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The Indirect Fiscal Benefits of Low-Skilled Immigration†

By Mark Colas and Dominik Sachs*

Low-skilled immigrants indirectly affect public finances through their effect on resident wages and 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 United States 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* H24, H75, J15, J24, J61, J82)

Low-skilled immigrants are widely considered a fiscal burden in the United States.[1] In his widely read blog, Paul Krugman (2006) on this issue concludes the following: "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 United States (Blau and Mackie 2017) estimates the fiscal impact of immigration to the United States. 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

* Colas: University of Oregon (email: mcolas@uoregon.edu); Sachs: University of St. Gallen (email: dominik.sachs@unisg.ch). Matthew Notowidigdo was coeditor for this article. We would like to thank Daniele Coen-Pirani, Jonathan M.V. Davis, Juan Dolado, Ben Elsner, Axelle Ferriere, Sebastian Findeisen, Lisandra Flach, Mette Foged, Tommaso Frattini, Ulrich Glogowsky, Emanuel Hansen, Bas Jacobs, Gaurav Khanna, Wojciech Kopczuk, Claus Kreiner, Keith Kuester, Fabian Lange, Ben Lockwood, Jonas Loebbing, Abdou Ndiaye, Andreas Peichl, Panu Poutvaara, Florian Scheuer, Monika Schnitzer, Stefanie Stantcheva, Holger Stichnoth, Kjetil Storesletten, Jan Stuhler, Juan Carlos Suárez-Serrato, Uwe Thuemmel, Aleh Tsyvinski, Alessandra Voena, Fabian Waldinger, Nicolas Werquin, Simon Wiederhold, Andreas Winkler, and Woan Foong Wong, as well as seminar participants at the CEPR Public Economics Symposium "Public Finance: Macro Insights," CESifo Public Sector Economics Area Conference, CRC "Rationality and Competition" Retreat, Ben Gurion University, University of Bonn, Hitotsubashi University, KU Ingolstadt, University of Pennsylvania, University of Pittsburgh, and University of Regensburg for helpful comments and suggestions. Financial support by Deutsche Forschungsgemeinschaft through CRC TRR 190 (project number 280092119) is gratefully acknowledged. We also thank Mehmet Ayaz, Lea Fricke, Oleksandr Morozov, and Taylor Watson for great research assistance.

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[1] Alesina, Miano, and Stantcheva (2018) found that 15 percent of survey respondents believed that an average immigrant received more than twice as much in transfers as the average US 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 United States worse off in terms of the economy in general, job opportunities, and social and moral values (http://news.gallup.com/poll/1660/immigration.aspx).

stated, "According 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.
>
> (Blau and Mackie 2017, 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 US 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 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

[2] https://trumpwhitehouse.archives.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 IB and ID, we distinguish between domestic-born and foreign-born workers. This distinction has been highlighted as having 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] For example, Dustmann, Schönberg, and Stuhler (2016, 44) emphasize that "wage and employment responses need to be studied jointly to obtain an accurate picture of the labor market impacts of immigration."

labor force participation, for example, this would decrease tax revenue. Thus, low-skilled immigration leads to indirect fiscal effects through general equilibrium changes both 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 health care 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, our preferred estimate indicates an indirect fiscal effect of $753 per year for one low-skilled immigrant—equal to nearly 30 percent of the yearly federal tax payments of the median low-skilled worker in the United States.[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 in relation to the direct fiscal effects as reported by the Blau and Mackie (2017). The report considers a number of scenarios that 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.

[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 Sachs, Tsyvinski, and Werquin (2020) and formalize this fixed point problem in terms of integral equations.

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

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 that allow for alternative skill stratifications (Borjas 2003; Dustmann, Frattini, and Preston 2013), domestic- and foreign-born complementarity (Ottaviano and Peri 2012), endogenous occupation choice (Peri and Sparber 2009; Llull 2018b), 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 Smith and Edmontson (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 United Kingdom and find that European Economic Area (non–European Economic Area) 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 (NPV) of fiscal contributions of an immigrant as a function of age of immigration and education for the United States.[10] He finds that low-skilled immigrants are a fiscal burden in NPV 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 in this paper, and we show that this mechanism leads to positive and quantitatively large fiscal effects.

More recently, Busch et al. (2020) analyze the 2015–2016 German refugee wave through the lens of a quantitative overlapping generations model that features imperfectly substitutable workers and a quantification of the Germany tax-transfer

[8] Blau and Mackie (2017) updates the results of Smith and Edmontson (1997) with more recent data and updated methods.

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

[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 (i) increases interest rates, thereby increasing the cost of servicing government debt, and (ii) decreases wage rates, 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 IVB.

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 wage 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, Frattini, and Preston 2013). Among other things, the different results come from different assumptions on skill stratification (two versus four 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 2018b; Piyapromdee 2021; Monras 2020). We show analytically how endogenous labor supply choices mitigate the wage changes but also lead to fiscal effects themselves.

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.

I. 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

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

[13] Preston (2014, 580) writes, "While 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 led 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 values of the elasticity of substitution that we use in our main model are those that are favored by Card (1999).

[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 online 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 online Appendix A.3, we define worker skills by their position in the wage distribution, rather than their education.

high-skilled: $e_i \in \{u, s\}$. Additionally, types vary in their productivity and the tax-transfer system they face. The latter reflects, for example, 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

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

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 $Y = F(\mathcal{L}_u, \mathcal{L}_s)$.[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 ($w_e = \frac{\partial \mathcal{F}}{\partial \mathcal{L}_e}$), and aggregate income is given by $Y_e = w_e \mathcal{L}_e$. 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 with respect to the skill ratio, $\mathcal{L}_s / \mathcal{L}_u$.

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 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

$$\begin{aligned} \mathcal{R} = & \int_{\mathcal{I}_u} \left[T(y_i, i) \nu_i + T(0, i)(1 - \nu_i) \right] m_i \, di \\ & + \int_{\mathcal{I}_s} \left[T(y_i, i) \nu_i + T(0, i)(1 - \nu_i) \right] m_i \, di, \end{aligned}$$

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

A. *Fixed Labor Supply*

In this section, we first focus on the case of the 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 IB, we allow for hours worked and participation to endogenously respond to immigrant inflows. We interpret these results as the long-run indirect fiscal effects.

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

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

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

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 is an imperfect substitute 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

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

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.

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

$$(3) \qquad \mathcal{L}_u \frac{\partial w_u}{\partial \mathcal{L}_u} + \mathcal{L}_s \frac{\partial w_s}{\partial \mathcal{L}_u} = 0$$

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

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

PROOF:

Note that with constant returns to scale, one has $F(\mathcal{L}_u, \mathcal{L}_s) = w_u \mathcal{L}_u + w_s \mathcal{L}_s$. Differentiating both sides with respect to to $\mathcal{L}_u$ and using $\frac{\partial F}{\partial \mathcal{L}_u} = w_u$ 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

[17] The report of the NAS (Blau and Mackie 2017) includes federal, state, and local taxes; incarceration costs; scholarship and student loan costs; education costs; government health-care costs; veterans' benefits; refugee support costs; public good costs; and a variety of federal- and state-level transfer programs in their calculation of direct fiscal effects.

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:

See Appendix A.A1.

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 that 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.

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*

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

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

PROOF:

See Appendix A.A2.

[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, chap. 7).

[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 $\kappa_u/\sigma \times y_i \times \left(\bar{T}'_u - \bar{T}'_s\right)$, where κ_u is the income share of low-skilled labor.

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.—If low-skilled immigration can potentially lead to fiscal gains, a natural question to ask is whether low-skilled immigration could be an effective way to raise government revenue. For this, we turn to the concept of the marginal value of public funds (MVPF) (Hendren and Sprung-Keyser 2020; Finkelstein and Hendren 2020), which is given by

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

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 that 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

[20] This can also be written in terms of the own-wage elasticity as $d\mathcal{R}^{ex}_{ind}(i) = |\gamma_{u,own}| \times y_i \times (\bar{T}'_s - \bar{T}'_u)$. 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 payments are affected in country 1. Thus, the fiscal effect is the same in both economies.

[21] In online Appendix B.1, 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).

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 posttax income resulting from the change in wages:

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

Note that this aggregate willingness to pay is negative whenever $\left(1 - \bar{T}_s'\right) < \left(1 - \bar{T}_u'\right)$ 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:

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

The MVPF is then given by

$$MVPF(i) = 1/\left[1 + \frac{d\mathcal{R}_{dir}(i)}{d\mathcal{R}_{ind}^{ex}(i)}\right]. \tag{5}$$

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 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.

B. *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 margins. The implied changes in labor supply, in turn, affect the

[22] Our measure of MVPF only accounts for residents' willingness to pay, not for the willingness to pay of the immigrant themself. 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 willingness to pay is also positive. In this case, immigration could be thought of as a spending program, and a higher MVPF would imply that the program is more cost-effective.

[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.

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 with respect to 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 dw_u/w_u and dw_s/w_s. The implied change in tax payment of residents is given by*

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

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

PROOF:
See Appendix A.A2.

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.

An important issue, however, is that the wage changes $\frac{dw_u}{w_u}$ and $\frac{dw_s}{w_s}$ are endogenous with respect to 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

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

[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.

The first term captures the wage change induced by immigration directly since $L^{Im}/\mathcal{L}_u$ 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

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

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

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

The bracket on the right-hand side captures the equilibrium change in the relative wage, 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

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

The expressions given by (9) and (10) constitute a system of integral equations. In Appendix A.A2 we derive the following result on the wage changes in general equilibrium.

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

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

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

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

PROOF:

See Appendix A.A2.

Note that, absent resident labor supply responses, an immigrant inflow leads to a relative wage change for low-skilled workers of $\frac{d\hat{w}_u}{w_u} = \gamma_{u,own}\left(\frac{L^{Im}}{\mathcal{L}_u}\right)$ and a relative wage change for high-skilled workers of $\frac{d\hat{w}_s}{w_s} = \gamma_{s,cross}\left(\frac{L^{Im}}{\mathcal{L}_u}\right)$. 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 $e \in \{u, s\}$, where 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*

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

where

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

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

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

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

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 A.A2.

How does this formula differ from that in Proposition 1? First of all, the indirect fiscal effect is scaled down by $1/\left(1 + \bar{\xi}^u \frac{\kappa_s}{\sigma} + \bar{\xi}^s \frac{\kappa_u}{\sigma}\right)$ 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 in taxes, while $\overline{\varepsilon_u T_u'}$ captures that low-skilled residents decrease their hours worked and pay less in 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 II and present the results in Section III. 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

$$d\mathcal{R}_{ind}(i) = RelWages(i) + FiscExternalities(i),$$

where

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

and

$$(11) \quad FiscExternalities(i) = \frac{y_i \times \frac{\kappa_s}{\sigma}}{1 + \bar{\xi}^u|\gamma_{u,own}| + \bar{\xi}^s|\gamma_{s,own}|}\Big(\overline{\varepsilon_s T_s'} - \overline{\varepsilon_u T_u'} + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}}\Big).$$

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.

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

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

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

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

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

$$\begin{aligned} NetCosts(i) &= -d\mathcal{R}_{dir}(i) - d\mathcal{R}_{ind}^{ex}(i) \\ &= -d\mathcal{R}_{dir}(i) - RelWages(i) - FiscExternalities(i). \end{aligned}$$

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

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

The differences between the MVPF with endogenous labor supply given by (12) and that with exogenous labor supply given by (5) reflect 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.

II. 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. 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 IIA, 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.[28] To obtain our sample of residents, we use data from the 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 for the fiscal cost associated with Medicaid. Programs like SNAP or 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 SIPP. With the SIPP, we estimate effective transfer phaseout 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 IIB and the effective tax rate calibration in Section IIC.[29]

A. *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 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 -0.51 ($\sigma = 1.5$) to -0.31 ($\sigma = 2.5$) for these two polar cases.[30]

Labor Supply Elasticities.—In our baseline specification, we assume that all individuals have common intensive and extensive labor supply elasticities. Specifically,

[28] The Congressional Budget Office estimates effective marginal tax rates for low- and medium- income workers in the United States (Congressional Budget Office 2015). We cannot use their estimates directly as they only provide the median, tenth, and ninetieth percentiles of marginal tax rates for different income groups. Further, their calculations do not include workers with income over 450 percent of the federal poverty line and do not account for TANF or Supplemental Security Income payments.

[29] Our quantification could be extended to account for the taxation of interest and pension income and for estate taxes. Accounting for interest 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.

[30] 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.

we set the intensive margin elasticity of $\varepsilon_i = 0.33$ and an extensive margin elasticity of $\eta_i = 0.25$ for all individuals *i*, based on the pooled estimates in Chetty (2012).[31]

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 online 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 percent.[32] Finally, the formula in Proposition 2 shows that the income of the immigrants also plays a role beyond 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. Again using 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.

B. *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 percent of the US population.[33] 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, 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.

[31] 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 that 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.

[32] The real interest rate on 30-year bonds was on average 0.99 (0.81) in the last 10 (5) 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 percent interest rate in online Appendix D.3.

[33] We use ACS data obtained from the US Integrated Public Use Microdata Series (Ruggles et al. 2021).

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

[35] Top wage incomes are underrepresented in most survey datasets. 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 $\alpha = 1.5$.

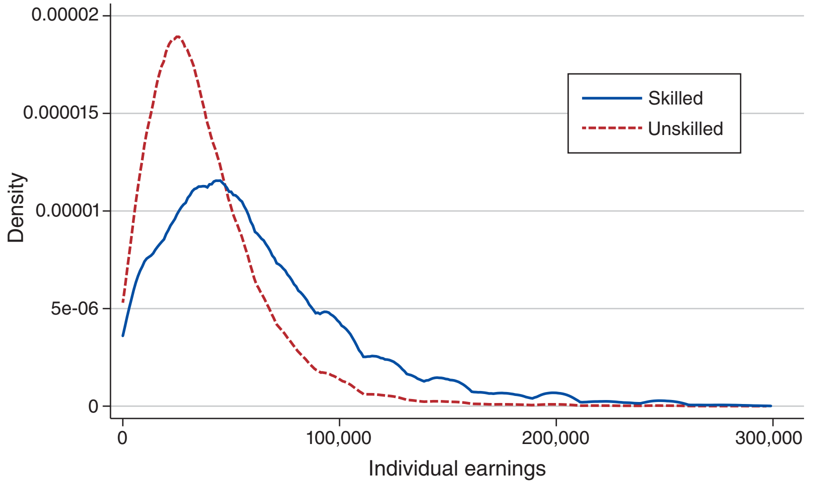

Figure 1. Kernel Density Plot of Individual Earnings for Low-Skilled and High-Skilled Individuals in Our Sample, Conditional on Having Positive Earnings

Notes: 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.

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.

SIPP.—We also incorporate data from the SIPP (US Census Bureau 2021), 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, 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 (Bureau of Labor Statistics 2019), 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 individu-

[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 online Appendix D.4.

al'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.

C. *Tax-Transfer System*

Income Taxes and the EITC.—To calculate marginal income and payroll tax rates, we use NBER's TAXSIM (Feenberg and Coutts 1993), 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 Online Appendix C.1.

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 the 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 percent for high-skilled workers and 20.4 percent for low-skilled workers. State income tax systems are less progressive. We find marginal state income tax rates of 4.9 percent and 4.1 percent for high- and low-skilled workers, respectively.

Welfare Programs.—SNAP benefits are declining in income; in the phaseout region of the SNAP benefit schedule, a dollar increase in monthly income is associated with a $0.24 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 percent (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 of 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 online Appendix C.2.

The dashed green line in the left of Figure 2 gives the marginal phaseout rate of social transfers, where social transfers are given by the sum of TANF and SNAP

[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 in 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 ages 53 and 60. We therefore do not have income information for the last few years of individuals' working lives. We therefore assume that income for the remainder of the working life is equal to a respondent's last-observed income.

[38] Online 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.

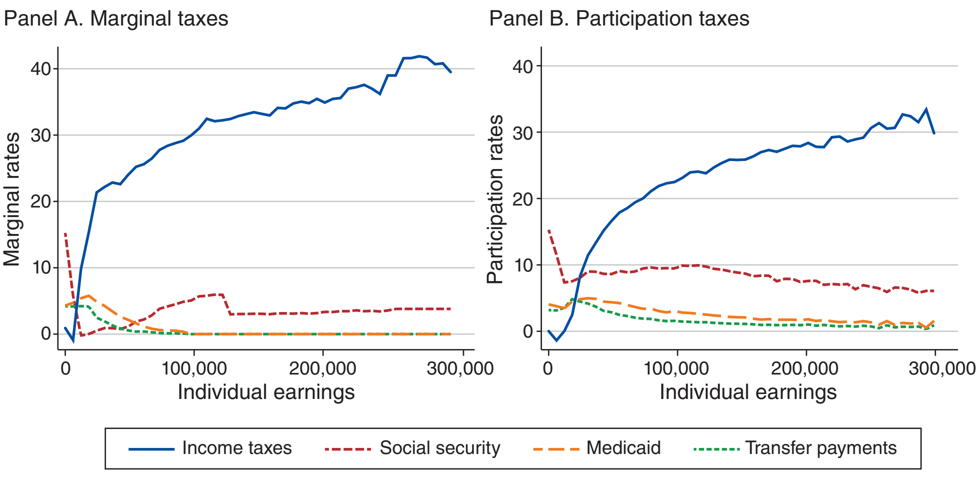

Figure 2. Marginal and Participation Tax Rates by Individual Earnings

Notes: 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 phaseouts.

benefits. We can see that the marginal phaseout rate of transfer payments is positive but small for low levels 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 phaseout 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 phaseout rates are shown in rows 3 and 4 in Table 1. The estimates of the average marginal phaseout rates of SNAP are small, at 0.3 percent for high-skilled workers and 1.1 percent for low-skilled workers. This might seem surprising given that the phaseout 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 phaseout rates of SNAP occur at relatively low income levels.[40] The estimates for TANF are even smaller—the average income-weighted TANF benefits are 0.1 percent for low-skilled workers and less than that for high-skilled workers. As with SNAP, TANF recipients have low incomes and

[39] The fact that the phaseout rate is so low reflects the facts that (i) take-up of TANF and SNAP is less than 100 percent and (ii) the plot shows the phaseout as a function of individual's earnings, holding spouses earnings constant. Regarding (i), one reason could be that individuals "bank" their eligibility for the future since there are are time limits in most states (Low et al. 2018). Regarding (ii), 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 phaseout rate of SNAP for households with four members. As with other demographic groups, the phaseout rate for those on SNAP is 24 percent. However, given that take-up is less than 100 percent, we estimate an average phaseout rate of only 15 percent for households whose income places them in the phaseout 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 phaseout rates.

Table 1—Estimates of Income-Weighted Effective Marginal Tax Rates

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

Notes: 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.

therefore receive little weight in the calculation of the income-weighted average marginal phaseout rate. Furthermore, only 2.5 million individuals received TANF in the average month in 2017.[41] Therefore, while the marginal phaseout 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 online 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 percent and 0.7 percent for low- and high-skilled workers, respectively.

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 percent until the maximum taxable earnings threshold, after which the marginal rate drops to 2.9 percent.[43]

[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.

[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 percent.

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-earning 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 online Appendix C.4.

The dotted green lines 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 postretirement. 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 percent for low-skilled workers and 10.4 percent 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 percent for low-skilled workers and 7.0 percent 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 percent for low-skilled workers and 3.4 percent for high-skilled workers.

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 percent.

[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.

II. 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 IIIB.

A. *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 percent 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 11 and 12 in online 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 $831 ($1,008) for high school graduates and $642 ($779) for high-school-dropout immigrants.

B. *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 NAS (Blau and Mackie 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 choose 79 years because the life expectancy at age 23 in the United States 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; veterans' benefits; refugee support costs; government health-care 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

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

[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] The NAS (Blau and Mackie 2017) also accounts for schooling costs, but these are less relevant here given that we consider low-skilled immigrants from age 23 onward.

Table 2—Indirect Fiscal Effects of Low-Skilled Immigrants

	Elasticity of substitution		
	1.5	2.0	2.5
1. No labor supply responses	1,004	753	602
2. Endogenous labor supply	1,133	913	765

Notes: 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.

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 percent the average costs of public goods, (iii) marginal costs are equal to 50 percent of average costs, and (iv) marginal costs equal average costs.[50] For all of these four scenarios, we can calculate the 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 \$1,525 with an MVPF of 0.54. In the case when marginal costs are equal to 25 percent of average costs and the direct fiscal effect is −\$86, we find a total fiscal effect of \$744 with an MVPF of 1.12. 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 \$1,703 with an MVPF of 0.36 when the direct effect is equal to \$695 and a total

[49] Dustmann and Frattini (2014) give a detailed discussion about this for the United Kingdom 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" (Blau and Mackie 2017, 266).

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

Table 3—Annuitized Direct Fiscal Effect of an Immigrant That Arrives at Age 23 and Dies at Age 79

Public goods scenario	High school dropout	High school graduate	Average
Zero marginal costs	−4,151	695	−1,388
$MC = 0.25 \times AC$	−4,922	−86	−2,165
$MC = 0.5 \times AC$	−5,693	−867	−2,942
$MC = AC$	−7,235	−2,429	−4,496

Notes: We use a discount rate of 1 percent. Only direct fiscal contributions are accounted for and rely on Figure 8-21 of Blau and Mackie (2017). We calculate the annuity value for the period of 23 until 65 (age of retirement).

effect of \$922 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]

IV. Robustness and Discussion

Section IVA 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 online Appendix A. Section IVB discusses the role of physical capital. Section IVC discusses further issues.

A. *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: (i) production with four imperfectly substitutable education groups and imperfect substitutability between experience levels, as utilized by Borjas (2003); (ii) production with imperfectly substitutable foreign-born and domestic-born workers, as in Ottaviano and Peri (2012); and (iii) production where skills are defined by an individual's position in the wage distribution rather than by their education, as in Dustmann, Frattini, and Preston (2013). The details are in online Appendixes A.1, A.2, and 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 (2018b) highlight the importance of occupation adjustments in mitigating the wage effects of immigration.[52] In online

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

[52] See also Foged and Peri (2016) and Patt et al. (2021) for evidence of task supply responses to immigrant inflows. Llull (2018b) estimates the effects of immigration on wages and welfare using a dynamic equilibrium

Table 4—Estimates of Annual Indirect Fiscal Effect of One Low-Skilled Immigrant under Different Model Specifications

Specification	Indirect effect	Section	Main reference/source of estimates
Baseline model		Sections I–III	Acemoglu and Autor (2011); Card (2009)
Exogenous resident labor supply	\$753		
Endogenous resident labor supply	\$913		
Education and experience groups	\$1,305	Online Appendix A.1	Borjas (2003)
Domestic- and foreign-born complementarity	\$759	Online Appendix A.2	Ottaviano and Peri (2012)
Skills by position in wage distribution	\$775	Online Appendix A.3	Dustmann, Frattini, and Preston (2013)
Endogenous task supply	\$1,918	Online Appendix A.4	Peri and Sparber (2009)
Decreasing returns to scale	\$802	Online Appendix A.5	Burnside (1996)

Notes: 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.

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 online 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.

B. *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 $Y = F(\mathcal{L}_u, \mathcal{L}_s, K)$ 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, $K^{\star}(\mathcal{L}_s, \mathcal{L}_u)$. Therefore, one can redefine production in terms of labor quantities given the endogenous capital level as

model that includes occupation, education, and labor force participation decisions. We discuss the implications of endogenous education choice on indirect fiscal effects in online Appendix A.6.

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

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 $F(\mathcal{L}_u, \mathcal{L}_s, K) = K^\alpha (G(\mathcal{L}_u, \mathcal{L}_s))^{1-\alpha}$, where $G(\cdot)$ is a CRTS labor aggregate. With elastic capital supply, the ratio of capital to the labor aggregate is constant. As we show in online Appendix B.6, we can therefore rewrite the production function as $\tilde{F}(\mathcal{L}_u, \mathcal{L}_s) = \bar{A}G(\mathcal{L}_u, \mathcal{L}_s)$, 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 were inelastic. Consider again the Cobb-Douglas production function that combines physical capital, K, with a labor aggregate G:

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

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

As we show in online Appendix B.6, the indirect fiscal benefit with inelastic labor supply for an immigrant of type i is given by

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

where $\gamma_{u,own}^{elast} = \frac{\partial \log(\partial G / \partial \mathcal{L}_u)}{\partial \log \mathcal{L}_u}$ is the own-wage elasticity of low-skilled labor when capital supply is perfectly elastic. This is simply equal to $\gamma_{u,own}^{elast} = \left(\frac{-1}{\sigma}\right)\kappa_s$, 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]

[53] As we show in online Appendix B.6, $\gamma_{u,own}^{elast} = \left(\frac{-1}{\sigma}\right)\kappa_s$, 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 nonseparable capital and capital-skill complementarity, as in the models in Lewis (2011) and Lewis (2013).

[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 percent in online Appendix A.5 and capital share parameter of $\alpha = 0.33$, we find that the indirect fiscal effect of an average

C. *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.[55] 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.

More structural approaches have been taken in the literature more recently—e.g., by Llull (2018b), who considers endogenous responses of workers along the occupation and education margin; by Bound et al. (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.[56] 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 themself. 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.[57]

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 are taxed at a different rate than the goods for which the relative prices decrease. An effect that probably matters more is the interaction between

low-skilled immigrant with inelastic capital supply will increase by $y_i \alpha(\tau_k - \bar{T}_l') = \$161$ compared to the case with elastic capital supply.

[55] See, for example, Card (1990); Cohen-Goldner and Paserman (2011); Llull (2018a); Monras (2020); Borjas (2015); and Edo (2020) for reduced-form evidence comparing the short- and long-run wage impacts.

[56] The NAS (Blau and Mackie 2017) summarizes 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.

[57] 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.

the prices for these services and resident labor supply. Cortés and Tessada (2011) show that high-skilled female native labor supply increased due to 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 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.

V. 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 United States, we find that the indirect fiscal effects of low-skilled immigration are sizable and positive. For some plausible scenarios, 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 US 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.

Appendix A. Theoretical Appendix

A1. *Relation between Own-Wage Elasticity and Elasticity of Substitution*

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

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

Now consider an increase of low-skilled labor by 1 percent. This increases the ratio of low-skilled over high-skilled labor by 1 percent (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 $1/\sigma$.

Next, derive the percentage change of w_u/w_s by using the cross- and own-wage elasticity. The numerator changes by $\gamma_{u,own}$ percent. The denominator changes by $\gamma_{s,cross}$ percent. 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 $\gamma_{u,own} + \gamma_{u,own} \frac{w_u \mathcal{L}_u}{w_s \mathcal{L}_s}$.

As a consequence, we have to have

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

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

A2. *Baseline Model with Labor Supply*

Proof of Proposition 1.—Note that tax revenue in this economy provided by residents is given by

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

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:

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

Taking derivatives yields

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

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

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

$$+ \gamma_{s,cross} \frac{\omega_j h_j}{\mathcal{L}_u} \int_{\mathcal{I}_s} \frac{\partial T(y_i, i)}{\partial y_i} h_i \omega_i w_s m_i di.$$

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

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

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

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

Finally, using Lemma 2 yields

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

Proof of Lemma 3.—Tax revenue is given by

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

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 implied endogenous responses of the residents along both the intensive and extensive margins. Then, it follows from the definitions of the labor supply elasticities that tax revenue changes according to

$$\text{(A1)}\quad d\mathcal{R}_{ind} = \int_{\mathcal{I}_u}T'(y_i,i)y_i\frac{dw_u}{w_u}(1+\varepsilon_i)\nu_i m_i di + \int_{\mathcal{I}_s}T'(y_i,i)y_i\frac{dw_s}{w_s}(1+\varepsilon_i)\nu_i m_i di + \int_{\mathcal{I}_u}T_{part}(y_i,i)y_i\frac{dw_u}{w_u}\eta_i\nu_i m_i di + \int_{\mathcal{I}_s}T_{part}(y_i,i)y_i\frac{dw_s}{w_s}\eta_i\nu_i m_i di.$$

Proof of Lemma 4.—The set of integral equations is given by

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

and

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

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 $\omega_i L_i / \mathcal{L}_u$ and integrating over $\mathcal{I}_u$ gives

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

which can be written as

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

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

Equivalently, we obtain

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

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

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

and

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

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 $\omega_i L_i / \mathcal{L}_e$ and integrating over $\mathcal{I}_e$ yields

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

Using $d\mathcal{L}_e \ = \ \int_{\mathcal{I}_e} dL_i \omega_i di$ and $\bar{\xi}^e \ = \ \left(\int_{\mathcal{I}_i} \xi_i \omega_i L_i di \right) / \mathcal{L}_e$ gives us

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

Therefore, we have

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

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

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

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

Now using the equilibrium wage changes:

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

and

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

as well as

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

implies the following:

$$\text{(A2)} \qquad d\mathcal{R}_{ind} = \frac{\frac{L^{Im}}{\mathcal{L}_u}|\gamma_{u,own}|Y_u}{1-\bar{\xi}^u\gamma_{u,own} - \bar{\xi}^s\gamma_{s,own}}\Bigg[-\frac{\int_{\mathcal{I}_u} T'(y_i,i)y_i(1+\varepsilon_i)\nu_i m_i di}{Y_u}$$
$$+\frac{\int_{\mathcal{I}_s} T'(y_i,i)y_i(1+\varepsilon_i)\nu_i m_i di}{Y_s}$$
$$-\frac{\int_{\mathcal{I}_u} T_{part}(y_i,i)y_i\eta_i\nu_i m_i di}{Y_u}$$
$$+\frac{\int_{\mathcal{I}_s} T_{part}(y_i,i)y_i\eta_i\nu_i m_i di}{Y_s}\Bigg],$$

and, hence,

$$\text{(A3)} \quad d\mathcal{R}_{ind}(i) = \frac{y_i|\gamma_{u,own}|}{1 + \bar{\xi}^u|\gamma_{u,own}| + \bar{\xi}^s|\gamma_{s,own}|}\Big(\bar{T}_s' - \bar{T}_u' + \overline{\varepsilon_s T_s'} - \overline{\varepsilon_u T_u'} + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}}\Big).$$

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

$$\text{(A4)} \quad d\mathcal{R}_{ind}(i) = \frac{y_i\frac{\kappa_s}{\sigma}}{1 + \bar{\xi}^u\frac{\kappa_s}{\sigma} + \bar{\xi}^s\frac{\kappa_u}{\sigma}}\Big(\bar{T}_s' - \bar{T}_u' + \overline{\varepsilon_s T_s'} - \overline{\varepsilon_u T_u'} + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}}\Big).$$

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