The Indirect Fiscal Benefits of Low-Skilled Immigration*

Mark Colas
University of Oregon

Dominik Sachs
University of Munich

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Abstract

Low-skilled immigrants indirectly affect public finances through their effect on native wages & labor supply. We operationalize this general-equilibrium effect in the workhorse labor market model with heterogeneous workers and intensive and extensive labor supply margins. We derive a closed-form expression for this effect in terms of estimable statistics. We extend the analysis to various alternative specifications of production technology and labor supply. Empirical quantifications for the U.S. reveal that the indirect fiscal benefit of one low-skilled immigrant lies between $770 and $2,100 annually. The indirect fiscal benefit may outweigh the negative direct fiscal effect that has previously been documented and challenges the perception of low-skilled immigration as a fiscal burden.

*mcolas@uoregon.edu and dominik.sachs@econ.lmu.de. We would like to thank Jonathan M.V. Davis, Juan Dolado, Ben Elsner, Axelle Ferriere, Sebastian Findeisen, Lisandra Flach, Tommaso Frattini, Ulrich Glogowsky, Wojciech Kopczuk, Fabian Lange, Andreas Peichl, Panu Poutvaara, Florian Scheuer, Monika Schnitzer, Stefanie Stantcheva, Kjetil Storesletten, Jan Stuhler, Uwe Thuemmel, Aleh Tsyvinski, Alessandra Voena, 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 as well as seminar participants at Ben Gurion University, University of Bonn, KU Ingolstadt, and University of Regensburg for helpful comments and suggestions. We also thank Mehmet Ayaz, Lea Fricke, Oleksandr Morozov and Taylor Watson for great research assistance.

1 Introduction

Low-skilled immigrants are widely considered a fiscal burden in the United States.[1] Perhaps most prominently, the National Academy of Sciences (NAS) recently published a detailed report on the economic and fiscal consequences of immigration in the U.S. (National Academy of Sciences, 2017). For most of the fiscal scenarios that the report considered, low-skilled immigrants have negative effects on public finances.[2] This NAS report was politically influential and cited by Donald Trump in his first address to congress in 2017, where he stated: "(a)ccording to the National Academy of Sciences, our current immigration system costs America's taxpayers many billions of dollars a year."[3]

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

> *"(b)eyond the taxes they pay and the programs they use themselves, the flow of foreign-born also affects the fiscal equation for many natives as well, at least indirectly... In a comprehensive analysis, these ripple effects in the economy would be accounted for; however, due to the complexity of operationalizing a general equilibrium approach into the accounting framework, they typically are omitted." (National Academy of Sciences, 2017, p.263)*

In this paper we take on this issue and operationalize the indirect fiscal effect that low-skilled immigrants have through their effect on native wages and native labor supply. Specifically, we derive closed-form expressions for this indirect fiscal effect in various models of immigration and the labor market. The formulas provide an intuitive understanding of the economic forces at work and allow for a transparent quantification. We quantify these formulas by combining existing empirical evidence with a detailed empirical quantification of the U.S. tax-transfer system. One low-skilled immigrant that enters the U.S. adds between $770 and $2,100 annually

[1] Alesina, Miano, and Stantcheva (2018) found that 15% of respondents to a survey in the United States believed that an average immigrant received more than twice the amount in government transfers as the average citizen. According to a 2019 Gallup poll, 42% of Americans believed immigration was making the tax situation in the U.S. worse, compared to only 20% who believe immigration improved the U.S. tax situation. This 42% is larger than the percentage of respondents who believe immigration made the US worse off in terms of 1) the economy in general, 2) job opportunities, and 3) social and moral values (`https://news.gallup.com/poll/1660/immigration.aspx`). The public's perception of the effect of immigration on public finances plays a large role in shaping natives' perceptions of immigration (Dustmann and Preston, 2007; Boeri, 2010).

[2] George Borjas, a member of the NAS panel, wrote a short user's guide on this report and stated "(r)egardless of which scenario, it is obvious that low-skill immigrants impose a fiscal burden in the long run..." (Borjas, 2016a, p.14).

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

to public finances through this indirect effect. This outweighs the direct fiscal costs for some scenarios of the NAS report and significantly reduces the burden in the other scenarios.

The insight that low-skilled immigration has a positive indirect fiscal effect relies on a simple economic mechanism. Consider the most simple textbook setup with two imperfectly substitutable skill levels and exogenous labor supply of natives.[4] In this setup, low-skilled immigration raises high-skilled wages and lowers low-skilled wages. Hence, tax payments of high-skilled natives increase whereas tax payments of low-skilled natives decrease. If immigrants are paid their marginal product, they do not affect the overall size of national income accruing to natives but only the distribution. Hence, what the low-skilled natives lose is what high-skilled natives gain. As a consequence, tax revenue from natives increases if high-skilled individuals face higher marginal tax rates than low-skilled individuals. We show that this effect boils down to the size of the wage effects as measured by the own-wage elasticity of low-skilled labor and the progressivity of the tax system as measured by the difference in the marginal tax rates of the two skill types. This allows for a transparent pen and paper calculation.

We then turn to our main model specification that includes two main extensions: individual productivity levels are continuously distributed conditional on skill level, as in the so-called "canonical model" (Acemoglu and Autor, 2011), and workers can respond to immigrant inflows via both intensive and extensive labor supply adjustments. We allow for labor supply elasticities to differ with income, gender and family status.[5] The labor supply responses of natives alter the indirect fiscal benefit because they have fiscal consequences themselves; if immigration decreases native labor supply, for example, this would decrease tax revenue. Further, these labor supply responses themselves induce wage effects which creates a fixed point problem. Following Sachs, Tsyvinski, and Werquin (2020), we formalize this in terms of integral equations and show that the indirect fiscal effect can be expressed as a closed-form expression of estimable statistics: own-wage elasticities, income-weighted averages of (i) labor supply elasticities, (ii) marginal tax rates, as well as (iii) products of participation (marginal)

[4] We will generally use the term "natives" to refer to all individuals already in the country at the time of an immigrant inflow, including foreign-born workers who immigrated earlier. In Section 6.2 and Section 6.4, we will explicitly distinguish between native-born workers and foreign-born workers, which 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).

[5] As emphasized by Dustmann, Schönberg, and Stuhler (2016, p. 44) "wage and employment responses need to be studied jointly to obtain an accurate picture of the labor market impacts of immigration". These authors also highlight that it is important to allow for labor supply responses to 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.

tax rates and extensive (intensive) marginal labor supply elasticities – all conditional on high school and college education. The formula also allows for a transparent decomposition of our indirect fiscal effect into effects that result from the change in relative wages holding labor supply fixed (as described in the previous paragraph) and fiscal externalities that arise from the change in native labor supply. As we discuss, this distinction is important for analyzing the welfare implications of the indirect fiscal effects.

We evaluate this formula 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. However, TAXSIM does not account for welfare-transfer programs nor does it account for future social security receipts, both which vary with income. To account for this, we use the SIPP to estimate Supplementary Nutrition Assistance Program (SNAP) and Temporary Assistance for Needy Families (TANF) receipts as a function of income and household characteristics. We use the NLSY79 combined with the ACS to understand how changes in current income change the distribution of the individual's earnings over the life cycle, and ultimately their receipt of social security payments in the future. The second 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.

Combining our empirical quantification of the U.S. tax system with our closed-form solutions for the indirect fiscal effect, we find that the indirect fiscal effect of one low-skilled immigrant is between \$770 and \$1,470 per year if we consider a plausible range for the elasticity of substitution between high and low-skilled labor as argued by Card (2009). We set these numbers into relation to the direct fiscal effects as reported by the National Academy of Sciences (2017). Using National Academy of Sciences (2017), we calculate an annualized direct fiscal cost associated with low-skilled immigrants under a number of scenarios which vary the marginal cost of public goods and the education of the immigrant. In almost all cases, the direct fiscal effect is negative and of a similar magnitude to the indirect fiscal effects we calculated. In some of the scenarios we consider, accounting for the indirect fiscal costs of immigrant turns the *total* fiscal effect from a fiscal burden to a fiscal surplus. While we are aware that this result of 'turning the sign' does not hold for all possible specifications, this clearly shows that the indirect fiscal effect of low-skilled immigration can be of the same order

Specification	Indirect Effect	Section	Main Reference/Source of Estimates
Simple Textbook Model	$1,104	Section 2	Borjas (2014)
Canonical Model		Sections 3 - 5	Acemoglu and Autor (2011), Card (2009)
Exogenous Native Labor Supply	$975		
Intensive Margin Adjustments	$1,113		Chetty (2012), Bargain, Orsini, and Peichl (2014)
Extensive Margin Adjustments	$1,074		"
Both Intensive and Extensive	$1,186		"
Education and Experience Groups	$1,873	Section 6.1	Borjas (2003)
Domestic- and Foreign-Born Complementarity	$1,065	Section 6.2	Ottaviano and Peri (2012)
Skills by Position in Wage Distribution	$1,017	Section 6.3	Dustmann, Frattini, and Preston (2013)
Endogenous Task Supply	$2,131	Section 6.4	Peri and Sparber (2009)
Decreasing Returns to Scale	$1,057	Section 6.5	Burnside (1996)

Table 1: Estimates of annual indirect fiscal effect of one low-skilled immigrant under different model specifications. For the "Simple Textbook Model" and the "Canonical 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 the "Canonical Model" with labor supply adjustments, we display our results with common labor supply elasticities. For all specifications, we show the indirect effect for the average low-skilled immigrant. See text for details on each specification.

of magnitude as the direct fiscal effect and of the opposite sign. It should be accounted for when calculating the fiscal effects of immigration.

There is some controversy in the literature over the appropriate model to analyze and estimate the wage effects of immigration. A natural concern therefore is that the indirect fiscal effects are also sensitive to these modeling choices. Therefore, we extend our model to allow for a variety of different production functions and labor supply responses. These extensions and the associated indirect fiscal effects are summarized in Table 1. First, we consider three alternative production specifications that have been utilized in the immigration literature: 1) production with four imperfectly substitutable education groups and imperfect substitution between experience levels, as utilized by Borjas (2003), 2) production with imperfectly substitutable foreign-born and domestic-born workers, as in Ottaviano and Peri (2012), and 3) production where skills are defined by an individual's position in the wage distribution, rather than their education, as in Dustmann, Frattini, and Preston (2013). We show that our formula extends naturally to these more elaborate production technologies. Next, we combine these expressions for the indirect fiscal effects with our empirical quantification of the effective tax rates to calculate the indirect fiscal effects in each setting. For all three specifications, we find indirect fiscal effects in the range of $1,000 to $1,900. When we use the same elasticity of substitution between skill levels in all three specifications, the indirect fiscal effects all lie within $250 of each other. As emphasized by Dustmann, Schönberg, and Stuhler (2016), these production functions have very different implications for which workers bear the largest incidence of low-skilled immigrant inflows.[6] However, for the sake of calculating indirect fiscal effects, these differences in production technology do not seem to be of first-order importance.

Next, we consider a model with endogenous task supply as in Peri and Sparber (2009).[7] In the model, low-skilled workers may react to additional low-skilled immigration by changing occupations and therefore changing their supply of manual and communication tasks. The authors estimate that low-skilled domestic-born workers 'upgrade' their occupation by supplying more communication tasks in response to immigration. For example, native construction workers may begin to work more as supervisors for newly arrived immigrants in response to immigrant inflows. This upgrading of occupations leads to an additional fiscal effect because these workers earn higher wages and therefore pay higher taxes. As such, we find an indirect fiscal benefit of over $2,130 in this framework, roughly half of which is due to endogenous occupation upgrading of domestic-born low-skilled workers.

Finally, we calculate the indirect fiscal effect when production exhibits decreasing returns to scale. When production exhibits decreasing returns to scale, 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 thereby shifting the distribution of national income from workers to firms. We show that this additional effect can be accounted for with an additional term in our indirect fiscal benefits formula which gives the difference in the tax rate of profits and the income weighted tax rates of all workers multiplied by the 1 minus the returns to scale of the production function. 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.

Related Literature The literature that studies the fiscal effects of immigration has primarily focused on the direct fiscal effect. Preston (2014) provides a comprehensive overview on the topic. Economists have employed a variety of methods to measure this direct fiscal impact of immigration. Borjas and Hilton (1996) quantify how much more likely immigrants are to participate in welfare programs. Dustmann and Frattini (2014) provide a detailed accounting approach for the UK and find that EEA (non EEA) immigrants on average contributed

[6]Ottaviano and Peri (2012) for example, show that in a model with domestic- and foreign-born complementary may imply that low-skilled domestic-born workers experience a wage increase as a result of low-skilled immigrant inflows.

[7]See also Foged and Peri (2016) and Patt, Ruhose, Wiederhold, and Flores (2020) for evidence of native task supply responses to immigrant inflows. Llull (2018) highlights the importance of occupation adjustments in mitigating the wage effects of immigration on natives.

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. Monras, Vázquez-Grenno, and Elias (2018) find that a policy which legalized 600,000 undocumented immigrants in Spain led to increases in payroll tax revenues.[8]

Storesletten (2000) takes a more macroeconomic model-based perspective and quantifies the net present value of fiscal contributions of an immigrant as a function of age and education for the U.S.. Storesletten (2003) provides a similar calculation for Sweden. Recently, Busch, Krueger, Ludwig, Popova, and Iftikhar (2020), analyze the welfare and fiscal effects of the 2015-2018 refugee wave in Germany through the lens of a quantitative OLG model.

We are the first paper to quantify the indirect fiscal effects of low-skilled immigration, which we show to be of a similar magnitude, but the opposite sign, of the direct effects of immigration estimated in the literature. While such indirect fiscal effects have been mentioned previously, the conjecture was that the effects are rather of second order compared to the direct fiscal effects.[9]

Roadmap We progress as follows. In Section 2 we use a simple benchmark model to illustrate the mechanism behind the indirect fiscal effect transparently. Section 3 presents our main quantitative model and Section 4 presents our empirical quantification. Section 5 presents our main quantitative results. In Section 6, which evaluate the indirect fiscal effects under various alternative environments. Section 7 concludes.

2 The Simple Benchmark Model

To highlight our result transparently, we start with the simple textbook model for the impact of immigration on native wages (Borjas, 2014; Bodvarsson and Van den Berg, 2009). Consider an economy that is populated by individuals that are either high-skilled or low-skilled. The mass of low-skilled individuals is N_u and the mass of high-skilled individuals is N_s. Denote individual labor supply by h_u and h_s. Production of the single consumption good, whose

[8]The authors estimate the causal effect of the amnesty program on province-level payroll tax revenue. As such, the effects on payroll tax revenue they find may include both direct and indirect fiscal effects given that the authors find the policy led to increases labor market opportunities for immigrants who were given amnesty.

[9]The authors of the NAS report write "(b)eyond the taxes they pay and the programs they use themselves, the flow of foreign-born also affects the fiscal equation for many natives as well, at least indirectly... In a comprehensive analysis, these ripple effects in the economy would be accounted for; however, due to the complexity of operationalizing a general equilibrium approach into the accounting framework, they typically are omitted. The fiscal impacts literature has generally concluded that these kinds of impacts are minor relative to overall economic activity." Preston (2014) writes "(w)hile interesting, the implied tax effects are not plausibly large relative to the effects that will be found by a simple accounting approach."

price is normalized to one, is described by a constant returns to scale production function $Y = F(L_u, L_s)$ where $L_u = N_u h_u$ and $L_s = N_s h_s$ denote the aggregate labor of each respective skill level. 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 and wages are equal to marginal products, i.e. $w_i = F_{L_i}$ for $i = u, s$. Finally, denote income of the two types of workers by $y_s = h_s w_s$ and $y_u = h_u w_u$ and denote aggregate income of the skill levels by $Y_s = y_s N_s$ and $Y_u = y_u N_u$.

For simplicity, we consider a very stylized tax system, where τ_u is the tax rate on low-skilled labor and τ_s is the tax rate on high-skilled labor. $\tau_u < \tau_s$ is a stylized way of measuring tax progressivity. Tax revenue in this economy is given by

$$\mathscr{R} = N_u \tau_u h_u w_u + N_s \tau_s h_s w_s.$$

In the following, we formally study how tax revenue $\mathscr{R}$ changes due to a small influx of low-skilled immigrants dN_u. This influx has a direct fiscal effect

$$d\mathscr{R}_{dir} = \tau_u w_u h_u \times dN_u. \tag{1}$$

One low-skilled immigrant pays (potentially negative) taxes equal to $\tau_u w_u h_u$. Multiplying this with the size of the immigration influx dN_u gives the direct fiscal effect of immigration. As documented in the introduction, the direct fiscal effect has already received much attention in the literature.

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

$$d\mathscr{R}_{ind} = N_u h_u \tau_u \frac{\partial w_u}{\partial N_u} dN_u + N_s h_s \tau_s \frac{\partial w_s}{\partial N_u} dN_u. \tag{2}$$

The following lemma helps to relate the size of the wage increase 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 native labor income is unchanged:*

$$N_u h_u \frac{\partial w_u}{\partial N_u} dN_u + N_s h_s \frac{\partial w_s}{\partial N_u} dN_u = 0 \tag{3}$$
$$\Rightarrow \gamma_{s,cross} = |\gamma_{u,own}| \times \frac{w_u L_u}{w_s L_s}.$$

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

Proof. Note that with constant returns to scale one has $F(N_u h_u, N_s h_s) = w_u N_u h_u + w_s N_s h_s$. Differentiating both sides w.r.t. to N_u and using $F_{L_u} = w_u$ yields the result. □

Intuitively, immigrants obtain their marginal product and do not affect the size of the overall pie accruing to natives. Immigrants only affect the distribution of the pie between high- and low-skilled natives. The income loss of one group equals the income gain of the other group.[10] 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 $\gamma_{u,own}$.

Based on Lemma 1, we can easily simplify the indirect fiscal effect and rewrite it as stated in the following proposition.

Proposition 1. *If native labor supply is exogenous, the indirect fiscal effect of low-skilled immigration* dN_u *is given by*

$$d\mathscr{R}_{ind}^{ex} = (\tau_s - \tau_u) \times |\gamma_{u,own}| \times y_u \times dN_u. \tag{4}$$

Proof. First, note that (3) implies $N_s h_s \frac{\partial w_s}{\partial N_u} = -N_u h_u \frac{\partial w_u}{\partial N_u}$. Inserting this into the indirect fiscal effect as defined in (2) yields:

$$d\mathscr{R}_{ind} = N_u h_u \tau_u \frac{\partial w_u}{\partial N_u} dN_u - \tau_s N_u h_u \frac{\partial w_u}{\partial N_u} dN_u = (\tau_u - \tau_s)\, L_u \frac{\partial w_u}{\partial L_u} h_u dN_u$$

which then yields (4). □

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

The formula for the indirect fiscal effect (4) is very simple and allows for a straightforward interpretation.[11] Since the change in overall income of natives is unaffected as shown in Lemma 1, the change in tax payment of natives would be zero if $\tau_s = \tau_u$. However, if taxes are progressive ($\tau_s > \tau_u$), 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. The size of the effect is proportional to low-skilled income and the own-wage elasticity of low-skilled wages.[12]

Note that the increase in tax revenue comes at the cost of native net incomes. However, in modern welfare analysis income gains of different individuals and tax revenue are not weighted equally and therefore this redistribution between individuals and the government have first-order welfare effects (Hendren, 2020), see also our discussion in Section 7.3. Additionally, when we account for endogenous labor supply of natives in the next sections, low-skilled immigration causes fiscal externalities which also have immediate welfare implications (Hendren, 2015).

Formula (4) allows for a straightforward quantification. As a normalization, we set $dN_u = 1$, i.e. we normalize it to one marginal immigrant. For a CRS production function, the own-wage elasticity is given by $\gamma_{u,own} = \frac{\frac{N_S y_S}{N_U y_U + N_S y_S}}{\sigma}$, where σ is the elasticity of substitution, which we assume to be in $[1.5, 2.5]$ (Card, 2009). Importantly, as we show in Appendix A.1, this relation does not require the elasticity of substitution to be constant – we are not imposing a CES production function. To quantify this, we use data from the 2017 American Community Survey (ACS). Average earnings of high school and college-education were $y_u = \$36,079$ and $y_s = \$67,432$, respectively. Further, we know that the share of workers with and without college education was .65 and .35.[13] As a final step, we need to quantify $\tau_s - \tau_u$. We take the approximation of the U.S. tax code by Heathcote, Storesletten, and Violante (2017) which implies $\tau_s = 0.254$ and $\tau_u = 0.180$. This implies that the indirect fiscal effect is given by

[11] A result that may be surprising, is that it is independent of the size of the native 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 natives due to one immigrant are smaller by a factor of 2 – 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 natives whose tax payment is affected in country 1. Thus, the fiscal effect is the same in both economies in nominal terms. Of course, the budget is twice as large in the first economy and therefore the relative indirect fiscal impact is indeed only half as large in the economy that is twice as large.

[12] Note that the formula can also be expressed in terms of the cross-wage elasticity of high-skilled wages $\gamma_{s,cross} = \frac{N_u}{w_s}\frac{\partial w_s}{\partial N_u}$ and then reads as $d\mathscr{R}^u_{ind} = (\tau_s - \tau_u) \times |\gamma_{s,cross}| \times y_s \times \frac{N_s}{N_u} \times dN_u$.

[13] Throughout the paper, we follow Borjas (2003), Peri and Sparber (2009), and Ottaviano and Peri (2012), and define low-skilled workers as those without any college experience and define high-skilled workers as workers with at least some college experience. In Appendix C.2, we consider an alternative skill classification, in which we divide workers with some college between the two skill groups as in Katz and Murphy (1992) or Card (2009). In Section 6.3, we define worker skills by their position in the wage distribution, rather than their education.

$$d\mathscr{R}_{ind} \in [828, 1380].$$

This is a sizeable number even if we consider the lower range of wage effects (i.e. $\sigma = 2.5$).[14] This indicates that the indirect fiscal effect should not be ignored in policy discussions. We will now be more serious about its calculation and address various shortcomings of this simple model. First, wage effects are likely to be smaller since native labor supply (or native behavior more generally – they may move or change their occupation) is endogenous. Second, the production structure is simplistic in the sense that all high school workers have exactly the same productivity and all college workers as well. Other production structures may be equally likely: e.g. even conditional on skill, natives and immigrants may be imperfect substitutes. Further, one can change the assumptions about the elasticity of capital supply (which was assumed to be infinite so far), returns to scale and perfect competition. Finally, the tax function considered here is too simplistic.

We address these issues one by one. First, in the next section, we move to what we consider our main or benchmark model. We extend the simple model by (i) allowing for a continuum of productivities (and therefore income levels) conditional on skill and (ii) accounting for endogenous labor supply of natives along the extensive and intensive margin. In Section 4, we introduce our quantification of tax-transfer system, which accounts for social security payments and welfare receipts in addition to income and payroll taxes. In Section 6, we then consider the robustness of the results for the other mentioned issues like skill-stratification, occupational choice of natives, imperfect substitutability of natives and immigrants etc.

3 The Main Model: Heterogeneity and Endogenous Labor Supply of Natives

We generalize the findings from the previous section in two important ways. First, we consider the so-called canonical model (Acemoglu and Autor, 2011) with two education levels (individuals with and without college education), and a continuous distribution of productivity for each education level. Further, we allow individuals to differ not only in terms of productivity but also other variables that may affect their tax payment. Second, we account for endogenous labor supply of natives along both the extensive and the intensive margin.

[14] We find $d\mathscr{R}_{ind} = \$1,104$ given our intermediate value for the elasticity of substitution of $\sigma = 2$.

We introduce the additional heterogeneity and show how the formula for the indirect fiscal effect in Proposition 1 extends to this setting in Section 3.1. We then further extend the setting to endogenous labor supply of natives in Section 3.2. Despite the complicated fixed-point nature of the problem in general equilibrium, we show that the indirect fiscal effect can be expressed as a closed-form expression.

3.1 Incorporating Heterogeneity

An individual is indexed by its type $i \in \mathcal{I}$. A type contains many characteristics. First, individuals differ in their skill level $e_i \in \{u, s\}$. Second, they differ in their productivity ω_i. Third, they differ in terms of their tax payments: even if they have the same income, they may face a different tax schedule because of family status, living in a different state etc. Finally, different types differ in their participation rates ν_i and their labor supply elasticities: ε_i is the hours elasticity, η_i is the participation elasticity and $\xi_i = \varepsilon_i + \eta_i$ is the total hours elasticity. Denote by $L_i = h_i \nu_i m_i$ aggregate labor of type i, where h_i is hours worked of type i and m_i is the measure of type i.

First, we focus on the case of exogenous labor supply of natives and therefore set $\varepsilon_i = \eta_i = 0$ and $\nu_i = 1$ for all i. In Section 3.2, we remove this assumption.

Aggregate effective low-skilled labor is given by:

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

where $\mathcal{I}_u$ is a subset of $\mathcal{I}$ made up of low-skilled types. Equivalently, define the aggregate effective high-skilled labor supply as:

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

where $\mathcal{I}_s$ is a subset of $\mathcal{I}$ made up of high-skilled types.

The production function reads as $\mathscr{F}(\mathscr{L}_u, \mathscr{L}_s)$ and we assume constant returns to scale.[15] Wages are equal to marginal products: $w_e = \frac{\partial \mathscr{F}}{\partial \mathscr{L}_e}$. Hence, an individual of type i has gross income $y_i = h_i \omega_i w_{e_i}$, where the latter element, the skill price w_e is endogenous w.r.t. the skill ratio, $\frac{\mathscr{L}_s}{\mathscr{L}_u}$. We again define the own-wage elasticities $\gamma_{e,own} = \frac{dw_e}{d\mathscr{L}_e} \frac{\mathscr{L}_e}{w_e}$ and the cross-wage elasticities $\gamma_{e,cross} = \frac{dw_e}{d\mathscr{L}_{e'}} \frac{\mathscr{L}_{e'}}{w_e}$ with $e \neq e'$. As in the simple model, the following relation between the own- and cross-wage elasticities holds. Lemma 1 generalizes to this setting.

[15] We discuss how to accommodate physical capital in production in Section 7.1. The implications are largely unchanged.

Lemma 2. *The cross- and own-wage elasticities are related through:*

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

Before we show how Proposition 1 extends to this setting, we need to specify the tax-transfer system. Given that there is a continuous income distribution, we study a less stylized tax function than in the previous section. We instead incorporate a flexible nonlinear tax-transfer system $T(y, i)$ that maps a (potentially negative) tax payment to each level of gross income y and type i.

As a first step, we stick to the assumption of exogenous native labor supply and only extend the production structure. For this case, Proposition 1 generalizes as follows:

Proposition 2. *Assume that labor supply of natives is exogenous. The fiscal effect of one immigrant of type i with low education (i.e. $e_i = u$) and ability ω_i is given by:*

$$d\mathscr{R}^{ex}_{ind}(i) = |\gamma_{u,own}| \times y_i \times \left(\bar{T}'_s - \bar{T}'_u\right) \tag{5}$$

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

Proof. See Appendix A.2.1. □

The formula is very similar to the formula in Proposition 1 but there are two differences. First, we have to specify not only the education level of the immigrant but also the ability level ω_i. A more productive immigrant supplies a greater amount of effective labor and therefore has a larger effect on native wages. Second, since there are more than two marginal tax rates in this economy, the objects of interest are the income-weighted average marginal tax rates of the two skill groups. 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.

3.2 Incorporating Endogenous Native Labor Supply

With endogenous labor supply, the changes in the wages for low- and high-skilled labor affect labor supply decisions along the intensive and extensive margin of workers with non-zero elasticities. The implied changes in labor supply, in turn, affect the equilibrium wages again, which then triggers a change in labor supply and so on and so forth. All these adjustment effects will imply additional fiscal effects.

To formalize this, as a first step, note that tax revenue in this economy is formally given by:

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

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

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

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

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

Proof. See Appendix A.2.2. □

In the first line, the indirect fiscal effects as described in Proposition 1 are scaled up by the intensive margin elasticities. The second line of (6) captures the change in tax revenue due to changes in labor force participation of natives. 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 w.r.t. to the labor supply responses. To obtain an expression for these wage changes and hence obtain a closed form solution, we follow Sachs, Tsyvinski, and Werquin (2020) and formalize the associated fixed point in terms of integral equations.[16] First, note that these equilibrium wage changes can be divided into the effects arising from immigrant inflows, low-skilled native labor supply responses, and high-skilled native labor supply responses as

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

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

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

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

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

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

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

(9) and (10) constitute a system of integral equations.

In Appendix A.2.3 we derive the following result, which relates wage changes to the immigration inflow and the weighted average of labor supply elasticities.

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

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

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

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

Proof. See Appendix A.2.3. □

Note that absent native labor supply responses, an immigrant inflow leads to percentage low-skilled wage change of $\frac{\hat{dw_u}}{w_u} = \gamma_{u,own}\frac{L^{Im}}{\mathscr{L}_u}$ and a percentage high-skilled wage change of $\frac{\hat{dw_s}}{w_s} = \gamma_{s,cross}\frac{L^{Im}}{\mathscr{L}_u}$. We'll refer to these wage effects without labor supply responses as "first-round effects". This lemma shows that, with labor supply responses, the changes in equilibrium wages are given by these first-round effects scaled by $\frac{1}{1+\bar{\xi}^u|\gamma_{u,own}|+\bar{\xi}^s|\gamma_{s,own}|} < 1$, which captures how much these first-round effects are mitigated by labor supply responses. In particular, 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 natives also have fiscal implications themselves. The changes in equilibrium hours, participation, and aggregate labor supply directly follow from Lemma 4 and the definition of the elasticities

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

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

We now combine Lemma 2, Lemma 4, and these equilibrium labor supply changes to rewrite the expression in Lemma 3 and obtain our main result.

Proposition 3. *The indirect fiscal effect of a low-skilled immigrant with effective labor supply* L^{Im} *is given by:*

$$dR_{ind} = \frac{y^{Im}|\gamma_{u,own}|}{1+\bar{\xi}^u|\gamma_{u,own}|+\bar{\xi}^s|\gamma_{s,own}|}\left(\bar{T}'_s - \bar{T}'_u + \overline{\varepsilon_s T'_s} - \overline{\varepsilon_u T'_u} + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}}\right)$$

where

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

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

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

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

Proof. See Appendix A.2.4. □

How does this formula differ from that in Proposition 2? First of all the indirect fiscal effect is scaled down by $\frac{1}{1+\bar{\xi}^u|\gamma_{u,own}|+\bar{\xi}^s|\gamma_{s,own}|}$ since the wage effects are mitigated. 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 native labor supply responses, which can be thought of as fiscal externalities. The term $\overline{\varepsilon_s T'_s}$ captures the fact that high-skilled natives increase their hours worked and pay more taxes while $\overline{\varepsilon_u T'_u}$ captures that low-skilled natives decrease their hours worked and pay less taxes. Finally, the changes in labor forces participation are captured by the difference $\overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}}$. The term $\overline{\eta_s T_{part,s}}$ captures the increase in labor force participation of high-skilled individuals and $\overline{\eta_u T_{part,u}}$ captures the decrease in the participation of low-skilled natives. Therefore, the total indirect fiscal effect arising from fiscal externalities is given by

$$FE_{ind} = \frac{y^{Im}|\gamma_{u,own}|}{1+\bar{\xi}^u|\gamma_{u,own}|+\bar{\xi}^s|\gamma_{s,own}|}\left(\overline{\varepsilon_s T'_s} - \overline{\varepsilon_u T'_u} + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}}\right) \quad (11)$$

These fiscal externalities have different welfare implications than the indirect fiscal effects that come from changes in relative wages holding labor supply fixed in that they capture efficiency gains for the natives. We discuss this in more detail Section 7.3 where we briefly discuss the welfare effects – as opposed to the fiscal effects only.[17]

Importantly, the indirect fiscal effect can be calculated without any numerical simulation methods. Instead, it can transparently be calculated once the empirical objects are known. These empirical objects are the labor supply elasticities (extensive and intensive margin) and tax rates (marginal tax rates and participation tax rates) for different groups. Importantly, even for a given income level, there may be different groups with different elasticities that also face different tax rates. We tackle the empirical exercise to quantify these income-weighted averages in the next section.

4 Empirical Quantification

To quantify the formula of Proposition 3, we need earnings distributions conditional on education. Further, we need to know marginal and participation tax rates as well as labor supply

[17]Intuitively, the changes in labor supply do not matter for utility of native workers themselves due to the envelope theorem. However, the change in tax revenue resulting from these changes in native labor supply has first-order welfare effects, see e.g. Hendren (2015).

elasticities along the earnings distributions. Note that even conditional on education and income, there is a distribution of tax rates and elasticities since family status, age, location, etc. are also determinants of an individual's tax burden and labor supply elasticity. Finally, we need a value for the own-wage elasticity of low-skilled wages.

In Section 4.1, we make assumptions on different 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. To obtain our sample of natives, we use data from the American Community Survey (ACS). To assign effective marginal and participation tax rates to all individuals in the sample, we make use of NBER's TAXSIM. However, TAXSIM does not account for the effective tax rates that are implied by welfare-transfer programs. Programs like the Supplementary Nutrition Assistance Program (SNAP) or Temporary Assistance for Needy Families (TANF) imply an increase in effective marginal tax rates since transfers are phased out as income increases. To account for this, we use data from the Survey of Income and Program Participation (SIPP). With the SIPP, we estimate effective transfer phase-out 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 4.2 and the effective tax rate calibration in Section 4.3.

4.1 Calibrated Parameters

Wage Elasticities The own-wage elasticity of low-skilled labor can also be written as

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

where σ is the elasticity of substitution between high-skilled and low-skilled individuals and κ_s is the income share of high-skilled labor, which we estimate as $\kappa_s = .79$, using our ACS sample (see description in the next section). For σ, Card (2009) concludes that values are likely to be between 1.5 and 2.5, which implies own wage elasticities ranging from -.51 ($\sigma = 1.5$) to -.31 ($\sigma = 2.5$) for these two polar cases.

Similarly, the own-wage elasticity of high-skilled labor is given by

$$\gamma_{s,own} = -\frac{1}{\sigma}\kappa_u$$

where κ_u is the income share of low-skilled labor. For our range of values for σ, this implies own-wage elasticity for high-skilled workers ranging from -.14 ($\sigma = 1.5$) to -.08 ($\sigma = 2.5$).

Labor Supply Elasticities A number of papers emphasize that labor supply elasticities differ across genders, marital statuses, and income levels. However, few papers estimate these elasticities across the income distribution for both genders. We therefore employ three different approaches to calibrate our labor supply elasticities. As a first pass, we assume all individuals have common intensive and extensive labor supply elasticities. Specifically, we set the intensive margin elasticity of $\varepsilon_i = .33$ and an extensive margin elasticity of $\eta_i = .25$, for all individuals i, based on the pooled estimates in Chetty (2012). Next, we allow labor supply elasticities to vary by gender and marital status.[18] We use estimates of gender and marital status specific intensive and extensive labor supply elasticities from Bargain, Orsini, and Peichl (2014), who estimate a discrete choice model to estimate elasticities. Finally, we consider the scenario in which labor supply elasticities can vary by gender, age, and income. For this we use estimates of intensive and extensive labor supply elasticities by gender, marital status and quintile of the income distribution from Bargain, Orsini, and Peichl (2014).[19]

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%.[20]

Finally, the formula in Proposition 3 shows that the income of the immigrants also plays a role beyond the education status. Since the exact income of an immigrant is not foreseeable before an immigrant has entered the country, we consider the case of taking expected immigrant income as reasonable. Using again data from the ACS, we find that the average annual gross income of an low-skilled immigrant worker in our sample is $30,317. We also

[18] An early literature, using data mostly from the 1980s, argued that labor supply elasticities were much larger for women than for men (Killingsworth and Heckman, 1986). Bishop, Heim, and Mihaly (2009), Heim (2007), and Blau and Kahn (2007) show that women's labor supply elasticities have decreased dramatically since 1980 and are now much closer to the labor supply elasticities of men.

[19] We choose to utilize the labor supply estimates from Bargain, Orsini, and Peichl (2014) because they estimate gender and income specific intensive and extensive margin elasticities using a common estimation procedure. Our results are robust to using estimates on extensive labor supply elasticities by wage percentile from Juhn, Murphy, and Topel (2002), who estimate extensive margin elasticities using a sample of U.S. men.

[20] The real interest rate on 30 year bonds was on average 0.99 in the last ten year (0.81 in the last 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% interest rate in Appendix C.3

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.

4.2 Data and Sample

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

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.[21] We also utilize data on each individual's education, which we use to determine an individual's skill group. An important choice is how to define these skill groups. For this, 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. An alternative approach to defining skills, employed by Katz and Murphy (1992) and Card (2009), is to divide workers with some college between the two skill groups. We consider this skill classification in Appendix C.2. In Section 6.3, we also consider the case where worker's skills are classified by their position in the wage distribution instead of their education as in Dustmann, Frattini, and Preston (2013).

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, 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

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

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

53,000 households from 2013 to 2016. From this dataset, we utilize data on household size, household earnings, and receipt of TANF and SNAP benefits over the year. We convert all monetary values to 2017 dollars.

One issue is that benefits receipts are generally underreported in household surveys, including the SIPP (Meyer, Mok, and Sullivan, 2015). To deal with this, we utilize data from the U.S. Bureau of Economic Analysis' National Income and Product Accounts (NIPA) tables, which report annual government spending on various U.S. programs. We multiply benefit receipt amounts in the SIPP by a multiplicative constant such that the total population-weighted benefit receipts in the SIPP are consistent with the aggregates from the NIPA tables.[22]

NLSY79 Our final data source is the NLSY79, a nationally representative panel dataset with data on over 12,000 individuals. Respondents were first interviewed in the year 1979, when respondents were between ages 14 and 22, were interviewed annually until 1994 and were interviewed bi-annually after 1994. Most importantly, the panel structure of the NLSY79 allows us to observe an individual's earnings over their life cycle, which determines an individual's social security benefit after retirement. Since we need data on as much of an individual's work

[22]Specifically, we utilize data from NIPA Table 3.12. We multiply SNAP benefits in the SIPP by a constant such they are consistent with SNAP benefits from this table and multiple TANF benefits in the SIPP by a constant such they are consistent with "Family assistance" benefits from this table multiplied by the fraction of TANF benefits which are spend on basic assistance.

history as possible, we drop from our sample individuals who drop out of the survey before age 50.[23] 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.

4.3 Tax-Transfer System

Income Taxes and the EITC. To calculate marginal income and payroll tax rates, we use NBER's TAXSIM, a tax calculator that replicates the federal and state tax codes in a given year, accounting for differential tax schedules and tax deductions and credits afforded by various demographic groups, e.g. by marital status or number of dependents.[24] Specifically, we begin by calculating the total income for each household head and their spouse for all households in the ACS. We then use TAXSIM to calculate the marginal income and payroll taxes for each individual, taking into account the individual's marital status (which determines filing status), number of children (a determinant in personal exemptions), age of children (a determinant in eligibility of the Dependent Care Credit, the Child Credit, and the Earned Income Tax Credit), location (which determines state income tax schedules), and age of the household head and spouse (which determine eligibility for various deductions and exemptions).

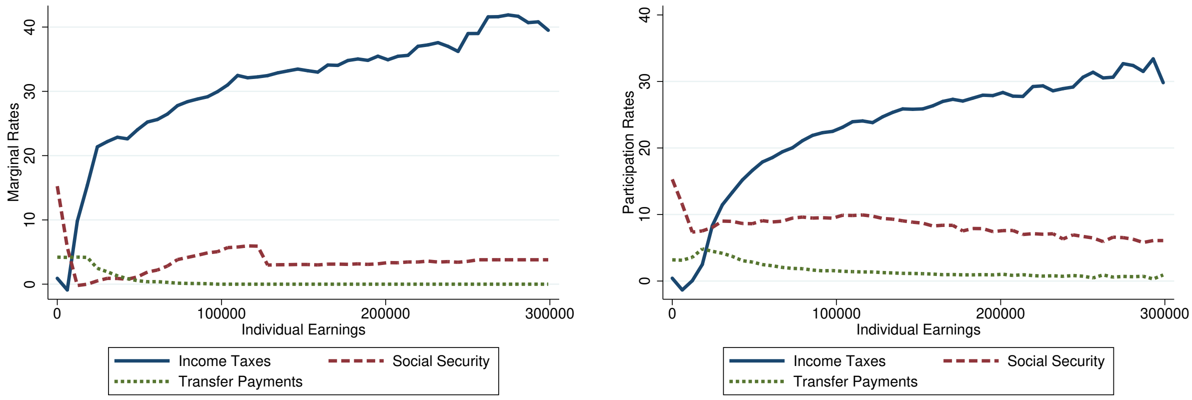
The solid blue line in Panel (a) of Figure 2 shows the average marginal tax rate arising from federal and state income taxes as a function of individual labor income. Panel (b) shows the same relationship for participation tax rates. As can be seen both are increasing in income, reflecting the progressivity of federal income tax schedule.[25]

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

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

[24]We focus on aggregate fiscal effects rather than distinguishing between state and federal fiscal effects.

[25]The small downward sloping portion for low incomes in each of the two curves arises because of the EITC, which leads to negative marginal and participation tax rates.



(a) Marginal Taxes

(b) Participation Taxes

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

We find marginal state income tax rates of 4.9% and 4.1% for high- and low-skilled workers, respectively.

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

The dashed green line in the left of Figure 2 gives the marginal phase-out rate of social transfers, where social transfers are given by the sum of TANF and SNAP benefits. We can see that the marginal phase-out rate of transfer payments is positive but small for low levels of income before approaching 0 for higher income levels.[26] The dashed green line in the right

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

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
Social Security		
Payroll Tax	10.4	13.9
Marginal Replacement Rate	7.0	11.9
Total	35.9	27.7

Table 2: Estimates of income weighted effective marginal tax rates. Each entry shows the income weighted average marginal tax rates arising from each source of effective tax rates in our sample of ACS data. Note that the marginal replacement rate of social security enters negatively into the calculation of effective marginal tax rates. See text for details.

panel of Figure 2 gives the social transfer phase-out associated with labor force participation, which is also small and mostly decreasing as a function of income.

The income-weighted average marginal SNAP and TANF phase-out rates are shown in rows 3 and 4 in Table 2. The estimates of the average marginal phase-out rates of SNAP are small, at 0.3% for high-skilled workers and 1.1% for low-skilled workers. This might seem surprising, given that the phase out rate of SNAP for those who receive SNAP as a function of income is quite large. However, the relevant statistic for the marginal effect of immigration is the average *income-weighted* marginal benefit. To better see this, consider the average income weighted phase-out rate of SNAP for households with four members. As with other demographic groups, the phase-out rate for those on SNAP is 24%. However, given that take-up is less than 100%, we estimate an average phase-out rate of only 15% for households whose income places them in the phase-out region of the SNAP formula. Among four-member households, only households with gross monthly income below $2,633 were eligible for SNAP. Therefore, only a fraction of households are eligible for SNAP and these households therefore receive little weight when calculating the income weighted marginal phase-out rates.[27]

The estimates for TANF are even smaller— the average income weighted TANF benefits 0.1% for low-skilled workers and less than that for high-skilled workers. As with SNAP, TANF recipients have low incomes and therefore receive little weight in the average marginal phase-

[27] To get a better sense of the magnitude, note that 21.5% of individuals belonging to four-member households have an average monthly income less than $2,633. Further, the average household income conditional on being above this threshold is over 7 times higher than the average household income conditional on being below this threshold. This implies that the average income weighted phase-out rate of households with four members is well under 1%. A back of the envelope calculation yields an income weighted average of $15\% \times 0.215 \times \frac{1}{8} + 0\% \times 0.785 \times \frac{7}{8} \approx .40\%$

out calculations. Furthermore, only 2.5 million individuals received TANF in the average month in 2017.[28] Therefore, while the marginal phase-out rates of TANF and SNAP for a given individual can potentially be large, the average income-weighted averages are quite small.

Social Security. Finally, our calculation of effective marginal tax rates includes social security benefits and payroll taxes. Payroll taxes are mostly decreasing with income; payroll taxes have a constant marginal tax rate of 15.3% until the maximum taxable earnings threshold after which the marginal rate drops to 2.9%.[29]

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

In order to calculate an individual's AIME, we need to know their distribution of income over their working life. This cannot be observed directly in the ACS, which only contains data on an individual's current income. We therefore first compute the AIME and 35th highest earning year for each individual in our NLSY79 sample. We then impute an AIME and 35th highest earning year for individuals in the ACS using similar individuals in the NLSY79.[30] The AIME is then used to determine the marginal rate of benefits associated with earnings and the 35th highest year of earnings is used to determine if current earnings will affect the individual's AIME. Details on this procedure can be found in Appendix B.3. Finally, a crucial element of this calculation is an individual's life expectancy, which determines how many years the individual receives benefits. To calculate life expectancy, we use estimates of life expectancy conditional on income from Chetty, Stepner, Abraham, Lin, Scuderi, Turner, Bergeron, and

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

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

[30] More specifically, we calculate the mean AIME and 35th highest year of the earnings by gender, marital status, education, age, and position in the income distribution for individuals in the NLSY79. We assign individuals in the ACS their corresponding group mean of AIME and 35th highest earning year.

Cutler (2016), who estimate life expectancy for household income percentiles using data from 1.4 billion tax and social security death records between 1999 to 2014.[31]

The dotted green line in the two panels of Figure 2 display the marginal tax rates and participation tax rates associated with the social security system, which we define as payroll taxes minus the marginal replacement rates.[32] At very low incomes, both marginal and participation tax rates are very high. This occurs because very low income levels are unlikely to be one of an individual's 35 highest earning years, and therefore do not increase their future social security benefits. Eventually, the social security tax begins to increase with income, as higher earnings imply higher social security benefits post-retirement. At the maximum taxable earnings threshold of $127,200, the payroll tax drops precipitously, leading to a drop in the marginal effective tax associated with social security.[33] 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 5th and 6th rows of Table 2 give the income weighted average payroll tax rates and marginal discounted replacement rates. We find a higher marginal rate for low-skilled workers than high-skilled workers, at 13.9% for low-skilled workers and 10.4% for high-skilled workers, reflecting that payroll taxes drop dramatically at the maximum taxable earnings threshold. We estimate an income weighted marginal social security replacement rates of 9.1% for low-skilled workers and 5.2% 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 13.9%-11.9%=2.0% for low-skilled workers 10.4%-7.0%=3.4% for high-skilled workers.

The final row of Table 2 displays $\bar{T}'_s$ and $\bar{T}'_u$, the income-weighted average marginal tax rates, as the sum of these elements. We obtain $\bar{T}'_u = 27.7\%$ for low-skilled workers and $\bar{T}'_s = 35.9\%$ for high-skilled workers. This implies a difference in income-weighted effective marginal tax rates of 8.2%.

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

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

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

5 Results

Table 3 displays estimates for the indirect fiscal effect of the average low-skilled immigrant 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 Panel I, we display the indirect fiscal effect with exogenous labor supply. With exogenous labor supply, the indirect fiscal effect can be easily calculated using (2). Combining our estimates of income weighted average marginal tax rates with our calibration of own-wage elasticities, we find indirect fiscal benefits of \$1,299 ($\sigma = 1.5$), \$975 ($\sigma = 2$), and \$780 ($\sigma = 2.5$).[34]

Next, in Panel II, we calculate the indirect fiscal effects when we allow for intensive, but not extensive, margin adjustments. In all three scenarios, allowing for intensive margin adjustments increases the indirect fiscal effect of low-skilled immigration. Panel III calculates the indirect fiscal effects with extensive, but without intensive margin labor supply adjustments. When elasticities are common or only vary by gender and marital status, the indirect fiscal effect is larger than the case with no labor supply responses. However, when extensive margin elasticities can vary by income, gender and marital status, the indirect effect decreases slightly. Extensive margin elasticities are generally decreasing in income, and therefore the decrease in participation by low-skilled workers and the resulting decrease in tax revenue outweighs the increase in tax revenue resulting from greater participation by high-skilled workers.

Finally, Panel IV displays the results when we allow for both intensive and extensive labor supply adjustments. When labor supply elasticities are common accross gender, marital status and income, we find indirect fiscal benefits of \$1,471 ($\sigma = 1.5$), \$1,186 ($\sigma = 2$), and \$993 ($\sigma = 2.5$). We can use (11) to calculate the indirect fiscal effects arising from fiscal externalities associated with changes in native labor supply. For the case of $\sigma = 2$, $FE_{ind} = \$430$ is due to the fiscal externalities. As we discuss in Section 7.3, these fiscal externalities play an important role in determining the welfare effects of immigration.

Tables 11 and 12 in Appendix C.1 repeat the analysis for the average high school dropout immigrant and the average high school graduate immigrant. From (3) we can see that the income of the immigrant only enters as a multiplicative constant, therefore, the indirect fiscal effects associated with high school dropouts (graduates) can easily be calculated by multiplying

[34] These results are slightly smaller than those in Section 2 because the model in that section multiplies tax differences by the income of the average low-skilled worker, not the average low-skilled immigrant.

	Elasticity of Substitution		
	1.5	2.0	2.5
I. No Labor Supply Responses	1299	975	780
II. Intensive Only			
Common Elasticity	1417	1113	916
By Gender and Marital Status	1303	979	784
By Income, Gender and Marital Status	1347	1015	815
III. Extensive Only			
Common Elasticity	1380	1074	878
By Gender and Marital Status	1335	1020	826
By Income, Gender and Marital Status	1268	965	779
IV. Intensive and Extensive			
Common Elasticity	1471	1186	993
By Gender and Marital Status	1339	1025	830
By Income, Gender and Marital Status	1313	1004	813

Table 3: Indirect Fiscal Effects of low-skilled immigrants with intensive and extensive margin labor supply responses. The three columns show the indirect fiscal effect under different assumptions of the elasticity of substitution, ranging from $\sigma = 1.5$ to $\sigma = 2.5$. Each row displays the indirect fiscal effect for different assumptions about the labor supply elasticity.

the effects in Table 3 by the ratio of income of the immigrant high school dropouts (graduates) over the income of all low-skilled immigrants. As such, the indirect fiscal effects for high school dropouts are roughly 15% smaller than those for all low-skilled immigrants and range from \$660 to \$1,220 while the indirect fiscal effects for high school graduates are roughly 10% larger than those for all low-skilled immigrants and range from \$860 to \$1,620.

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

Our approach is as follows: we first consider the lifetime direct fiscal effect of a low-skilled immigrant who arrives at age 23 and lives until the age of 79. We choose 23 since this is the median age of arrival for low-skilled immigrants in the ACS and we chose 79 years because the life expectancy at age 23 in the U.S. is roughly 79.[35] 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. Further, we need to make an assumption about how immigrants affect government spending on public goods.[36] We consider four different

[35]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`

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

scenarios, similar as in the NAS report: (i) there are zero marginal costs of public goods and hence no costs are assigned to immigrants, (ii) marginal costs are equal to 25% the average costs of public goods, (iii) marginal costs are equal to 50% of average costs, and (iv) marginal costs equal average costs.[37] For all of these four scenarios, we can calculate the net present value (NPV) direct fiscal effect of low-skilled immigrants. To make this number comparable to our annual indirect fiscal effect, we calculate the annuity value for the period of 23 until 66 (age of retirement) that corresponds to the NPV of the lifetime direct fiscal effect.

Table 4 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 \$660 to \$1220 for high school dropouts and \$860 to \$1620 for high school graduates. Accounting for these indirect effects in scenarios (ii) and (iii) can turn high school graduates from a fiscal burden into a small fiscal surplus. More generally, comparing the numbers in Table 4 with the numbers in Table 3, one can see that indirect fiscal effects are economically meaningful in comparison to the direct fiscal effects and should therefore be taken into account.

Public Goods Scenario	High School Dropout	High School Graduate	Average
Zero Marginal Costs	-4,075	683	-1,363
MC = 0.25 × AC	-4,832	-84	-2,126
MC = 0.5 × AC	-5,589	-851	-2,888
MC = AC	-7,103	-2,385	-4,414

Table 4: Annuitized direct fiscal contributions of an immigrant that arrives at age 23 and dies at age 79. We use a discount rate of 1%. Only direct fiscal contributions are accounted for and rely on Figure 8-21 of National Academy of Sciences (2017). We calculate the annuity value for the period of 23 until 65 (age of retirement).

6 Extensions and Robustness

We now examine the sensitivity of our results to several alternative model specifications. Sections 6.1 through Section 6.3 consider alternative production functions utilized in the immigration literature. As we focus on differences in production functions, we consider the case with

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

exogenous native labor supply. Section 6.4 considers the case when workers can endogenously choose their supply of communication- and manual-intensive tasks. Section 6.5 considers the case with decreasing returns to scale and Section 6.6 discusses additional extensions.

6.1 Imperfectly Substitutable Education and Experience

In Sections 2 and 3, we assumed that all workers within a given a skill group are perfectly substitutable. We now change these assumptions and follow Borjas (2003), who considers a nested-CES production function in which narrower education groups and experience levels are imperfect substitutes. In particular, we assume that production takes the form of a two-level nested CES function.[38] The top level of the production function combines labor supplies of four education groups: high school dropouts, high school graduates, some college, and college graduates. Letting e index education groups, output Y is given by

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

where $\mathscr{L}_e$ is the labor aggregate of labor of education group e, and σ_E is a parameter which dictates the elasticity of substitution between education groups. In contrast to our model above, which only had two imperfectly substitutable skill groups, the production function here allows for four imperfectly substitutable education groups. Therefore, an increase in the number of high school dropouts, for example, affects the relative wages of dropouts to high school graduates, in addition to the relative wages of high-skilled versus low-skilled workers.

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

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

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

[38] We abstract away from physical capital (or alternatively assume that capital supply is perfectly elastic) in Sections 6.1 through 6.5. We discuss the role of capital in Section 7.1.

Experience Group	HS Dropout	HS Graduate
1-5	1,595	1,368
6-10	1,803	1,597
11-15	1,720	1,650
16-20	1,844	1,732
21-25	1,825	1,786
26-30	1,948	1,926
31-35	2,043	2,016
36-40	2,172	2,056
Education Average	1,932	1,834
Overall Average	1,873	

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

experience levels are imperfectly substitutable in production. Immigrant inflows therefore change the relative wages of different experience groups within the same education level. As such, the fiscal effects of immigrant inflows need to account for changes in wages, and therefore tax payments, of all experience-education groups.

As we show in Appendix A.3, if labor supply is inelastic, the indirect fiscal benefit of an immigrant in experience group a and education group e with productivity level ω is given by

$$d\mathcal{R}_{ind}^{\text{Borjas}}\left(a,e,\omega\right) = y_{a,e}\left(\omega\right)\left[\underbrace{\left(\bar{T}'_{a'\neq a,e}-\bar{T}'_{a,e}\right)\left|\tilde{\gamma}_{a,e,own}\right|}_{\text{Experience Effect}}+\underbrace{\left(\bar{T}'_{e'\neq e}-\bar{T}'_{e}\right)\left|\gamma_{e,own}\right|}_{\text{Education Effect}}\right]. \tag{12}$$

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

	Baseline	$1/\sigma_X = 0$	$1/\sigma_X = 0$,$1/\sigma_E = .5$
HS Dropout	1,932	1,949	1,267
HS Graduate	1,834	1,855	1,205
Average	1,873	1,892	1,230

Table 6: Indirect Fiscal Effects using model from Borjas (2003) under alternative parameter values. The first column gives the baseline indirect fiscal effects using the parameter estimates form Borjas (2003). The second column sets $1/\sigma_X = 0$ such that all experience groups within an education groups are perfect substitutes. The third column again sets $1/\sigma_X = 0$ and additionally sets the $1/\sigma_E = .5$ such that the elasticity of substitution between education groups is equal to 2.

Results Following Borjas (2003), we set $\sigma_X = 3.5$ and set $\sigma_E = 1.3$. The indirect fiscal effect associated with a worker in each of the experience group for both high school dropouts and high school graduates are given in Table 5. The first column gives the indirect fiscal effect associated with high school dropouts and the second column gives the effect associated with high school graduates. The fiscal effect of both education levels is increasing in experience level, reflecting that incomes are increasing in experience. Across all experience groups, the average high school dropout is associated with a \$1,932 indirect fiscal benefit and the high school graduate with a \$1,834 indirect fiscal benefit. The average low-skilled immigrant across education groups leads to a fiscal benefit of \$1,873.

To better understand why the indirect fiscal effect here is larger than in the previous sections, we now perform several alternative calculations in Table 6. First, to understand the role of the "Experience Effect", we calculate the indirect fiscal benefit when experience groups are perfect substitutes within education, by setting $\frac{1}{\sigma_X} = 0$. This has only a slight effect on the indirect fiscal effect: the average indirect fiscal effect increases from \$1,873 in the baseline case to \$1,892 in the case when experience groups are perfect substitutes within education group.

Next, to understand the role of the elasticity of substitution parameter, we calculate the indirect fiscal benefit under the assumption that the elasticity of substitution is equal to 2 by setting $\sigma_E = 2$. This reduces the average fiscal benefit to \$1,230, similar in magnitude to the effect we found in Section 3. Therefore, despite the key differences between the production function here and that presented in Section 3, both production functions lead to similar estimates of the indirect fiscal effect of low-skilled immigration, once we use comparable parameter estimates.

6.2 Domestic-Born and Foreign-Born Complementarity

Ottaviano and Peri (2012) consider a model in which domestic- and foreign-born workers are imperfect substitutes within education and experience groups. The production function takes a similar structure to that in the previous section but has two important differences. First, instead of assuming all four education groups aggregate within a single CES aggregator, we now follow Ottaviano and Peri (2012) and instead use a two level nested structure to model complementarity between education groups. High school dropouts and high school graduates aggregate to low-skilled workers and individuals with some college and college graduates aggregate to high-skilled workers. This specification allows for one elasticity of substitution between high-skilled and low-skilled workers and a second elasticity of substitution between narrow education groups. Second, within each skill-education-experience group, we allow for the possibility that domestic- and foreign-born workers may be imperfectly substitutable in production. Ultimately the production function takes the form of a four-level nested CES labor aggregate function, with a top nest corresponding to skill groups (high skill and low skill), a second nest corresponding with education groups within these two skill groups (high school graduate and dropout within low-skilled workers, some college and college graduate within high-skilled), a third nest corresponding with to 8 experience groups within each education group, and a final nest aggregating domestic- and foreign-born workers.[39]

Results We quantity the model using parameters estimates from Ottaviano and Peri (2012). Table 7 gives the indirect fiscal effect associated with an immigrant with average income in each experience group for both high school dropouts and high school graduates. The average high school dropout immigrants leads to an indirect fiscal benefit of \$920 while the average high school graduate immigrant leads leads to an indirect fiscal benefit of \$1,161. Taken together, this implies the average low-skilled immigrant leads to an average indirect fiscal effect of \$1,065.

To better understand the implications of the nesting structure on the indirect fiscal effects, we sequentially recalculate the indirect fiscal effects under the assumptions that labor supplies in each of the CES nests are perfectly substitutable. The results are given in Table 8. In the second column, we assume domestic- and foreign-born workers within experience-education-skill groups are perfect substitutes. This leads to a fiscal benefit of \$1,057. In the next column,

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

Experience Group	HS Dropout	HS Graduate
1-5	796	888
6-10	945	1,014
11-15	876	1,026
16-20	868	1,112
21-25	838	1,111
26-30	915	1,206
31-35	996	1,289
36-40	1,014	1,321
Education Average	920	1,161
Overall Average	1,065	

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

we additionally assume workers of difference experience groups within the same education level are perfect substitutes. This implies a fiscal benefit of $1,065. Finally, we remove imperfect substitutability between narrow education groups. This model now shares the same structure as the model presented in Section 3, as all workers within the two skill groups and perfectly substitutable. We find a indirect fiscal benefit of $1,059 in this case.

As emphasized by Dustmann, Schönberg, and Stuhler (2016) and Ottaviano and Peri (2012), the inclusion of domestic-foreign complementarity in the production function has strong implications for which workers bear the incidence of low-skilled immigrant inflows. Most importantly, allowing for domestic-foreign complementarity implies that low-skilled foreign born workers who immigrated in the past experience the largest wages decreases as a result of new low-skilled immigrant inflows, while low-skilled domestic-born workers only experience small wage decreases or even wage increases. However, as we show here, domestic-foreign immigrant complementary does not play a first-order role in determining the indirect fiscal effect of immigration. Further, imperfect substitablility between experience and education groups play almost no role in the indirect fiscal benefit. In fact, the indirect fiscal benefits calculated using the production function in Ottaviano and Peri (2012) and the production function in Borjas (2003) are quite similar if we use comparable estimates of the elasticity of substitution between education groups. Therefore, while allowing for imperfect substitutability within skill groups may play important roles in determining the incidence of immigrant inflows, it plays little role in determining the indirect fiscal effect.

		Make Perfect Substitutes		
	Baseline	Nativity	Experience	Education
HS Dropout	920	913	920	899
HS Graduate	1,161	1,153	1,161	1,165
Average	1,065	1,057	1,065	1,059

Table 8: Indirect Fiscal Effects using model from Ottaviano and Peri (2012) under alternative parameter values. The first column gives the baseline indirect fiscal effects using the parameter estimates form Ottaviano and Peri (2012). The second column assumes domestic- and foreign-born workers within the same experience-education group are perfect substitutes. The third column assumes all education groups within the same education groups are perfect substitutes. The fourth columns assumes education groups are perfect substitutable within skill groups.

6.3 Skills Defined by Position in Wage Distribution

Dustmann, Frattini, and Preston (2013) argue than an immigrant's education level might give an inaccurate approximation of a worker's skills, given that education of immigrants and natives are not equivalent. They instead propose an alternative skill classification in which a worker's skill is characterized by his/her position in the wage distribution. Therefore, immigrants at a given position in the wage distribution compete with natives at the same position of the wage distribution, regardless of their education levels.

To formalize this, let total output be given by the CES aggregator

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

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

As we show in Appendix A.4, the indirect fiscal benefit associated with with an immigrant in skill type j and productivity ω if labor supply is inelastic is given by

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

where $y_j\left(\omega\right)$ is the income level of workers in skill group j with productivity ω, $\bar{T}'_{k\neq j}$ is the income weighted average marginal tax rate of all other groups $k \neq j$, and $\bar{T}'_j$ is the income weighted average marginal tax rate income group j. Given the CES production function, the

Decile of Wage Distribution	Indirect Fiscal Effect	Percent of LS Immigrants
1	970	20
2	1,182	22
3	1,366	17
4	1,625	10
5	1,825	9
6	1,768	7
7	1,460	5
8	643	4
9	-588	3
10	-10,924	2
Overall Average	1,017	

Table 9: Indirect Fiscal Effects using model from Dustmann, Frattini, and Preston (2013). The second columns gives the indirect fiscal effect for an immigrant in each decile of the wage distribution. The right column gives the percent of total low-skilled immigrants in each wage decile. The bottom row gives the weighted average of the indirect fiscal effects across the wage distribution.

own-wage elasticity has the simple expression $\frac{1-\kappa_j}{\sigma}$, where κ_j is the income share of workers in skill group j.

Results We define skill groups using deciles of the wage distribution.[40] The results are not sensitive to the grouping of j. We use our central value for the elasticity of substitution between skill groups and set $\sigma = 2$.[41]

The results are displayed in Table 9. The second column gives the indirect fiscal effect associated with an immigrant of a given decile of the wage distribution with the average income conditional on their wage decile. The third column gives the percent of total low-skilled immigrants who fall into a given wage decile. For the most part, the indirect fiscal benefit is increasing in wage decile up until the 5th decile, reflecting the fact that income is increasing in the wage decile. Starting with the 6th decile, the indirect fiscal benefit decreases as the average marginal tax rates increase relative to the average marginal tax rates of groups. The weighted average indirect fiscal effect is \$1,017, similar to the fiscal effect found in Section 3 when we set $\sigma = 2$.

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

[41] Using data from the UK, Dustmann, Frattini, and Preston (2013) find that an elasticity of substitution between skill group of 0.6 fits their reduced form evidence best. Using this value as the elasticity of substitution yields and an average indirect fiscal benefit of low-skilled immigrants of \$2,766. We believe the value of $\sigma = 2$ to be more appropriate for the US context.

6.4 Endogenous Occupational Choice of Natives

We consider the more elaborate model of immigration and the labor market developed by Peri and Sparber (2009). In this framework, low-skilled domestic-born workers differ from low-skilled foreign-born workers in that they choose different occupations. Low-skilled foreign-born workers tend to choose occupations with a high manual task and lower communication task intensity than low-skilled natives. Since manual tasks and communication tasks are complementary in production, low-skilled domestic workers and low-skilled foreign-born workers are now imperfect substitutes. In essence, the differences in task concentration between domestic- and foreign-born workers provide a microfoundation for the domestic- and foreign-born complementarity documented by Ottaviano and Peri (2012).

Additionally, low-skilled workers may react to additional low-skilled immigration by changing their task supply. Indeed the authors estimate that low-skilled domestic-born workers 'upgrade' their occupation by supplying more communication intensive tasks in response to immigration. For example, domestic-born construction workers may begin to to work more as supervisors for newly arrived immigrants in response to immigrant inflows. This upgrading of skills by domestic-born workers leads to an additional fiscal effects.

Perfectly competitive firms produce a numeraire output good using cognitive, communication and manual tasks. Cognitive tasks are supplied inelastically by high- high-skilled individuals. Communication and manual tasks are performed by low-skilled individuals. Denote by M total manual task supply and by C total communication task supply. These tasks are aggregated in the following way

$$Y_u = \left(\theta_u M^{\frac{\sigma_u - 1}{\theta_u}} + (1 - \theta_u)\, C^{\frac{\sigma_u - 1}{\sigma_u}}\right)^{\frac{\sigma_u}{\sigma_u - 1}}. \tag{13}$$

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

We assume that high-skilled workers (inelastically) supply cognitive tasks; aggregate high-skilled labor Y_s is simply given by the sum of the cognitive task supplied in the economy. High-skilled labor Y_s and the aggregate of low-skilled labor, Y_u are then aggregated according to:

$$Y = A\left(\theta Y_u^{\frac{\sigma-1}{\sigma}} + (1-\theta)\, Y_s^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}, \tag{14}$$

where Y is the produced amount of the numeraire output good. The parameter σ corresponds with the elasticity of substitution between high-skilled labor and the low-skilled aggregate; higher values of σ imply low-skilled and high-skilled workers are more substitutable in production and therefore changes in this factor ratio will have smaller effects on wages. Total factor productivity is given by A and θ gives the factor intensity of low-skilled labor.

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

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

$$d\mathcal{R}^{\text{PS}}_{ind} = \bar{T}'_s N_s \frac{dy_s}{dN_f} dN_f + \bar{T}'_f N_f \frac{dy_f}{dN_f} dN_f + \bar{T}'_d N_d \frac{dy_d}{dN_f} dN_f. \tag{15}$$

That is, the total indirect fiscal effect is given by the change in income of each type of worker as a result of the inflow multiplied by the number of workers of that type and the marginal tax rate. It's important to note that changes in income for low-skilled workers, $\frac{dy_f}{dN_f}$ and $\frac{dy_d}{dN_f}$, arise for two reasons. First, low-skilled immigrant inflows change task prices w_c and w_m, and therefore the incomes of foreign- and domestic-born workers. Second, income will change as a result of changes in task supplies in response to these inflows. For example, if low-skilled domestic-born workers respond to immigrant inflows by increasing the amount of communication task they supply (perhaps by moving into managerial occupations), this will lead to an additional change in native income in response to immigrant inflows. We show in Appendix A.5 how this formula can be written as a function of structural parameters and task supply elasticities.

Quantification We quantify the indirect fiscal effects in this setting by combining income data from the ACS, tax estimates from TAXSIM, estimates of task intensities from ONET, and selected parameter estimates from PS. The procedure we use for estimating income and marginal tax rates are similar to those in other sections. Details on this quantification can be found in Appendix B.5. Here we focus on the parameter estimates we take from PS.

PS estimate the elasticity of substitution between manual and communication tasks, σ_u, using state level variation in immigrant inflows. We set $\sigma_u = 1$ as the preferred estimates from PS and the set the elasticity of substitution between low and high-skilled workers as $\sigma = 1.75$, based on the calibration in PS. PS also use across-state immigrant variation to estimate the elasticities of task supplies with respect to the immigrant share of low-skilled workers. We directly use these estimates of task supply elasticities in our quantification.[42] Most notably, PS find that domestic-born workers respond to low-skilled immigrant inflows by increasing their communication task supply but do not change their manual task supply, and that foreign-born workers do not change their task supplies in response to immigrant inflows.

Results First of all, we calculate the indirect fiscal effect which would result if workers do not adjust their labor supply. We find this number to be $d\mathcal{R}_{ind}^{PS,ex} = \$1,115$, which is in a similar ballpark as the numbers we have found in Section 4. This is not surprising since the elasticity of substitution between high and low-skilled labor σ is chosen to be 1.75 in this calculation which is in the range of values considered Section 3.[43]

However, once we allow workers to optimally chose their occupations in response to immigrant inflows, the difference between the total indirect fiscal effect here and that in Section 4 is quite stark. Low-skilled domestic-born workers respond to the immigrant inflow by switching into higher-paying communication-intensive occupations. This increases their wages and, in turn, their tax payments. Ultimately, the indirect fiscal effect increases to $d\mathcal{R}_{ind}^{PS} = \$2,131$ with endogenous occupation sorting.

[42]Specifically, letting $j \in \{f, d\}$ index low-skilled worker types, we denote task supply elasticities as

$$\eta_j^c = \frac{dc^j}{dF}\frac{1}{c^j} \quad \text{and} \quad \eta_j^m = \frac{dm^j}{dF}\frac{1}{m^j} \; \forall \, j = f, d$$

where $F = \frac{N_f}{N_f + N_d}$ give the foreign-born share of low-skilled workers. These task supply intensities give the percentage change in task supply due to a one percentage point increase in the share of immigrants. We set $\eta_c^f = \eta_m^f = \eta_m^d = 0$ and take $\eta_c^d = 0.33$ based on the estimates in PS.

[43]In fact, using $\sigma = 1.75$ for the model in Section 3 with no labor supply adjustments, we would obtain a number of $1,114, which shows that the fact that foreign- and domestic-born workers differ in their occupations does not seem to play a major role per se in determining this short run effect.

6.5 Decreasing Returns to Scale

Throughout the paper, we have considered production functions that exhibit constant returns to scale. We now calculate the indirect fiscal effect of immigration with decreasing returns to scale. Consider a general production function with two inputs:

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

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

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

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

In the case of constant returns to scale, the indirect fiscal effects arose because of change in relative incomes of high-skilled and low-skilled workers. With decreasing returns to scale, there is a second effect arising from an increase in firm profits relative to worker income. As we show in Appendix A.6 the indirect fiscal effect with decreasing returns to scale is given by

$$d\mathcal{R}_{ind}^{\mathrm{DRS}}\left(\omega\right) = y_u(\omega)\left[\underbrace{\left(\bar{T}'_s - \bar{T}'_u\right)\left|\tilde{\gamma}_{u,own}\right|}_{\text{Factor Ratio Effect}} + \underbrace{\left(1-\lambda\right)\left(\tau_p - \bar{T}'_I\right)}_{\text{Scale Effect}}\right]. \tag{16}$$

Consider the first term of (16), which we refer to as the "factor ratio effect". The term $\tilde{\gamma}_{u,own}$ gives the own-wage elasticity for low-skilled workers, holding total output constant. Specifically, this term is given by $\tilde{\gamma}_{u,own} = \gamma_{u,own} + \kappa_u\left(1-\lambda\right)$, where $\kappa_u = \frac{L_u w_u}{L_s w_s + L_u w_u}$ is the income share of low-skilled labor.[44] This factor ratio effect gives the indirect fiscal effect as a result of changing the relative wages of high-skilled relative to low-skilled workers.

In addition to changing the factor ratio, an influx of low-skilled labor also increases the scale of production and therefore increases profits at the cost of worker wages. We refer to the resulting fiscal effect as the "scale effect", which is the second term in (16). The term $\bar{T}'_I$ gives

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

the income-weighted average marginal tax of all workers. A smaller value of λ implies lower returns to scale and therefore a greater redistribution of surplus from workers to profits. The fiscal effects of the redistribution are scaled by the differences in the average tax rates between firms and workers, $\left(\tau_p - \bar{T}_I'\right)$. This scale effect is unique to the decreasing returns case and arises from the fact that resources are redistributed from workers to firms when production exhibits decreasing returns.

Results To calculate the fiscal effects with decreasing returns to scale, we need estimates of the profit tax τ_p, income weighted marginal tax rates, and the returns to scale, λ, and $\tilde{\gamma}_{u,own}$, the own-wage elasticity of low-skilled labor, holding scale constant. For the profit tax, we use the weighted average of the state and federal corporate tax rates and the business income weighted average income tax rate, which is the tax rate that applies for pass-through businesses.[45] This gives us an estimate of $\tau_p = 36.8\%$. We estimate marginal tax rates using the same procedure as described in Section 4.[46] Finally, we take our value of $\lambda = .9$ from Burnside (1996), who estimates returns to scale for US industries.[47]

Finally, note that the own-wage elasticity with decreasing returns to scale is given by

$$\gamma_{u,own} = \left(\lambda - 1 + \frac{1}{\sigma}\right)\frac{w_u L_u}{\lambda Y} - \frac{1}{\sigma},$$

where again σ is the elasticity of substitution between low- and high-skilled labor. Therefore, the own-wage elasticity holding scale constant is simply given by

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

where we used the fact that $\frac{w_u L_u}{\lambda Y} = \frac{w_u L_u}{L_s w_s + L_u w_u} = \kappa_u$ by Euler's homogenous function theorem. Therefore, $\tilde{\gamma}_{u,own}$ is the same as the own-wage elasticity with constant returns to scale, given the same value of the elasticity of substitution between low- and high-skilled labor.

Putting this together, we estimate that if production exhibits decreasing returns to scale, the indirect fiscal effect associated with the average low-skilled immigrant is equal to \$1,057 given an elasticity of substitution of $\sigma = 2$. Recall that with constant returns to scale and

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

[46] We estimate a marginal tax rate for all workers as $\bar{T}_I' = 34.2\%$.

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

$\sigma = 2$, we calculated an indirect fiscal effect with exogenous labor supply of \$975. The small increase in the fiscal effect with decreasing returns occurs because of the scale effect: profits increase relative to labor income and profits face a higher marginal tax rate than labor income.[48]

6.6 Further Potential Extensions

We now discuss other potential extensions of our framework and discuss in what direction this should affect our results.

Endogenous Education Low-skilled natives may respond to low-skilled immigrant inflows by further investing in their education (Llull, 2018). This would likely increase the indirect fiscal effects of immigration as increased education leads to increased lifetime income and therefore increased tax payments. As shown in Colas, Findeisen, and Sachs (2018), this fiscal externality associated with attending college is quantitatively important.[49]

Monopsonistic Labor Markets Amior and Manning (2020) emphasize that most of the immigration literature rests on the assumption of perfectly competitive labor markets. They argue that this assumption is problematic because markdowns on wages in a setting with monopsony power are likely to be endogenous to immigration because labor supply of immigrants tends to be relatively inelastic.[50] In this case, low-skilled immigration would not only imply redistribution from low- to high-skilled workers but also from workers to firms, similar to the decreasing-returns to scale extension in Section 6.5. An important difference to Section 6.5 is that immigrants are not paid their marginal product in such a setting. This implies that the economic pie accruing to natives would increase thereby reinforcing the indirect fiscal benefit.

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

[48]It's worth noting that corporate tax rates dropped substantially in 2018 to a weighted average of 25.7%. Performing this calculating with 2018 corporate tax rates implies an indirect fiscal effect of \$817.

[49]Colas, Findeisen, and Sachs (2018) estimate average lifetime fiscal externalities of attending college ranging roughly \$60,000 to \$90,000, conditional on parental income.

[50]Using US census data, the authors show that the assumption that markdowns are exogenous is rejected by the data.

7 Discussion

In this section we discuss and address limitations of our analysis. First, in Section 7.1 we discuss the role of physical capital. In Section 7.2, we discuss some critical issues about the assumptions we made when estimating the indirect fiscal effect. Then, in Section 7.3, we discuss how the indirect fiscal effects affect overall welfare.

7.1 The Role of Physical Capital

Throughout our analysis we have abstracted away from the role of capital in production. Here we show that physical capital can easily be accommodated into our formulas and does not significantly change our results.

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

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

Note that $\tilde{F}$ is a function of only labor quantities and exhibits constant returns to scale. Therefore, Proposition 3 can still be applied if we interpret the own-wage elasticity γ_{own} as the wage elasticity given optimal capital adjustments.[51]

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

Additionally, with physical capital, an inflow of low-skilled immigrants may lead to an increase in the quantity of physical capital, which may lead to additional fiscal benefits that we have not accounted for.

[51] Note that the above does not rely on a particular production function (such as Cobb-Douglas) or separability of capital in the production function more generally. The above arguments also apply to cases with non-separable capital and capital-skill complementarity, as in the models in Lewis (2011) and Lewis (2013).

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

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

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

As we show in Appendix A.7, the indirect fiscal benefit with inelastic labor supply is given by

$$d\mathcal{R}_{ind}(\omega) = y_u(\omega)\left[\underbrace{\left(\bar{T}_s' - \bar{T}_u'\right)|\gamma_{u,own}^{elast}|}_{\text{Skill Ratio Effect}} + \underbrace{\alpha\left(\tau_k - \bar{T}_I'\right)}_{\text{Capital Labor Ratio Effect}}\right] \tag{17}$$

where $\gamma_{u,own}^{elast} = \frac{\partial^2 G}{\partial L_u \partial L_u}\frac{L_u}{\partial G/\partial L_u}$ is the own-wage elasticity of low-skilled labor when capital supply is perfectly elastic.[52] One reasonable assumption is that when physical capital supply is inelastic, returns to physical capital have a similar tax rate as firm profits. Therefore using the marginal tax rate for profit we calculated of 36.8% in the previous section, and capital share parameter of α=.33, we find that the indirect fiscal effect of an average low-skilled immigrant with inelastic capital supply will increase by $y_u(\omega)\alpha\left(\tau_k - \bar{T}_I'\right) = \$273$ compared to the case with elastic capital supply.

7.2 Neglected 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.[53] 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.

More structural approaches have been taken in the literature more recently, e.g. by Llull (2018) who considers endogenous responses of natives along the occupation and education

[52] This is also equal to the own-wage elasticity when $\alpha = 0$.

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

margin, by Monras (2020) who considers a dynamic spatial equilibrium model and by Colas (2019) who also considers sectoral choices of natives.

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. However we focus on the indirect fiscal effect, which operates through a low-skilled immigrant's effect on native wages, independent of the taxes paid and benefits received by the immigrant themselves. As such, an immigrant's documentation status is unlikely to have a first-order effect on their indirect fiscal effect conditional on their income level $y_u(\omega)$.[54]

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

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

[54] 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 in the canonical model.

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

7.3 Welfare Effects – Immigration Surplus

The focus of this paper lies on enriching the estimation of fiscal effects of low-skilled immigration. Here, we briefly describe how the indirect fiscal effect affects the overall picture of welfare. We consider the concept of the immigration surplus which is an application of the Kaldor-Hicks compensation test (Kaldor, 1939; Hicks, 1939, 1940) to test the desirability of immigration from the perspective of natives and which is a leading approach to think about welfare in the immigration literature (see e.g. Borjas (2014)). We focus on our main model from Section 3 and derive the following result:

Proposition 4. *The Kaldor-Hicks surplus accruing to natives for one low-skilled immigrant with income y^{Im} is given by:*

$$Surplus_{Kaldor-Hicks}(y^{Im}) = dR_{dir} + \frac{y^{Im}|\gamma_{u,own}|}{1+\bar{\xi}^u|\gamma_{u,own}|+\bar{\xi}^s|\gamma_{s,own}|}\left(\overline{\varepsilon_s T'_s} - \overline{\varepsilon_u T'_u} + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}}\right)$$

where dR_{dir} is the direct fiscal effect.

Proof. See Appendix A.2.5. □

The Kaldor-Hicks surplus is simply given by the direct fiscal effect plus the fiscal externality. The fact that the first-order immigration surplus is non-zero beyond the direct fiscal effect is novel. Note that the term would be zero if (i) if labor supply of natives were exogenous or (ii) if the tax system were proportional and labor supply elasticities were common between low- and high-skilled workers. The endogeneity of labor supply combined with the progressivity of the tax system jointly imply a surplus: while the labor supply responses do not have a direct effect on native welfare due to the envelope theorem, they affect native welfare due to the implied indirect fiscal effects. Recall from Section 5 that we calculated a fiscal externality of \$430. This implies a – so far neglected – surplus effect of \$430. This highlights that the indirect fiscal effects are not just about redistributing money from natives to the government. Note that these fiscal externalities are even larger in the setting of Section 6.4, where endogenous occupational choice of natives is modeled.

Inverse Optimum Weights as in Hendren (2020) Given that compensation is not available without any efficiency costs, the Kaldor-Hicks test gives an incomplete picture. Hendren

(2020) extends this test to account for distortionary costs of redistribution. He shows that this can be achieved by weighting the gains and losses of individuals with so-called inverse optimum weights from the optimal tax literature.[55] Concretely, the gain (or loss) of an individual with income y has to be weighted by $g(y)$ in the surplus calculation, where $g(y)$ is the weight that the government has implicitly used when designing the tax schedule. These weights are normalized such that on average they are equal to one and one is the weight on government revenue. We apply his extension here to the immigration surplus.[56]

Proposition 5. *The Hendren surplus accruing to natives of one low-skilled immigrant is given by:*

$$Surplus_{Hendren}(y^{Im}) = dR_{dir} + \frac{y^{Im}|\gamma_{u,own}|}{1+\bar{\xi}^u|\gamma_{u,own}|+\bar{\xi}^s|\gamma_{s,own}|} \times \left(\overline{g_s\left(1-T'_s\right)} - \overline{g_u\left(1-T'_u\right)} + \bar{T}'_s - \bar{T}'_u + \overline{\varepsilon_s T'}_s - \overline{\varepsilon_u T'}_u + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}} \right)$$

where $\overline{g_e\left(1-T'_e\right)}$ is the income-weighted average of the product of the welfare weights and $(1-T')$ conditional on skill e.

Proof. See Appendix A.2.5. □

First of all, note that the new terms $\overline{g_s\left(1-T'_s\right)} - \overline{g_u\left(1-T'_u\right)} + \bar{T}'_s - \bar{T}'_u$ capture the mechanical distributional effects between natives and the government. They add up to zero if $g(y) = 1$ for all y because in such a case each dollar is valued equally regardless of whether it accrues to high-skilled natives, low-skilled natives or to the government. However, this is not the case for distortive taxation. We use the weight function $g(y)$ as calibrated by Hendren (2020), which is generally decreasing in income and therefore gives higher weight to low-skilled individuals than to high-skilled individuals. For such weights, even if we ignore taxes and endogenous labor supply, the first-order immigration surplus is not equal to zero. The income losses of low-skilled receive a higher weight than the income gains of high-skilled which captures that the compensation of the poor would imply efficiency costs.[57] Quantification of the formula in Proposition 5 reveals that the novel term in the surplus (absent the direct fiscal effect) takes

[55] Going one step further, Tsyvinski and Werquin (2019) generalize the Kaldor-Hicks compensation principle to a setting where taxes are not only distortionary but the distortions imply general equilibrium effects on wages, which creates a complicated fixed-point problem. The authors analytically describe the tax reform that achieves compensation in such a setting and provide a quantitative application to the case of automation.

[56] Hendren (2020) shows these weights can be obtained from inverting optimal tax formulas.

[57] This also captures the point that (Borjas, 2016b, p.191): "Although the mythical average person may be unaffected, immigration creates many winners and losers. [...] immigration turns out to be just another government redistribution program."

the value -\$353.[58] This shows that the distributional costs are first-order and roughly 2 times as high as the fiscal externalities. Yet, on the other hand, the number says that low-skilled immigration could be implemented in a Pareto-improving manner if immigrants had a positive direct fiscal effect above \$353 which could for example be achieved by appropriately set visa fees.

8 Conclusion

In this paper, we explore the indirect fiscal effect of immigration that works through the impact on the native wage distribution and native labour supply. Applying these formulas to the U.S., we find that the indirect fiscal effects of low-skilled immigration are sizable and positive for low-skilled immigrants. For some plausible scenario they turn low-skilled immigration form a fiscal burden to a fiscal surplus.

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

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A Theoretical Appendix

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

To understand the relationship $\gamma_{u,own} = \frac{\frac{N_s y_s}{N_u y_u + N_s y_s}}{\sigma}$, first recall the definition of the elasticity of substitution

$$\sigma = -\frac{\frac{\partial L_u}{\partial L_s} \Big/ \frac{L_u}{L_s}}{\frac{\partial w_u}{\partial w_s} \Big/ \frac{w_u}{w_s}}.$$

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

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

As a consequence, we have to have

$$-\frac{1}{\sigma} = \gamma_{u,own} + \gamma_{u,own} \frac{w_u L_u}{w_s L_s}$$

which yields the result: $\gamma_{u,own} = \frac{\frac{N_s y_s}{N_u y_u + N_s y_s}}{\sigma}$.

A.2 Canonical Model with Labor Supply

A.2.1 Proof of Proposition 2

Note that tax revenue in this economy is given by:

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

The indirect fiscal effect associated with an immigrant with productivity ω_j, hours h_j and tax payments $T(y_j, j)$ is given by the effect of an immigrant minus the direct effect

$$d\mathscr{R}^{ex} = \frac{dR}{d\mathscr{L}_u} \omega_j h_j - T(y_j, j).$$

Taking derivatives yields

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

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

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

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

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

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

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

A.2.2 Proof of Lemma 3

Tax revenue is given by

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

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

$$\begin{aligned} &\int_{i\in\mathcal{I}_u} T'(y_i,i) y_i \frac{dw_u}{w_u}\left(1+\varepsilon_i\right)\nu_i m_i di + \int_{i\in\mathcal{I}_s} T'(y_i,i) y_i \frac{dw_s}{w_s}\left(1+\varepsilon_i\right)\nu_i m_i di \\ &+ \int_{i\in\mathcal{I}_u} T_{part}(y_i,i) y_i \frac{dw_u}{w_u}\eta_i \nu_i m_i di + \int_{i\in\mathcal{I}_s} T_{part}(y_i,i) y_i \frac{dw_s}{w_s}\eta_i \nu_i m_i di \end{aligned} \tag{18}$$

A.2.3 Proof of Lemma 4

The set of integral equations is given by

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

and

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

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

$$\int_{\mathcal{I}_u} \frac{dL_i}{L_i} \frac{\omega_i L_i m_i}{\mathscr{L}_u} di = \int_{\mathcal{I}_u} \xi_i \Bigg(\gamma_{u,own} \frac{L^{Im}}{\mathscr{L}_u} \frac{\omega_i L_i m_i}{\mathscr{L}_u}$$

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

which can actually be written as

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

where $d\mathscr{L}_u = \int_{i \in \mathcal{I}_u} dL_i \omega_i m_i di$ and $\bar{\xi}^u$is the income-weighted average total hours elasticity high-school educated labor.

Equivalently, we obtain

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

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

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

and

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

Next, we obtain the wage changes for $j = s, u$. Using the definition of the total hours elasticity, we obtain:

$$\frac{dw_j}{w_j} = \frac{d\mathscr{L}_j}{\mathscr{L}_j} \frac{1}{\bar{\xi}^j}$$

We also obtain the labor supply changes of the different types i:

$$\forall i \in \mathcal{I}_u : \frac{dL_i}{L_i} = \frac{\xi_i \gamma_{u,own}}{1 - \bar{\xi}^u \gamma_{u,own} - \bar{\xi}^s \gamma_{s,own}} \frac{L^{Im}}{\mathscr{L}_u}$$

$$\forall i \in \mathcal{I}_s : \frac{dL_i}{L_i} = \frac{\xi_i \gamma_{s,cross}}{1 - \bar{\xi}^u \gamma_{u,own} - \bar{\xi}^s \gamma_{s,own}} \frac{L^{Im}}{\mathscr{L}_u}$$

$$\forall i \in \mathcal{I}_u : \frac{dh_i}{h_i} = \frac{\varepsilon_i \gamma_{u,own}}{1 - \bar{\xi}^u \gamma_{u,own} - \bar{\xi}^s \gamma_{s,own}} \frac{L^{Im}}{\mathscr{L}_u}$$

$$\forall i \in \mathcal{I}_s : \frac{dh_i}{h_i} = \frac{\varepsilon_i \gamma_{s,cross}}{1 - \bar{\xi}^u \gamma_{u,own} - \bar{\xi}^s \gamma_{s,own}} \frac{L^{Im}}{\mathscr{L}_u}$$

$$\forall i \in \mathcal{I}_u : \frac{d\nu_i}{\nu_i} = \frac{\eta_i \gamma_{u,own}}{1 - \bar{\xi}^u \gamma_{u,own} - \bar{\xi}^s \gamma_{s,own}} \frac{L^{Im}}{\mathscr{L}_u}$$

$$\forall i \in \mathcal{I}_s : \frac{d\nu_i}{\nu_i} = \frac{\eta_i \gamma_{s,cross}}{1 - \bar{\xi}^u \gamma_{u,own} - \bar{\xi}^s \gamma_{s,own}} \frac{L^{Im}}{\mathscr{L}_u}$$

A.2.4 Proof of Proposition 3

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

Now use:

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

and

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

as well as

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

which together implies

$$\begin{aligned} dR_{ind} =& \frac{\frac{L^{Im}}{\mathscr{L}_u} |\gamma_{u,own}| Y_u}{1 - \bar{\xi}^u \gamma_{u,own} - \bar{\xi}^s \gamma_{s,own}} \Bigg(- \frac{\int_{i \in \mathcal{I}_u} T'(y_i, i) y_i \left(1 + \varepsilon_i\right) \nu_i m_i di}{Y_u} + \frac{\int_{i \in \mathcal{I}_s} T'(y_i, i) y_i \left(1 + \varepsilon_i\right) \nu_i m_i di}{Y_s} \\ & - \frac{\int_{i \in \mathcal{I}_u} T_{part}(y_i, i) y_i \eta_i \nu_i m_i di}{Y_u} + \frac{\int_{i \in \mathcal{I}_s} T_{part}(y_i, i) y_i \eta_i \nu_i m_i di}{Y_s} \Bigg) \end{aligned} \tag{19}$$

and hence

$$dR_{ind} = \frac{y^{Im} |\gamma_{u,own}|}{1 + \bar{\xi}^u |\gamma_{u,own}| + \bar{\xi}^s |\gamma_{s,own}|} \left(\bar{T}'_s - \bar{T}'_u + \overline{\varepsilon_s T'}_s - \overline{\varepsilon_u T'}_u + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}} \right) \tag{20}$$

A.2.5 Kaldor-Hicks Surplus

To obtain the Kaldor-Hicks surplus, one has to add up the monetized gains and losses of all citizens and the fiscal effects. Denote the directly fiscal effect by dR_{dir}. The indirect fiscal effect is given by (see Proposition 3):

$$dR_{ind} = \frac{y^{Im}|\gamma_{u,own}|}{1+\bar{\xi}^u|\gamma_{u,own}|+\bar{\xi}^s|\gamma_{s,own}|}\left(\bar{T}'_s - \bar{T}'_u + \overline{\varepsilon_s T'}_s - \overline{\varepsilon_u T'}_u + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}}\right).$$

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

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

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

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

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

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

$$\begin{aligned} Surplus_{Hendren}(y^{Im}) =& dR_{dir} + \frac{y^{Im}|\gamma_{u,own}|}{1+\bar{\xi}^u|\gamma_{u,own}|+\bar{\xi}^s|\gamma_{s,own}|}\times \\ &\left(\overline{g_s\left(1-T'_s\right)} - \overline{g_u\left(1-T'_u\right)} + \bar{T}'_s - \bar{T}'_u + \overline{\varepsilon_s T'}_s - \overline{\varepsilon_u T'}_u + \overline{\eta_s T_{part,s}} - \overline{\eta_u T_{part,u}}\right) \end{aligned}$$

A.3 Indirect Fiscal Effect with Four Education Groups and Imperfectly Substitutable Experience Groups

Consider the case when the ratios of labor across education groups is held constant. That is, if an immigrant inflows causes an increase in the labor supply of a given education group $\mathscr{L}_e$, labor supplies of other groups scale proportionally. Then total production as a function of workers of education level e can be written as

$$Y = C\mathscr{L}_e(\cdot)$$

where C is a constant. The elasticities of wages with respect to labor of education group e and experience group a are given by

$$\tilde{\gamma}_{a'e,ae} = \frac{\partial^2 \mathscr{L}_e}{\partial L_{a'e} \partial L_{ae}} \frac{L_{a'e}}{\partial \mathscr{L}_e / \partial L_{ae}}$$

for $a' \neq a$ and

$$\tilde{\gamma}_{ae,ae} = \frac{\partial^2 \mathscr{L}_e}{\partial L_{ae} \partial L_{ae}} \frac{L_{ae}}{\partial \mathscr{L}_e / \partial L_{ae}}.$$

Let $\kappa_e = \frac{\sum_{a'} w_{a'e}\mathscr{L}_{a'e}}{\sum_{e'}\sum_{a'} w_{a'e'}\mathscr{L}_{a'e'}}$ be the share of total factor payments that go to education level e, and let $\kappa_{ae} = \frac{w_{ae}\mathscr{L}_{ae}}{\sum_{a'} w_{a'e}\mathscr{L}_{a'e}}$ be the fraction of wage payments to education group e that go to education group e and experience group a. Note that when education group ratios are not held constant, factor price elasticities are given by

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

for $a' \neq a$ and $e' \neq e$,

$$\gamma_{a'e,ae} = -\frac{1-\kappa_e}{\sigma}\kappa_{ae} + \tilde{\gamma}_{a'e,ae},$$

for $a' \neq a$, and

$$\gamma_{ae,ae} = -\frac{1-\kappa_e}{\sigma}\kappa_{ae} + \tilde{\gamma}_{ae,ae}.$$

The indirect fiscal effect is given by

$$d\mathcal{R}_{ind}(a,e,\omega) = h_{ae}\omega\left[\sum_{e'\neq e}\sum_{a'}\left(\bar{T}'_{a'e'}L_{a'e'}\frac{\partial w_{a'e'}}{\partial L_{ae}}\right) + \sum_{a'\neq a}\left(\bar{T}'_{a'e}L_{a'e}\frac{\partial w_{a'e}}{\partial L_{ae}}\right) + \left(\bar{T}'_{ae}L_{ae}\frac{\partial w_{ae}}{\partial L_{ae}}\right)\right],$$

which we rewrite as

$$d\mathcal{R}_{ind}\left(a,e,\omega\right)=h_{ae}\omega\left[\sum_{e'\neq e}\sum_{a'}\left(\bar{T}'_{a'e'}\frac{L_{a'e'}w_{a'e'}}{L_{ae}}\gamma_{a'e',ae}\right)+\sum_{a'\neq a}\left(\bar{T}'_{a'e}\frac{L_{a'e}w_{a'e}}{L_{ae}}\gamma_{a'e,ae}\right)+\left(\bar{T}'_{ae}w_{ae}\gamma_{ae,ae}\right)\right].$$

Plugging in the factor price elasticities from above yields

$$\begin{aligned}d\mathcal{R}^{\text{Borjas}}_{ind}\left(a,e,\omega\right)=&h_{ae}\omega\left[\frac{\kappa_{ae}}{L_{ae}\sigma_E}\left(\kappa_E\sum_{e'\neq e}\sum_{a'}\left(\bar{T}'_{a'e'}\frac{L_{a'e'}w_{a'e'}}{L_{ae}}\right)-\right.\right.\\&\left.(1-\kappa_E)\sum_{a'\neq a}\left(\bar{T}'_{a'e}\frac{L_{a'e}w_{a'e}}{L_{ae}}\right)-(1-\kappa_E)\left(\bar{T}'_{ae}w_{ae}\right)\right)+\\&\left.\sum_{a'\neq a}\left(\bar{T}'_{a'e}\frac{L_{a'e}w_{a'e}}{L_{ae}}\tilde{\gamma}_{a'e,ae}\right)+\left(\bar{T}'_{ae}w_{ae}\tilde{\gamma}_{ae,ae}\right)\right].\end{aligned}$$

Applying Euler's homogeneous function theorem to the top and bottom rows of the above equation and simplifying as in Section A.4 yields

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

A.4 Indirect Fiscal Effects in Dustmann, Frattini, and Preston (2013)

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

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

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

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

Plugging this into the indirect fiscal effect and rearranging yields:

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

which can be rewritten in terms of elasticities as

$$d\mathcal{R}_{ind}\left(j,\omega\right)=h_j\left(\omega\right)\sum_{k\neq j}\left(\bar{T}'_k-\bar{T}'_j\right)\frac{w_kL_k}{L_j}\gamma_{k,j}$$

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

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

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

where $\kappa_k = \frac{y_k N_k}{Y}$.

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

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

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

$$d\mathcal{R}_{ind}(j,\omega) = y_j(\omega)\times\left(\bar{T}_{k\neq j}' - \bar{T}_j\right)\times|\gamma_{j,own}| = y_j(\omega)\times\left(\bar{T}_{k\neq j}' - \bar{T}_j\right)\frac{1-\kappa_j}{\sigma}$$

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

A.5 Indirect Fiscal Effect in Peri and Sparber (2009)

This indirect fiscal effect in the long run can be decomposed into three terms:

$$d\mathcal{R}_{ind} = \underbrace{d\mathcal{R}_{ind}^{SR}}_{\text{short run effect}} + \underbrace{d\mathcal{R}_{ind}^{SORT}}_{\text{sorting effect}} + \underbrace{d\mathcal{R}_{ind}^{PR}}_{\text{secondary price effect}}. \tag{21}$$

The first term we refer to as the "short run" effect. This is equal to the indirect fiscal effect holding all task intensities constant, i.e. we have $dc_j = dm_j = 0$ for $j = f, d$. This short run indirect fiscal effect of low-skilled immigration is given by

$$\mathcal{R}_{ind}^{SR} = \underbrace{\frac{N_d}{N_f}\left(\bar{T}_d' - \bar{T}_f'\right)y_d \times \gamma_{w_d,N_f}\Big|_{dc_j=dm_j=0} dN_f}_{\text{Fiscal effect from low-skilled natives}} \tag{22}$$

$$+\underbrace{\frac{N_s}{N_f}\left(\bar{T}_s' - \bar{T}_f'\right)y_s \times \gamma_{w_s,N_f}\Big|_{dc_j=dm_j=0} dN_f}_{\text{Fiscal effect from high-skilled workers}}, \tag{23}$$

where $\gamma_{w_d,N_f}\Big|_{dc_j=dm_j=0}$ and $\gamma_{w_s,N_f}\Big|_{dc_j=dm_j=0}$ are 'short run' cross-wage elasticities that capture how the wages of low and high-skilled natives change due to immigration by low-skilled natives under the assumption that past immigrants and low-skilled natives do not react. We can decompose the short run indirect fiscal effect of an immigrant into the sum of two effects: 1) the fiscal effect resulting from changing the wages of low-skilled natives and immigrants and 2) the fiscal effect resulting from changing the relative wages of low-skilled immigrants and high-skilled workers.

The second term is the sorting effect. When immigrants enter the economy, low-skilled workers respond to adjusting their task supplies c_j and m_j. The fiscal effect of sorting is given by

$$d\mathcal{R}_{ind}^{SORT} = \underbrace{\bar{T}_f' f(1-f)\left(w_m m_f \eta_f^m + w_c c_f \eta_f^c\right) dN_f}_{\text{Immigrant Sorting Effect}} + \underbrace{\bar{T}_d'(1-f)^2\left(w_m m_d \eta_d^m + w_c c_d \eta_d^c\right) dN_f}_{\text{Native Sorting Effect}}. \quad (24)$$

The first term of (24) measures the change in tax revenue resulting from changes in the task intensities of low-skilled immigrants. The second term measures the change in task supplies of low-skilled natives. This term plays a similar role to the standard labor supply adjustment to wage changes except that workers here also adjust both task supplies in response in immigrant inflows. The sign is theoretically ambiguous and depends on the elasticities of task supplies with respect to immigrant inflows.

Finally, these changes in task intensities again change factor ratios and lead to an additional effect on equilibrium task prices, and therefore an additional effect on indirect fiscal effect that we denote by $d\mathcal{R}_{ind}^{PR}$, whose exact formula is given in Appenix A.5. In general we find this effect to be quantitively small.

The indirect fiscal effect is given by

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

First note that the effect of immigration N_f on task supplies can be written:

$$\frac{dM}{dN_f} = m^f + N_d \frac{dm^d}{dN_f} + N_f \frac{dm^f}{dN_f} = m_m^f + \left(\frac{dM}{dN_f}\right)_{ind}$$

and

$$\frac{dC}{dN_f} = c^f + N_d \frac{dc^d}{dN_f} + N_f \frac{dc^f}{dN_f} = c^f + \left(\frac{dC}{dN_f}\right)_{ind}$$

where

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

and

$$\left(\frac{dM}{dN_f}\right)_{ind} = m^d \eta_m^d (1-f)^2 + m^f \eta_m^f f^2$$

give the change in task supplies gives by endogenous task responses.

Further, the individual income elascities of high-skilled, foreign, and domestic workers can be written as:

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

$$= \underbrace{\frac{\partial y_s}{\partial M} m^f + \frac{\partial y_s}{\partial C} c^f}_{\text{direct effect}} + \underbrace{\frac{\partial y_s}{\partial M}\left(\frac{dM}{dN_f}\right)_{ind} + \frac{\partial y_s}{\partial C}\left(\frac{dC}{dN_f}\right)_{ind}}_{\text{indirect price effect}}$$

2. $$\frac{dy_f}{dN_f} = \frac{dw_m}{dN_f} m^f + \frac{dw_c}{dN_f} c^f + \underbrace{w_m \frac{dm^f}{dN_f} + w_c \frac{dc^f}{dN_f}}_{\text{sorting effect}}$$

3. $$\frac{dy_d}{dN_f} = \frac{dw_m}{dN_f} m^d + \frac{dw_c}{dN_f} c^d + \underbrace{w_m \frac{dm^d}{dN_f} + w_c \frac{dc^d}{dN_f}}_{\text{sorting effect}}$$

Further, we can also write

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

and

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

Rearranging terms, we can now write:

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

where each of the three terms is given by:

1. Direct Effect:

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

$$d\mathcal{R}^{SR}_{ind} = \bar{T}'_s N_s \frac{dy_s}{dN_f}|_{dc_j=dm_j=0} dN_f +$$
$$\bar{T}'_f N_f \frac{dy_f}{dN_f}|_{dc_j=dm_j=0} dN_f + \bar{T}'_d N_d \frac{dy_d}{dN_f}|_{dc_j=dm_j=0} dN_f.$$

where

$$\frac{dy_s}{dN_f}|_{dc_j=dm_j=0} = \frac{\partial y_s}{\partial M} m^f + \frac{\partial y_s}{\partial C} c^f,$$

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

and

$$\frac{dy_d}{dN_f}|_{dc_j=dm_j=0} = \left[m^d \left(\frac{\partial w_m}{\partial M} m^f + \frac{\partial w_m}{\partial C} c^f \right) + c^d \left(\frac{\partial w_c}{\partial M} m^f + \frac{\partial w_c}{\partial C} c^d \right) \right]$$

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

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

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

Plugging this in and writing in terms of elasticities yields (22):

$$\mathcal{R}^{SR}_{ind} = \underbrace{\frac{N_d}{N_f} \left(\bar{T}'_d - \bar{T}'_f \right) y_d \times \gamma_{w_d, N_f} \Big|_{dc_j=dm_j=0} dN_f}_{\text{Fiscal effect from low-skilled natives}}$$
$$+ \underbrace{\frac{N_s}{N_f} \left(\bar{T}'_s - \bar{T}'_f \right) y_s \times \gamma_{w_s, N_f} \Big|_{dc_j=dm_j=0} dN_f}_{\text{Fiscal effect from high-skilled workers}},$$

where $\gamma_{w_d, N_f}\Big|_{dc_j=dm_j=0}$ and $\gamma_{w_s, N_f}\Big|_{dc_j=dm_j=0}$ are 'short run' cross-wage elasticities that capture how the wages of low and high-skilled natives change due to immigration by low-skilled natives under the assumption that past immigrants and low-skilled natives do not react.

2. Sorting Effect:

   The fiscal effect of sorting is given by

$$\underbrace{\bar{T}'_f N_f \left(w_m \frac{dm_f}{dN_f} + w_c \frac{dc_f}{dN_f} \right) dN_f}_{\text{Immigrant Sorting Effect}} + \underbrace{\bar{T}'_d N_d \left(w_m \frac{dm_d}{dN_f} + w_c \frac{dc_d}{dN_f} \right) dN_f}_{\text{Native Sorting Effect}}.$$

The terms in brackets multiplied by dN_f give the change in income per past immigrant and native. Multiplying this with their amount and the marginal tax rate gives the implied tax effects.

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

$$\underbrace{\bar{T}_f' N_f \left(w_m m_f \eta_f^m \frac{df}{dN_f} + w_c c_f \eta_f^c \frac{df}{dN_f} \right) dN_f}_{\text{Immigrant Sorting Effect}} + \underbrace{\bar{T}_d' N_d \left(w_m m_d \eta_d^m \frac{df}{dN_f} + w_c c_d \eta_d^c \frac{df}{dN_f} \right) dN_f}_{\text{Native Sorting Effect}} .$$

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

$$d\mathcal{R}_{ind}^{SORT} = \underbrace{\bar{T}_f' f(1-f) \left(w_m m_f \eta_f^m + w_c c_f \eta_f^c \right) dN_f}_{\text{Immigrant Sorting Effect}} + \underbrace{\bar{T}_d' (1-f)^2 \left(w_m m_d \eta_d^m + w_c c_d \eta_d^c \right) dN_f}_{\text{Native Sorting Effect}} .$$

3. Indirect Price Effect

Collecting the remaining terms yields the indirect price effect:

$$\begin{aligned}
&(d\mathcal{R}_{ind}/dN_f)_{\text{indirect effect}} = \\
&\bar{T}_s' N_s \left[\frac{\partial y_s}{\partial M} \left(\frac{dM}{dN_f} \right)_{ind} + \frac{\partial y_s}{\partial C} \left(\frac{dC}{dN_f} \right)_{ind} \right] \\
&\bar{T}_f' N_f \left[m^f \left(\frac{\partial w_m}{\partial M} \left(\frac{dM}{dN_f} \right)_{ind} + \frac{\partial w_m}{\partial C} \left(\frac{dC}{dN_f} \right)_{ind} \right) + c^f \left(\frac{\partial w_c}{\partial M} \left(\frac{dM}{dN_f} \right)_{ind} + \frac{\partial w_c}{\partial C} \left(\frac{dC}{dN_f} \right)_{ind} \right) \right] \\
&\bar{T}_d' N_d \left[m^d \left(\frac{\partial w_m}{\partial M} \left(\frac{dM}{dN_f} \right)_{ind} + \frac{\partial w_m}{\partial C} \left(\frac{dC}{dN_f} \right)_{ind} \right) + c^d \left(\frac{\partial w_c}{\partial M} \left(\frac{dM}{dN_f} \right)_{ind} + \frac{\partial w_c}{\partial C} \left(\frac{dC}{dN_f} \right)_{ind} \right) \right]
\end{aligned} \tag{25}$$

We can rearrange this to yield

$$\begin{aligned}
&(d\mathcal{R}_{ind}/dN_f)_{\text{indirect effect}} = \\
&\left(\frac{dM}{dN_f} \right)_{ind} \left[\bar{T}_s' N_s \frac{\partial y^s}{\partial M} + \bar{T}_f' N_f \frac{\partial y^f}{\partial M} + \bar{T}_d' N_d \frac{\partial y^d}{\partial M} \right] + \\
&\left(\frac{dC}{dN_f} \right)_{ind} \left[\bar{T}_s' N_s \frac{\partial y^s}{\partial C} + \bar{T}_f' N_f \frac{\partial y^f}{\partial C} + \bar{T}_d' N_d \frac{\partial y^d}{\partial C} \right] .
\end{aligned} \tag{26}$$

A.6 Indirect Fiscal Effect with Decreasing Returns to Scale

The indirect fiscal effect associated with an immigrant with productivity ω is

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

We can rewrite this as

$$d\mathcal{R}_{ind}^{\text{DRS}}(\omega) = h_u(\omega)\omega\left[\tau_p \frac{\partial \pi}{\partial L_u} + \bar{T}'_s L_s \frac{\partial w_s}{\partial L_u} + \bar{T}'_u L_u \frac{\partial w_u}{\partial L_u}\right],$$

Consider the effect of the inflow on profits:

$$\frac{\partial \pi}{\partial L_u} = \left(\frac{\partial \pi}{\partial w_s}\frac{\partial w_s}{\partial L_u} + \frac{\partial \pi}{\partial w_u}\frac{\partial w_u}{\partial L_u}\right)$$

By Hotelling's lemma $\frac{\partial \pi}{\partial w_s} = -L_s$ and same for low-skilled labor. Therefore:

$$\frac{\partial \pi}{\partial L_u} = -\left(L_s \frac{\partial w_s}{\partial L_u} + L_u \frac{\partial w_u}{\partial L_u}\right)$$

Let

$$\frac{\partial I}{\partial L_u} = L_s \frac{\partial w_s}{\partial L_u} + L_u \frac{\partial w_u}{\partial L_u}$$

be the change in original worker income as a result of an immigrant inflow. Note that with CRS, $\frac{\partial I}{\partial L_u} = 0$.

Then

$$\frac{\partial \pi}{\partial L_u} = -\frac{\partial I}{\partial L_u}$$

We can write the indirect effect as:

$$d\mathcal{R}_{ind}^{\text{DRS}}(\omega) = h_u(\omega)\omega\left[-\tau_p \frac{\partial I}{\partial L_u} + \bar{T}'_s L_s \frac{\partial w_s}{\partial L_u} + \bar{T}'_u L_u \frac{\partial w_u}{\partial L_u}\right],$$

Let $\kappa_s = \frac{L_s w_s}{L_s w_s + L_u w_u}$ be the high-skilled fraction of income. Adding and subtracting some terms:

$$d\mathcal{R}_{ind}^{\text{DRS}}(\omega) = h_u(\omega)\omega\left[-\tau_p \frac{\partial I}{\partial L_u} + \bar{T}'_s\left(L_s \frac{\partial w_s}{\partial L_u} - \kappa_s \frac{\partial I}{\partial L_u}\right) + \bar{T}'_u\left(L_u \frac{\partial w_u}{\partial L_u} - \kappa_u \frac{\partial I}{\partial L_u}\right) + \left(\bar{T}'_s \kappa_s + \bar{T}'_u \kappa_u\right)\frac{\partial I}{\partial L_u}\right]$$

Rearranging a bit:

$$d\mathcal{R}_{ind}^{\text{DRS}}(\omega) = h_u(\omega)\omega\left[\left(\bar{T}'_I - \tau_p\right)\frac{\partial I}{\partial L_u} + \bar{T}'_s\left(L_s \frac{\partial w_s}{\partial L_u} - \kappa_s \frac{\partial I}{\partial L_u}\right) + \bar{T}'_u\left(L_u \frac{\partial w_u}{\partial L_u} - \kappa_u \frac{\partial I}{\partial L_u}\right)\right],$$

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

$$L_s \frac{\partial w_s}{\partial L_u} - \kappa_s \frac{\partial I}{\partial L_u} + L_u \frac{\partial w_u}{\partial L_u} - \kappa_u \frac{\partial I}{\partial L_u} = L_s \frac{\partial w_s}{\partial L_u} + L_u \frac{\partial w_u}{\partial L_u} - \frac{\partial I}{\partial L_u} = 0$$

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

$$d\mathcal{R}_{ind}^{\text{DRS}}(\omega) = h_u(\omega)\omega \left[\left(\bar{T}_I' - \tau_p \right) \frac{\partial I}{\partial L_u} + \left(\bar{T}_u' - \bar{T}_s' \right) \left(L_u \frac{\partial w_u}{\partial L_u} - \kappa_u \frac{\partial I}{\partial L_u} \right) \right],$$

The term $\kappa_u \frac{\partial I}{\partial L_u}$ is the effect of immigration on low-skilled income that occurs through the scale effect that arises from changing the total income but keeping share going to low-skilled workers constant. Therefore, we can think of the whole term as $N_u h_u \frac{\partial w_u}{\partial L_u} - \kappa_u \frac{\partial I}{\partial L_u}$ as the total change in low-skilled income from immigration minus the scale effect. Therefore, this whole term captures the effect of immigration on wages, holding scale (output) constant. Write $\frac{\partial \tilde{w}_u}{\partial L_u}$ as the effect of immigration on wages, holding scale constant.

By Euler's homogenous function theorem, we have:

$$L_u w_u + L_s w_s = \lambda F$$

where λ gives returns to scale $F(tL_u, tL_s) = t^{\lambda} F(L_u, L_s)$. Taking derivatives of both sides w.r.t. L_u:

$$w_u + L_u \frac{\partial w_u}{\partial L_u} + L_s \frac{\partial w_s}{\partial L_u} = \lambda w_u$$

Therefore (recall $\frac{\partial I}{\partial L_u} = L_u \frac{\partial w_u}{\partial L_u} + L_s \frac{\partial w_s}{\partial L_u}$)

$$\frac{\partial I}{\partial L_u} = (\lambda - 1)\, w_u$$

Then we know that

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

which yields

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

where $\tilde{\gamma}_{u,own}$ is own-wage elasticity, holding scale constant.

A.7 Indirect Fiscal Effect with Inelastically Supplied Capital

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

$$Y = \left(\theta_k K^\rho + \theta_l F\left(L_u, L_s\right)^\rho\right)^{1/\rho}$$

First, consider the case when capital supply is perfectly elastic. In this case, the capital labor ratio is constant. In this case, we can write $K = \bar{A}L$ where $\bar{A}$ is the constant capital labor ratio. The production function can be written as

$$Y = CF\left(L_u, L_s\right)$$

where C is a constant. The elasticities of wages with respect to low-skilled labor with perfectly elastic capital supply are given by

$$\gamma_{s,u}^{elast} = \frac{\partial^2 F}{\partial L_s \partial L_u} \frac{L_s}{\partial F / \partial L_u}$$

and

$$\gamma_{u,u}^{elast} = \frac{\partial^2 F}{\partial L_u \partial L_u} \frac{L_u}{\partial F / \partial L_u}.$$

Now consider the case in which capital supply is perfectly inelastic. Let $\kappa_L = \frac{w_u L_u + w_s L_s}{Y}$ be the share of factor payments that go to labor, let $\kappa_K = 1 - \kappa_L$, and let $\kappa_u = \frac{w_u L_u}{w_u L_u + w_s L_s}$ be the share of wage payments that go to low-skilled labor.

Let r give the price of capital. Factor price elasticities are given by

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

$$\gamma_{s,u} = -\frac{\kappa_K}{\sigma} \kappa_u + \gamma_{s,u}^{elast}$$

$$\gamma_{u,u} = -\frac{\kappa_K}{\sigma} \kappa_u + \gamma_{u,u}^{elast}$$

The indirect fiscal effect is given by

$$d\mathcal{R}_{ind}\left(\omega\right) = h_u(\omega)\omega \left[\tau_k K \frac{\partial r}{\partial L_u} + \bar{T}_s' L_s \frac{\partial w_s}{\partial L_u} + \bar{T}_u' L_u \frac{\partial w_u}{\partial L_u}\right],$$

which we rewrite as

$$d\mathcal{R}_{ind}\left(\omega\right) = h_u(\omega)\omega \left[\tau_k \frac{Kr}{L_u} \gamma_{r,u} + \bar{T}_s' \frac{L_s w_s}{L_u} \gamma_{s,u} + \bar{T}_u' w_u \gamma_{u,u}\right].$$

Plugging in the factor price elasticities from above yields

$$d\mathcal{R}_{ind}(\omega) = h_u(\omega)\omega\Bigg[\frac{\kappa_u}{L_u\sigma}\left(\tau_k Kr\frac{w_uL_u + w_sL_s}{Y} - \bar{T}_s' L_s w_s \frac{Kr}{Y} - \bar{T}_u' L_u w_u \frac{Kr}{Y}\right) + \\ \bar{T}_s' \frac{L_s w_s}{L_u}\gamma_{s,u}^{elast} + \bar{T}_u' w_u \gamma_{u,u}^{elast}\Bigg].$$

Pulling out $\kappa_K = \frac{Kr}{Y}$ from the first line yields

$$d\mathcal{R}_{ind}(\omega) = h_u(\omega)\omega\Bigg[\kappa_K\frac{\kappa_u}{L_u\sigma}\left(\tau_k(w_uL_u + w_sL_s) - \bar{T}_s' L_s w_s - \bar{T}_u' L_u w_u\right) + \\ \bar{T}_s' \frac{L_s w_s}{L_u}\gamma_{s,u}^{elast} + \bar{T}_u' w_u \gamma_{u,u}^{elast}\Bigg].$$

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

$$d\mathcal{R}_{ind}(\omega) = h_u(\omega)\omega\Bigg[(w_uL_u + w_sL_s)\kappa_K\frac{\kappa_u}{L_u\sigma}\left(\tau_k - \bar{T}_I'\right) + \\ \bar{T}_s' \frac{L_s w_s}{L_u}\gamma_{s,u}^{elast} + \bar{T}_u' w_u \gamma_{u,u}^{elast}\Bigg]$$

which can be simplified to

$$d\mathcal{R}_{ind}(\omega) = h_u(\omega)\omega\left[w_u\frac{\kappa_K}{\sigma}\left(\tau_k - \bar{T}_I'\right) + \bar{T}_s' \frac{L_s w_s}{L_u}\gamma_{s,u}^{elast} + \bar{T}_u' w_u \gamma_{u,u}^{elast}\right]$$

Further, we know that F is constant returns to scale, which implies that $w_u\gamma_{u,u}^{elast} = -\frac{L_s w_s}{L_u}\gamma_{s,u}^{elast}$. We can therefore write

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

Rearranging this equation yields

$$d\mathcal{R}_{ind}(\omega) = y_u(\omega)\left[\left(\bar{T}_s' - \bar{T}_u'\right)|\gamma_{u,own}^{elast}| + \frac{\kappa_K}{\sigma}\left(\tau_k - \bar{T}_I'\right)\right]. \tag{27}$$

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

B Empirical Appendix

B.1 Data Cleaning and Sample Selection in the ACS

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

When calculating taxes, we account for an individuals wage income and business income as sources of taxable income. However, all income weighted averages are weighted by wage incomes and sample weights.

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

We begin by estimating average monthly benefits received as a function of monthly income and household size using data from the SIPP. We begin by calculating total monthly SNAP benefits and TANF benefits for each household in the SIPP. To deal with underreporting, we estimate these estimated monthly benefits such that the total benefits received match national aggregates reported from the Bureau of Economic Analysis. Next, we divide household by household size and estimate monthly TANF and SNAP benefits as linear spline in household income. We estimate a separate spline for each household size. Next, using these function of benefits as a function of income, we can calculate the *marginal* average monthly benefits as a function of monthly income and household size. We aggregate these monthly estimates to yearly estimates by taking the income weighted average across months for each household in the SIPP. We then take the income weighted average of the average marginal benefits rates for both low-skilled and high-skilled workers.

B.3 Calculation of Marginal Replacement Rates of Social Security Benefits

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

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

$$DRR_i = \text{Marginal Yearly Social Security}(AIME_i)\frac{1}{35}\left(\frac{1+g}{1+r}\right)^{65-age_i}\sum_{t=66}^{T_i}\left(\frac{1}{1+r}\right)^{t-65} \quad (28)$$

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

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

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

1. An individual's education - high school dropout, high school graduate, some college, or college graduate
2. Whether or not an agent is married
3. 5-year age bins

4. Whether or not the agent has children living in their household
5. Quintiles of the income distribution, conditional on working and conditional on the above characteristics.

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

B.4 A Model of Labor Supply in the Peri and Sparber (2009) Model

We model the task supply decision a bit more generally than Peri and Sparber (2009). Low-skilled natives and immigrants maximize utility by choosing their labor supply $h_j \; \forall \; j = f, d$ (i.e. how many hours and overall intensity of work) and their communication and manual task intensities $\tilde{c}_j$ and $\tilde{m}_j$ (i.e. how much of their time to devote to each task) taking task prices as given. A worker's task supply is given by the product of their labor supply and their task intensity: $c_j = h_j \tilde{c}_j$ and $m_j = h_j \tilde{m}_j$. All else equal, workers prefer higher income, but may receive disutility from increasing their labor supply or from different task intensities. We can write the agent of type j's problem as

$$\max_{\tilde{c}_j, \tilde{m}_j, h_j} \left[U_j \left(y_j, \tilde{c}_j, \tilde{m}_j, h_j \right) \right] \tag{29}$$

subject to the constraint

$$y_j = c_j w_c + m_j w_m$$

where $c_j = h_j \tilde{c}_j$ and $m_j = h_j \tilde{m}_j$.

The worker's problem (29) is quite general and allows for many types of labor supply behavior. In particular, we place no restrictions on the relationship between c_j and m_j (for example that they sum to one). Further, we allow for comparative and absolute advantage by allowing the utility function to vary by worker type, j. For example, native workers may find it easier to supply communication tasks relative to immigrant workers. While we do not formally spell out this assumption, the reader should think of natives having a comparative advantage in communication tasks and immigrants having a comparative advantage in manual tasks. Most importantly, our specification nests the worker's problem in the Peri and Sparber (2009).[59]

[59] In Peri and Sparber (2009), workers of each type choose manual task specification, l_j to maximize income

$$\max_{l_d} \left[(l_j)^{\delta} \mu_j w_m + (1 - l_j)^{\delta} \zeta_j w_c \right]$$

As shown empirically in Peri and Sparber (2009), adjustment of task supplies may be an important margin for workers to respond to low-skilled immigrant inflows. If low-skilled immigrants supply relatively more manual tasks compared to the average low-skilled worker, inflows of low-skilled immigrants will increase the ratio of manual to communication tasks, and therefore decrease the ratio of manual wages to communication wages. Workers may respond by supplying relatively more communication tasks and therefore partially insulate themselves from the negative wage effects of immigration.

B.5 Quantifying the Fiscal Effect in Peri and Sparber (2009)

We now calculate the indirect fiscal benefits and its decomposition as expressed in equation 21. In order to evaluate this equation, we need estimates of the following:

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

We take estimates of items (1) - (3) directly from Peri and Sparber (2009). Specifically, Peri and Sparber (2009) estimate the state level task prices of manual and cognitive tasks, w_m and w_c, using variation in task supplies and wages across occupations. We take the national average of these task prices for our measures of w_m and w_c. Peri and Sparber (2009) estimate the elasticity of substitution between manual and communication tasks, σ_u, using state level variation in immigrant inflows. We set $\sigma_u = 1$ as the preferred estimates from Peri

where δ is a parameter which measures diminishing returns to task specialization and μ_j and ζ_j are parameters which represent fixed productivity levels in manual and communicative tasks, respectively.

This is a special case in our model in which we let $m_j = (l_j)^\delta \mu_j$ and $c_j = (1 - l_j)^\delta \zeta_j$ and the utility function

$$U_j\left(y_j, \tilde{c}_j, \tilde{m}_j, h_j\right) = \left\{ \begin{array}{ll} y_j, & \text{for } \left(\frac{c_j}{\zeta_j}\right)^{1/\delta} + \left(\frac{m_j}{\mu_j}\right)^{1/\delta} = 1 \\ -\infty, & \text{otherwise} \end{array} \right\}$$

and Sparber (2009) and the set the elasticity of substitution between low and high-skilled workers as $\sigma = 1.75$, based on the calibration in Peri and Sparber (2009). Peri and Sparber (2009) also use across-state immigrant variation to estimate the elasticities of task supplies with respect to the immigrant share of low-skilled workers. They find that natives respond to low-skilled immigrant inflows by increasing their communication task supply but do not change their manual task supply, and that immigrants do not change their task supplies in response to immigrant inflows. We therefore set $\eta_c^f = \eta_m^f = \eta_m^d = 0$ and take $\eta_c^d = 0.33$ from their estimates.

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

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

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

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

Object	Value	Desription	Source
Task Prices			
w_m	773	Manual task wage	PS inflated to 2017
w_c	820	Communication task wage	PS inflated to 2017
w_s	$69,311$	Skilled income	ACS
Production Parameters			
σ	1.75	Elasticity of substitution, skilled and unskilled workers	PS
σ_u	1	Elasticity of substitution, manual and communication tasks	PS
Task Supply Elasticities			
η_c^d	.33	Elasticity of native communication task supply with respect to immigrants	PS
η_m^d,η_m^f,η_c^f	0	Other task supply elasticities	PS
Population Shares			
$\frac{N_f}{N}$	0.069	Low skilled immigrants as fraction of population	ACS
$\frac{N_d}{N}$	0.318	Low skilled natives as fraction of population	ACS
$\frac{N_s}{N}$	0.613	High skilled workers as fraction of population	ACS
Task Supplies			
c_f	12.47	Communication task supply of low skilled immigrants	O*Net and ACS
c_d	19.15	Communication task supply of low skilled natives	O*Net and ACS
m_f	27.71	Manual task supply of low skilled immigrants	O*Net and ACS
m_d	29.18	Manual task supply of low skilled natives	O*Net and ACS
Marginal Tax Rates			
$\bar{T}_f'$	0.299	Marginal tax rate of low skilled immigrants	Taxsim and ACS
$\bar{T}_d'$	0.293	Marginal tax rate of low skilled natives	Taxsim and ACS
$\bar{T}_s'$	0.369	Marginal tax rate of high skilled workers	Taxsim and ACS

Table 10: Summary of data sources and calibrated values. "PS" refers to estimates taken from Peri and Sparber (2009).

C Further Quantitative Results

C.1 Indirect Fiscal Effects in Canonical Model with for High School Dropouts and High School Graduates

Tables 11 and 12 show the indirect fiscal effects for the average high school dropout immigrant and the average high school graduate immigrant.

C.2 Indirect Fiscal Effects in Canonical Model with Alternative Skill Definitions

In Section 3 we followed Borjas (2003), Peri and Sparber (2009) and Ottaviano and Peri (2012) and defined low-skilled workers as those with no college experience and defined high-skilled workers as individuals with some college and college graduates. An alternative way to delineate skills is to divide individuals with some college between low-skilled and high-skilled workers, as in Card (2009) or Katz and Murphy (1992).

In this section we replicate our baseline results from Section 5, except we define skill groups as in Card (2009), by dividing individuals with some college evenly between the groups. Overall the indirect fiscal effects here are slightly smaller than our baseline result. This makes sense, the skill definitions we use in this section imply a smaller high-skilled share of income

	Elasticity of Substitution		
	1.5	2.0	2.5
I. No Labor Supply Responses	1108	831	665
II. Intensive Only			
Common Elasticity	1208	949	781
By Gender and Marital Status	1112	835	669
By Income, Gender and Marial Status	1149	866	695
III. Extensive Only			
Common Elasticity	1177	916	749
By Gender and Marital Status	1139	870	704
By Income, Gender and Marital Status	1082	823	665
IV. Intensive and Extensive			
Common Elasticity	1254	1011	847
By Gender and Marital Status	1142	874	708
By Income, Gender and Marial Status	1120	857	694

Table 11: Indirect Fiscal Effects for high school dropouts with intensive and extensive margin labor supply responses. See description from Table 3.

	Elasticity of Substitution		
	1.5	2.0	2.5
I. No Labor Supply Responses	1433	1075	860
II. Intensive Only			
Common Elasticity	1563	1227	1010
By Gender and Marital Status	1438	1080	865
By Income, Gender and Marital Status	1485	1120	899
III. Extensive Only			
Common Elasticity	1523	1184	969
By Gender and Marital Status	1473	1125	911
By Income, Gender and Marital Status	1399	1065	859
IV. Intensive and Extensive			
Common Elasticity	1622	1308	1095
By Gender and Marital Status	1477	1130	915
By Income, Gender and Marital Status	1449	1108	897

Table 12: Indirect Fiscal Effects for high school graduates with intensive and extensive margin labor supply responses. See description from Table 3.

	Elasticity of Substitution		
	1.5	2.0	2.5
No Labor Supply Responses	1221	916	733
Intensive Only			
Common Elasticity	1332	1046	861
By Gender and Marital Status	1222	919	736
By Income, Gender and Marial Status	1266	955	766
Extensive Only			
Common Elasticity	1295	1008	824
By Gender and Marital Status	1245	952	770
By Income, Gender and Marial Status	1181	898	725
Intesnive and Extensive			
Common Elasticity	1381	1113	932
By Gender and Marital Status	1246	954	773
By Income, Gender and Marial Status	1223	935	757

Table 13: Indirect Fiscal Effects with intensive and extensive margin labor supply responses with alternative skill definition.

and therefore a smaller own-wage elasticity for low-skilled workers, holding the parameter σ constant. However the results are still in the same ballpark as those presented in Section 5.

C.3 Indirect Fiscal Effects in Canonical Model with Real Interest Rate=2

In Section 3 we chose a real interest rate of 1%. In Table 14 we replicated our baseline results under the assumption of a real interest rate of 2%. The table shows the indirect fiscal effects of the average low-skilled immigrant. The effects range from $682 to $1,309.

	Elasticity of Substitution		
	1.5	2.0	2.5
I. No Labor Supply Responses	1141	856	685
II. Intensive Only			
Common Elasticity	1244	977	804
By Gender and Marital Status	1145	860	689
By Income, Gender and Marital Status	1188	896	719
III. Extensive Only			
Common Elasticity	1233	959	784
By Gender and Marital Status	1181	903	730
By Income, Gender and Marital Status	1110	845	682
IV. Intensive and Extensive			
Common Elasticity	1309	1055	884
By Gender and Marital Status	1185	907	734
By Income, Gender and Marital Status	1155	883	715

Table 14: Indirect Fiscal Effects with intensive and extensive margin labor supply responses with real interest rate of 2%.