the last few years of individual's working lives. We therefore assume that income for the remainder of the working life is equal to a respondent's last observed income.

After dealing with these data issues, we can calculate an individual's AIME as the average of their 35 highest income years, adjusted for inflation, and an individual's 35th highest income year. We calculate the average of these two statistics conditional the following characteristics:

1. An individual's education - high school dropout, high school graduate, some college, or college graduate

2. Whether or not an agent is married

3. 5-year age bins

4. Whether or not the agent has children living in their household

5. Quintiles of the income distribution, conditional on working and conditional on the above characteristics.

For individuals in the ACS, we impute AIME and 35th highest earning year as the average of these two statistics conditional on the characteristics above.

	Elasticity of Substitution		
	1.5	2.0	2.5
I. No Labor Supply Responses	1003	753	602
II. Endogenous Labor Supply			
Common Elasticity	1132	913	765
By Income and Marital Status	1034	791	641
By Income, Gender and Marital Status	1005	769	623

Table 8: Indirect Fiscal Effects of low-skilled immigrants using estimates of labor supply elasticities from Bargain, Orsini, and Peichl (2014). The three columns show the indirect fiscal effect under different assumptions of the elasticity of substitution, ranging from $\sigma = 1.5$ to $\sigma = 2.5$. Each row displays the indirect fiscal effect for different assumptions about the labor supply elasticity.

Finally, a crucial element of this calculation is an individual's life expectancy, which determines how many years the individual receives benefits. To calculate life expectancy, we use estimates of life expectancy conditional on income from Chetty et al. (2016), who estimate life expectancy for household income percentiles using data from 1.4 billion tax and social security death records.[76]

C.5 Results Using Labor Supply Elasticities from Bargain, Orsini, and Peichl (2014)

Table 8 shows the indirect fiscal effect when we use estimates of labor supply elasticities from Bargain, Orsini, and Peichl (2014), who estimate a discrete choice model to estimate elasticities. The first two rows show the calculated indirect fiscal effect with no labor supply responses, and when using an estimate of extensive and intensive labor supply elasticities from Chetty (2012). In the third row, we allow labor supply elasticities to vary by gender and marital status. We use estimates of gender and marital status specific intensive and extensive labor supply elasticities from Bargain, Orsini, and Peichl (2014). Finally, in the fourth row, we consider the scenario in which labor supply elasticities can vary by gender, age, and income. For this we use estimates of intensive and extensive labor supply elasticities by gender, marital status and quintile of the income distribution from Bargain, Orsini, and Peichl (2014).[77]

Tables 9 and 10 display the extensive and intensive labor supply elasticities estimated in Bargain, Orsini, and Peichl (2014). The first column displays the income quintile. The next four columns display the labor supply elasticities for married females, single females, married males, and single males, respectively.

[76]We calculate each individuals household's income percentile within their age. We then use the gender specific life expectancy associated with this income percentile.

[77]We choose to utilize the labor supply estimates from Bargain, Orsini, and Peichl (2014) because they estimate gender and income specific intensive and extensive margin elasticities using a common estimation procedure. Our results are very similar if we use estimates on extensive labor supply elasticities by wage

Income Quintile	Females Married	Females Single	Males Married	Males Single
1	0.12	0.19	0.07	0.20
2	0.12	0.31	0.05	0.25
3	0.12	0.23	0.05	0.20
4	0.12	0.16	0.04	0.16
5	0.11	0.09	0.02	0.10

Table 9: Estimates of extensive margin labor supply elasticities from Bargain, Orsini, and Peichl (2014) by income quintile, gender, and marital status.

Income Quintile	Females Married	Females Single	Males Married	Males Single
1	0.02	0.03	0.02	0.01
2	0.02	0.03	0.03	0.02
3	0.02	0.04	0.03	0.02
4	0.02	0.05	0.03	0.02
5	0.04	0.06	0.05	0.04

Table 10: Estimates of intensive margin labor supply elasticities from Bargain, Orsini, and Peichl (2014) by income quintile, gender, and marital status.

C.6 Quantifying the Fiscal Effect in Peri and Sparber (2009)

We now calculate the indirect fiscal benefits and its decomposition as expressed in equation 24. In order to evaluate this equation, we need estimates of the following:

1. (w_m, w_c, w_s) – the task prices of manual, communication, and cognitive tasks.
2. (σ, σ_u) – the elasticities of substitution between high-skilled and low-skilled workers, and between manual tasks and cognitive tasks.
3. $\left(\eta_c^f, \eta_f^m, \eta_d^c, \eta_d^m\right)$ – the elasticities of task intensities with respect to immigrant inflows.
4. (N_f, N_d, N_s) – the number of low-skilled foreign-born, low-skilled domestic-born and high-skilled workers.
5. (c_f, c_d, m_f, m_d) – the task intensities of low-skilled foreign-born and domestic-born workers
6. $\left(\bar{T}_f', \bar{T}_d', \bar{T}_s'\right)$ – marginal tax rates faced by low-skilled foreign-born, low-skilled domestic-born, and high-skilled workers.

We take estimates of items (1) - (3) directly from Peri and Sparber (2009). Specifically, Peri and Sparber (2009) estimate the state level task prices of manual and cognitive tasks, w_m and w_c, using variation in task supplies and wages across occupations. We take the national

percentile from Juhn, Murphy, and Topel (2002), who estimate extensive margin elasticities using a sample of U.S. men.

average of these task prices for our measures of w_m and w_c. Peri and Sparber (2009) estimate the elasticity of substitution between manual and communication tasks, σ_u, using state level variation in immigrant inflows. We set $\sigma_u = 1$ as the preferred estimates from Peri and Sparber (2009) and set the elasticity of substitution between low- and high-skilled workers as $\sigma = 1.75$, based on the calibration in Peri and Sparber (2009). Peri and Sparber (2009) also use across-state immigrant variation to estimate the elasticities of task supplies with respect to the immigrant share of low-skilled workers. They find that domestic-born workers respond to low-skilled immigrant inflows by increasing their communication task supply but do not change their manual task supply, and that immigrants do not change their task supplies in response to immigrant inflows. We therefore set $\eta_f^c = \eta_f^m = \eta_d^m = 0$ and take $\eta_d^c = 0.33$ from their estimates.

To measure (4)-(6) we follow Peri and Sparber (2009) closely using data from the 2017 ACS downloaded from IPUMS (Ruggles, Alexander, Genadek, Goeken, Schroeder, and Sobek, 2010) and data on task composition of occupations from ONET. We define low-skilled workers as workers with a high school degree or less. We can therefore calculate N_f, N_d and N_s directly from the 2017 ACS as the number of low-skilled foreign-born, low-skilled domestic-born and high-skilled workers. To estimate the task supplies, we proceed in two steps. The ONET dataset measures the task requirement for each census occupation code. We use the procedure described in Peri and Sparber (2009) to assign a manual and communication intensity to each occupation. Then, for each worker in the ACS, we calculate the manual and communication task requirements associated with the worker's occupation. Let $\tilde{c}_j$ and $\tilde{m}_j$ represent the average communication and manual task intensity of workers of type j.

Recall that the task supplies are defined as the task intensities multiplied by labor supply: $c_j = h_j\tilde{c}_j$ and $m_j = h_j\tilde{m}_j$. Note that the worker's budget constraint can be rewritten as

$$y_j = h_j \left(\tilde{c}_j w_c + \tilde{m}_j w_m\right),$$

where task prices, w_c and w_m, are known values from Peri and Sparber (2009), and the average income of workers of type j, y_j, can be estimated directly from the ACS. We can therefore use this equation to solve for h_j for low-skilled foreign-born and domestic-born and therefore for all four task supplies, c_f, c_d, m_f, and m_d.

D Further Quantitative Results

D.1 Quantification: Welfare and Distributional Effects

We calculate the welfare effects of immigration using the so-called inverse optimum weights as in Hendren (2020), see Appendix B.3 for the theory. These are the welfare weights for which the current U.S. tax-transfers system is optimal according to optimality conditions

Object	Value	Desription	Source
Task Prices			
w_m	773	Manual task wage	PS inflated to 2017
w_c	820	Communication task wage	PS inflated to 2017
w_s	$69,311$	Skilled income	ACS
Production Parameters			
σ	1.75	Elasticity of substitution, skilled and unskilled workers	PS
σ_u	1	Elasticity of substitution, manual and communication tasks	PS
Task Supply Elasticities			
η_c^d	.33	Elasticity of domestic-born communication task supply with respect to immigrants	PS
$\eta_m^d, \eta_m^f, \eta_c^f$	0	Other task supply elasticities	PS
Population Shares			
$\frac{N_f}{N}$	0.069	Low-skilled foreign-born as fraction of population	ACS
$\frac{N_d}{N}$	0.318	Low-skilled domestic-born as fraction of population	ACS
$\frac{N_s}{N}$	0.613	High-skilled workers as fraction of population	ACS
Task Supplies			
c_f	12.47	Communication task supply of low-skilled foreign-born	ONET and ACS
c_d	19.15	Communication task supply of low-skilled domestic-born	ONET and ACS
m_f	27.71	Manual task supply of low-skilled foreign-born	ONET and ACS
m_d	29.18	Manual task supply of low-skilled domestic-born	ONET and ACS
Marginal Tax Rates			
$\bar{T}'_f$	0.31	Marginal tax rate of low-skilled foreign-born	Tax quantification
$\bar{T}'_d$	0.30	Marginal tax rate of low-skilled domestic-born	Tax quantification
$\bar{T}'_s$	0.37	Marginal tax rate of high-skilled workers	Tax quantification

Table 11: Summary of data sources and calibrated values. "PS" refers to estimates taken from Peri and Sparber (2009).

from the optimal income tax literature. Hendren (2020) shows that by using these weights, one can extend the Kaldor-Hicks surplus to account for distortionary costs of compensation.[78] If the welfare effect is positive with such weights, then a Pareto improvement can be achieved because the losers can be compensated.[79]

For the U.S., Hendren (2020) calibrates a weight function which is generally decreasing in income and thus gives higher weight to low-skilled than high-skilled individuals. For such weights, low-skilled immigration will lead to negative distributional effects because the income losses of low-skilled receive a higher weight than the income gains of high-skilled.

Table 12 summarizes the welfare effects associated with the distributional effects and the indirect fiscal effects of immigration as formalized in Proposition 3. In the first three columns, we calculate the welfare effects using the welfare weights of Hendren (2020), where the utility of all residents, both domestic-born and foreign-born, are considered. Given the intermediate value of $\sigma = 2$, quantification of the formula in Proposition 3 reveals a distributional effect of -\$1,318. This quantifies the welfare costs caused by the increase in inequality associated with low-skilled immigration. The magnitude of this distributional effect is sensitive to how the social welfare weights differ with income: here we use the welfare weights of Hendren (2020), which are the welfare weights implicitly used by the U.S. government.[80]

[78] Going one step further, Schulz et al. (2022) generalize the compensation principle to a setting where distortive taxes also imply general equilibrium effects on wages, which creates a complicated fixed-point problem. The authors analytically describe the tax reform that achieves compensation in such a setting.

[79] One underlying assumption that this can be achieved with a standard tax schedule, is that for a given income level, all individuals are affected in the same way. This assumption is apparently violated in our model where at a certain income level, both low and high-skilled individuals are present and hence compensating policies would need to condition on skill.

[80] Note that generally, the weights that Hendren (2020) obtained, depend on his calibration of the income distribution, the tax-transfer system calibration and the elasticities, which is not the same calibration for these objects as in our paper. We consider it as a reasonably good approximation to work with his weights,

However, this distributional effect is partially offset by the two welfare effects related to indirect fiscal effects: the fiscal externalities associated with changes in resident labor supply and the tax mitigation effect. Evaluating (23) with common labor supply elasticities and $\sigma = 2$, we find a fiscal externality of $329, roughly one third of the entire indirect fiscal effect.[81] The distributional effect is further mitigated by the fact that the tax burden for low-skilled residents decreases while the tax burden for high-skilled residents increases. This tax mitigation effect creates an additional surplus of $525. Therefore, the two novel welfare effects associated with the indirect fiscal effect — the fiscal externality and the tax mitigation effect — imply an additional, so far neglected, surplus of $854. All together, this implies a welfare effect beyond the direct fiscal effect of -$464 compared to a pure distributional effect of -$1,318.

In the last three columns, we calculate the effects on domestic-born welfare by only assigning non-zero welfare weights to domestic-born individuals.[82] The distributional effects are significantly muted as domestic-born are more likely to be skilled than previous immigrants. For $\sigma = 2$, we find a distributional effect for domestic-born of -$932. This implies a welfare effect beyond the direct fiscal effect of -$213.

Overall, these welfare effects of residents are rather small in magnitude compared to estimates of wage gains that low-skilled immigrants experience as a result of coming to the United States. Clemens, Montenegro, and Pritchett (2008) find that U.S. immigrants from the countries in their sample have 200% to 1500% higher wages than observably identical individuals who remain in their home country. For a low-skilled Mexican male immigrant, this implies an income gain of nearly $20,000 annually.[83] Hendricks and Schoellman (2018) find that immigrants from low- and middle-income countries increase their wages by 200% to 300% upon arriving in the United States. This suggests that the overall welfare effects are likely to be positive if the welfare of the immigrants themselves are accounted for.

D.2 Total Marginal and Participation Tax Rates

Figure 3 shows the total marginal and participation tax rates by individual earnings as the sum of the effective tax rates arising from income taxes, social security, and transfer payments.

in particular because the welfare results are not the main results of this paper. The weights of Lockwood and Weinzierl (2016) are very similar, who study how welfare weights implicitly used by the U.S. government have changed over time.

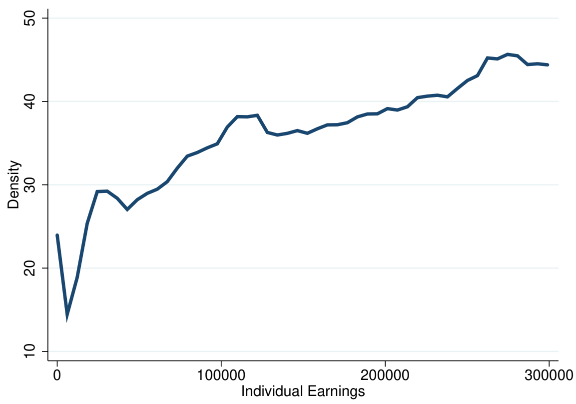
[81] Note that holding labor supply elasticities constant, the fiscal externality is the same fraction of the indirect fiscal effect for any value of the elasticity of substitution, σ. Therefore, the result that the fiscal externality is over one third of the fiscal surplus is true for any value of the elasticity of substitution.

[82] We again utilize the use the welfare weights of Hendren (2020) and set the weights for foreign-born individuals to zero. We then we normalize the welfare weights such that are equal to one on average.

[83] The average low-skilled male Mexican immigrant in our dataset has an average wage income of $32,841. Clemens, Montenegro, and Pritchett (2008) estimate that Mexican immigrants have wages 2.53 times higher than observably identical Mexicans who do not immigrate. We calculate the average income gain as $32,841 - \frac{32,841}{2.53} = 19,860$.

	All Residents			Domestic-Born Only		
	1.5	2.0	2.5	1.5	2.0	2.5
I. Distributional Effect	-1634	-1318	-1104	-1157	-932	-781
II. Fiscal Externality	409	329	276	409	329	276
III. Tax Mitigation	651	525	440	484	390	327
Total	-574	-464	-388	-264	-213	-178

Table 12: Welfare effects of low-skilled immigrants absent direct fiscal effects. The right panel displays the welfare effects when only domestic-born residents receive positive social welfare weights. Within each panel, the three columns show the indirect fiscal effect under different assumptions of the elasticity of substitution, ranging from $\sigma = 1.5$ to $\sigma = 2.5$ with common labor supply elasticities.



(a) Marginal Taxes

(b) Participation Taxes

Figure 3: Total marginal and participation tax rates by individual earnings. Panel (a) gives the marginal effective tax rates as the sum of marginal races from income taxes, the social security system, and transfer programs. Panel (b) reports the total participation tax rates implied by income taxes, the social security system, and transfer programs.

	Elasticity of Substitution		
	1.5	2.0	2.5
I. No Labor Supply Responses	845	634	507
II. Endogenous Labor Supply	970	782	655

Table 13: Indirect Fiscal Effects with intensive and extensive margin labor supply responses with real interest rate of 2%.

	Elasticity of Substitution		
	1.5	2.0	2.5
I. No Labor Supply Responses	961	721	577
II. Endogenous Labor Supply	1080	871	729

Table 14: Indirect Fiscal Effects with intensive and extensive margin labor supply responses with alternative skill definition.

Panel (a) gives the marginal effective tax rates as the sum of marignal races from income taxes, the social security system, and transfer programs. Panel (b) reports the total participation tax rates implied by income taxes, the social security system, and transfer programs.

D.3 Indirect Fiscal Effects in Baseline Model with Real Interest Rate of 2%

In Section 2 we chose a real interest rate of 1%. In Table 13 we replicated our baseline results under the assumption of a real interest rate of 2%. The table shows the indirect fiscal effects of the average low-skilled immigrant.

D.4 Indirect Fiscal Effects in Baseline Model with Alternative Skill Definitions

In Section 2, we defined low-skilled workers as those with no college experience and defined high-skilled workers as individuals with some college and college graduates. An alternative way to delineate skills is to divide individuals with some college between low-skilled and high-skilled workers, as in Card (2009) or Katz and Murphy (1992).

In this section we replicate our baseline results from Section 4, except we define skill groups as in Card (2009), by dividing individuals with some college evenly between the groups. Overall, the indirect fiscal effects here are slightly smaller than our baseline result. This makes sense, the skill definitions we use in this section imply a smaller high-skilled share of income and therefore a smaller own-wage elasticity for low-skilled workers, holding the parameter σ constant. However, the results are still in the same ballpark as those presented in Section 4.

	Elasticity of Substitution		
	1.5	2.0	2.5
I. No Labor Supply Responses	855	641	513
II. Endogenous Labor Supply	965	778	651

Table 15: Indirect Fiscal Effects for high school dropouts with intensive and extensive margin labor supply responses. See description from Table 2.

	Elasticity of Substitution		
	1.5	2.0	2.5
I. No Labor Supply Responses	1106	830	664
II. Endogenous Labor Supply	1248	1006	843

Table 16: Indirect Fiscal Effects for high school graduates with intensive and extensive margin labor supply responses. See description from Table 2.

D.5 Indirect Fiscal Effects in Baseline Model with for High School Dropouts and High School Graduates

Tables 15 and 16 show the indirect fiscal effects for the average high school dropout immigrant and the average high school graduate immigrant.