# Are Immigrants a Shot in the Arm for the Local Economy?*

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**Abstract**

Most research on the effects of immigration focuses on the effects of immigrants as adding to the supply of labor. This paper studies the effects of immigrants on local labor *demand*, due to the increase in consumer demand for local services created by immigrants. This effect can attenuate downward pressure from immigrants on non-immigrants' wages, and also benefit non-immigrants by increasing the variety of local services available. For this reason, immigrants can *raise* native workers' real wages, and each immigrant

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could create more than one job. Using US Census data from 1980 to 2000, we find considerable evidence for these effects: Each immigrant creates 1.2 local jobs for local workers, most of them going to native workers, and 62% of these jobs are in non-traded services. Immigrants appear to raise local non-tradables sector wages and to attract native-born workers from elsewhere in the country. Overall, it appears that local workers benefit from the arrival of more immigrants.

Most economic research on the effects of immigration focuses on the effects of immigrants as adding to the supply of labor. Prominent examples include Card (1990), Borjas (2003), and Aydemir and Borjas (2011) who look for wage effects of immigration as a rightward shift of the labor supply curve; and Ottaviano and Peri (2012), who argue that immigration adds a new factor of production, labor with a different skill mix. See Friedberg and Hunt (1995) for numerous other examples. This is also the approach to immigration implicit in some objections to immigration in the political arena. For example, Senator Jeff Sessions of Alabama recently objected to a proposed immigration reform bill on grounds that it would lead to a rise in the supply of labor and a drop in some native-born workers' wages.[1]However, in general equilibrium immigrants will affect not only labor *supply*, but also labor *demand*. Many accounts by journalists and other non-economists emphasize the point that immigrants do not serve only as additional workers, but also as additional consumers, and as a result can provide a boost for the local labor market by increasing demand for barbers, retail store workers, auto mechanics, school teachers, and the like.

This paper studies the effects of immigrants on local labor demand, due to the

[1] Dylan Matthews, "No, the CBO report doesn't mean immigration brings down wages," *Washington Post*, June 19, 2013.

increase in consumer demand for local services created by immigrants. We show how in a simple general equilibrium model this demand effect can provide two benefits to local native-born workers: It can soften the effect of the increase of labor supply on wages, by shifting the demand for labor to the right just as the supply is also shifting to the right; and it can lead to an increase in the diversity of local services, conferring an indirect benefit on native-born consumers. Taken together, these effects mean that local real wages can *rise* as a result of immigration, even in a model where native-born and immigrant labor are perfect substitutes. We take these propositions to US Census data from 1980 to 2000, and find that each immigrant on average generates 1.2 local jobs for local workers, most of them going to native-born workers, and 62% of them in the non-tradables sector. These findings are consistent with a strong effect of local labor demand, generating substantial increases in local services diversity.

Along the way we offer a modest innovation in empirical technique: We use a new measure of 'non-tradedness' that is easy to implement and has enormous explanatory power, and which is related to the techniques used by Jensen and Kletzer (2006) and Gervais and Jensen (2012).

The effect of local services demand has had much informal discussion, but little scholarly attention. In journalistic accounts of crackdowns on illegal immigrants, for example, local consumer demand effects are sometimes presented as a central part of the story. For example, following more stringent immigration enforcement in Oklahoma City, some residents complained that the moves were 'devastating' to the local economy:[2]

[2] Devona Walker, "Immigration crackdown called devastating to economy," *Washington Post*, September 18, 2007.

> At Maxpollo, a Hispanic-owned restaurant on S Harvey, Tex-Mex music is played a little above conversation level. The late-afternoon lunch crowd, primarily Hispanic workers, has thinned.
>
> "All of our customers here are Hispanic, said Luiz Hernandez, whose father Max Hernandez owns Maxpollo. "We are going to lose a lot of business. While restaurant employees are not illegal, he assumes many customers are.

Similar stories followed a major federal raid on illegal immigrants in Postville, Iowa in 2008 that incarcerated 10% of the town's population. From one journalist's account:[3]

> Empty storefronts and dusty windows break up a once vibrant downtown. Businesses that catered to the town's Latino population have been hardest hit. Most closed last summer.

A similar story from the *Washington Post*:[4]

> For now, Postville residents – immigrants and native-born – are holding their breath. On Greene Street, where the Hall Roberts' Son Inc. feed store, Kosher Community Grocery and Restaurante Rinconcito Guatemalteco sit side by side, workers fear a chain of empty apartments, falling home prices and business downturns. The main street, punctuated by

[3] Jens Manuel Krogstad, "Postville economy in shambles," *Waterloo/Cedar Falls Courier*, Monday, May 11, 2009.

[4] Spencer S. Hsu, "Immigration Raid Jars a Small Town; Critics Say Employers Should Be Targeted." *Washington Post* Sunday, May 18, 2008, p. A01.

> a single blinking traffic signal, has been quiet; a Guatemalan restaurant temporarily closed; and the storekeeper next door reported a steady trickle of families quietly booking flights to Central America via Chicago.
>
> "Postville will be a ghost town," said Lili, a Ukrainian store clerk who spoke on the condition that her last name be withheld.

As one writer summarized the point in general:

> Population growth creates jobs because people consume as well as produce: they buy things, they go to movies, they send their children to school, they build houses, they fill their cars with gasoline, they go to the dentist, they buy food at stores and restaurants. When the population declines, stores, schools, and hospitals close, and jobs are lost. This pattern has been seen over and over again in the United States: growing communities mean more jobs. (Chomsky (2007), p.8).

We formalize these effects in a simple model of a local economy, or 'town,' with both a tradeables sector and a sector that produces non-tradable services (such as haircuts, food services, and the like). To capture the importance of diversity in local services, that sector is assumed to be monopolistically competitive. The demand for labor in the tradeables sector is exogenous, depending on world markets for the tradable goods, but the demand for labor in the non-tradable services sector is affected by the size of the local population. Adding immigrants to this local economy shifts the labor supply curve to the right but also, by adding to the demand for local services, shifts the labor demand curve to the right (to a smaller degree). The latter shift we term the 'shot in the arm' effect. The net effect is to lower the local equilibrium wage in terms of tradables, but raise the wage in terms of non-tradable services, because of the increased local diversity of those services. The overall real wage could go up or down, depending on how strong the shot-in-the-arm effect is; if it goes up, then in equilibrium $1,000$ immigrants will result in the creation of more than $1,000$ local jobs.

Local demand effects have not been the focus of the majority of immigration research, but there are exceptions. Giovanni et al. (2015) present a rich many-country model of immigration and trade in which local non-traded services respond in a manner similar to what we study in this paper. The paper is calibrated rather than estimated, but the simulation shows that for realistic parameter values the potential welfare benefits of increased service variety due to immigration are large. Olney (2015) shows that when immigrants in a German town send more money back home in the form of remittances, the reduction in local consumer spending has a negative effect on local wages for non-immigrant workers. Cortes (2008), focussing on supply-side effects on the service sector, shows that immigration is correlated with reductions in the local price of labor-intensive services.[5] Mazzolari and Neumark (2012) examine the effect of immigrants on local diversity of services in California. The study finds that more immigrants are associated with fewer small retail stores and more big-box retailers, but that immigrants support a wider range of ethnic restaurants. The focus is quite different from ours, however. That paper focusses on the effect on a higher *share* in immigrants in the local population, controlling for size (p. 1123). The thought experiment under study can be thought of as adding

[5]Our study and Cortes (2008) can be viewed as complementary. In Section 4.2 we identify some features of the data that are inconsistent with a pure labor-supply effect, but there is no reason the non-traded sector could not be affected by labor-supply and local-demand effects at the same time.

1,000 immigrants and removing 1,000 native-born workers. In our case, however, the relevant thought experiment is simply adding 1,000 immigrants. Olney (2012) shows that low-skill immigration in the US is correlated with increases in entry of small establishments in the same city, concentrated in low-skill intensive industries. Olney shows that the effect is more plausibly due to the labor-supply effect of immigrants than the effects of immigrants as consumers because the effect is found in mobile low-skill intensive industries but not in non-traded services. However, as with Mazzolari and Neumark (2012), the focus is on changes in the *share* of immigrants in the local population rather than an increase in the local population due to immigration. Another difference between our study and these is that by examining decennial Census data rather than annual data we are looking at more long-run effects.[6]

An important theory paper closely related in spirit to what we do here is Brezis and Krugman (1996), in which manufacturers use labor, capital and local non-traded inputs to produce tradeable output. Non-traded inputs are produced in a monopolistically-competitive industry. Immigration into a town expands the local labor force, initially lowering wages; this encourages entry into the non-traded services sector, expanding the range of inputs for use by local manufacturers, thereby raising labor productivity and encouraging capital to flow into the town. In the new steady state, wages are higher than they were before the immigration. Our approach stresses increased variety of non-traded consumer services – which we will show has strong support in the data – rather than non-traded inputs produced by firms, but the mechanism that drives the stories is similar. Another related study is Moretti

[6] Altonji and Card (1991) also discuss local-demand effects of immigrants, but without making a distinction between traded and non-traded goods, or raising the issue of local diversity of services. General-equilibrium effects on the non-traded sector also feature prominently in some work on trade reform; see Kovak (2013).

(2010), which measures the effect of one additional tradeable sector job on employment in the local non-traded sector, implicitly through local demand effects such as we emphasize.[7]

We also draw on the literature that investigates whether immigrants to a town displace or attract non-immigrant workers, or in other words, whether the immigrants induce non-immigrants to move away from the town, or attract a net movement of non-immigrant workers to the town. For example, Wozniak and Murray (2012) find no displacement effect with annual data from the American Community Surveys, and a modest attraction effect for low-skill native workers, which they argue could be caused by low-skill workers unable to move away due to liquidity constraints. Wright et al. (1997) find either attraction or at least no displacement effect once city size has been adequately controlled for. Peri and Sparber (2011) review the evidence on displacement, reviewing the different estimation methods that have been used to test for it, and create simulated data to test the reliability of the different methods. They find that studies that have found a significant displacement effect have used an estimator that is biased in favor of that finding, and that studies that use a more reliable estimator have found either no displacement or a modest attraction effect. We will use findings from these papers in designing our own empirical approach.

Although we draw on well-established literatures, we put together the pieces in a new way that tells a coherent story centered on the local non-traded sector. Our theory model shows a theoretical criterion (Propositions 1 and 4) and an empirical criterion (Proposition 5) for local native workers to benefit from immigrants through

[7] The theoretical paper Borjas (2013) appears at first blush to be related, but the model has no non-traded sector. In that model, the Home economy produces only one good, and when immigrants come in, their tastes change so that the total world demand for that good rises.

this channel, which motivates our aggregate employment regression (Section 4.1) and regressions on population change (Section 4.3). Our distinction between the effect on labor demand in traded and in non-traded sectors (Proposition 2) allows us to interpret the employment effects we find in the regressions in terms of this same equilibrium mechanism, and motivates our use of a measure of non-tradedness in our employment regressions as detailed in Sections 2.2, 3, and 4.1. The evidence in Section 4.2 that immigrants raise wages in the local non-traded sector relative to the traded sector provides evidence for a demand-side effect, separate from the supply-side effects studied by Cortes (2008) and Olney (2012). Together, these provide an empirical case for the 'shot-in-the-arm' effect as distinct from other effects that have been the focus of other research.

In the following section we present the basic theory model we use to clarify these issues, and some refinements. The following sections present our empirical method, the data, and our empirical results, respectively. The final section presents a summary and conclusion.

# 1 A Basic Model.

We look at a model with a monopolistically competitive local-services sector of the Dixit and Stiglitz (1977) variety, in order to be able to discuss endogenous diversity of such services, and a tradeable-goods sector, which for simplicity we specify as perfectly competitive. The model is similar in spirit to Brezis and Krugman (1996). For the time being we employ three simplifying assumptions: (i) we ignore the effects of immigration on the housing market; (ii) we assume that local labor supply is perfectly inelastic (thus disallowing mobility of native-born workers); and (iii) we treat native-born and immigrant workers as perfect substitutes. Later we will relax these assumptions.

## 1.1 Preferences

Consider a model of a local economy that we can refer to as a 'town.' Everyone who lives there has the same utility function:

$$U(S,T) = \frac{S^{\theta}T^{1-\theta}}{\theta^{\theta}(1-\theta)^{1-\theta}}, \tag{1}$$

where $S$ is a composite of non-tradable services consumption and $T$ is a composite of tradable goods consumption. Composite services consumption is defined by:

$$\left(S = \int_0^n \left(c^i\right)^{\frac{\sigma-1}{\sigma}} di\right)^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

where $c^i$ is consumption of service $i$, $n$ is the measure of services available, and $\sigma > 1$ is a constant. The indirect utility function derived from maximizing (2) subject to a given expenditure on services is:

$$S = \frac{E^S}{P^S}, \tag{3}$$

where $E^S$ is total spending on services and $P^S$ is a price index for services given by:

$$P^S = \left(\int_0^n p(j)^{1-\sigma} dj\right)^{\frac{1}{1-\sigma}}, \tag{4}$$

where $p(j)$ is the price of service variety $j$.

There are $n$ different tradeable goods. Composite tradables consumption is defined by:

$$T = u^T(c^T), \tag{5}$$

where $c^T$ is the $n$-dimensional vector of consumptions of the different tradable goods and $u^T$ is an increasing, concave, linear homogeneous function. The indirect utility function derived from $u^T$ is:

$$v^T(E^T, q) = \frac{E^T}{\kappa(q)}, \tag{6}$$

where $E^T$ is expenditure on tradeables, $q$ is the price vector for tradeables, and $\kappa$ is the linear homogeneous price index derived from $u^T$. The prices for tradeables are fixed and exogenous (the town is not large enough to affect prices for tradeables on its own). Without loss of generality, we choose units so that the aggregate price of tradeables is unity:

$$\kappa(q) = 1. \tag{7}$$

As a result, all prices in the model can be said to be denominated 'in terms of tradeables.'

## 1.2 Technology.

There is free entry into the services sector. Production of $x$ units of any service requires

$$\alpha + \beta x \tag{8}$$

units of labor, where $\alpha$ and $\beta$ are positive constants.

Each tradeable good $i$ is produced with labor $L^i$ and sector-specific capital $K^i$ through a linear homogeneous production function $f^i$. The capital available in each tradeables industry is fixed and exogenous,[8] and each producer takes all prices as given. Each tradeables firm will choose the level of employment to maximize its profits, taking wages and output prices as given. In the aggregate, this generates an allocation of labor within the tradables sector that solves:

$$r(q, w, K) \equiv max_{\{L_i\}} \left\{ \sum_i q^i y^i - wL^i | y^i = f^i(L^i, K^i) \right\} \tag{9}$$

Here $K \equiv (K^1, \ldots, K^n)$ is the vector of industry-specific capital endowments, $y^i$ is the output of tradables sector $i$, and $r(q, w, K)$ is the income capital-owners receive from tradable-goods production. We can add up the labor demands from the various traded-goods industries to find the total labor demand for the tradeables sector, $L^T \equiv \sum_i L^i$. By the envelope theorem,

$$r_2(q, w, K) = -L^T < 0, \tag{10}$$

where a subscript denotes a partial derivative. If we vary $w$ and trace out the values of $L^T$ that result, we derive a labor-demand curve for the tradables sector. By standard arguments, $r$ is convex with respect to $w$, and so the value of $L^T$ that maximizes (9) is a decreasing function of $w$, or:

$$r_{22}(q, w, K) > 0. \tag{11}$$

In other words, the tradeables sector's labor-demand curve slopes downward.

[8] Allowing for capital mobility reinforces the main story, a point made forcefully both by Brezis and Krugman (1996) and by Olney (2012).

## 1.3 Equilibrium.

Free entry in the services sector leads to zero profits. This together with profit maximization by each firm leads to a price $p^j$ for each service-providing firm $j$ equal to:

$$p^j = \left(\frac{\sigma}{\sigma - 1}\right)\beta w, \tag{12}$$

a quantity $x^j$ equal to:

$$x^j = \frac{(\sigma - 1)\alpha}{\beta}, \tag{13}$$

and a total number of services equal to:

$$n = \frac{E^S}{\sigma\alpha w}, \tag{14}$$

where $E^S$ is total expenditure on services, all as in Dixit and Stiglitz (1977). Since zero profits imply that total expenditure on services is equal to the wage bill in the service sector, the demand for labor in the service sector must satisfy:

$$L^S = \frac{E^S}{w}. \tag{15}$$

In addition, the price index for services (4) reduces to:

$$P^S = n^{\frac{1}{(1-\sigma)}}\left(\frac{\sigma}{\sigma - 1}\right)\beta w, \tag{16}$$

which is decreasing in the number of varieties $n$. This is a crucial feature of monopolistic competition. Variety matters to consumers, so if the price of each service is unchanged but the variety of services increases, the utility obtained from one dollar spent on services rises, so the cost of one util falls. Of course, this drop in the real price index for services consumption due to increased variety is not captured by official consumer price statistics.

By the Cobb-Douglas preferences, $E^S$ must be equal to $\theta$ times total town income. Total income is equal to labor income plus capital income, and can be written as:

$$I(w, L) = wL + r(q, w, K). \tag{17}$$

Consequently, labor demand in services can be written:

$$\begin{aligned} L^S &= \frac{\theta I(w, L)}{w} \\ &= \theta L + \theta \frac{r(q, w, K)}{w} \\ &= \theta L + \theta r\left(\frac{1}{w}q, 1, \frac{1}{w}K\right). \end{aligned} \tag{18}$$

From (18) it is clear that labor demand in services is decreasing in $w$ but it is also increasing in $L$ for a fixed value of $w$. This is because an increase in local population increases the local demand for services. In effect, holding $w$ constant, each new arrival to the town will generate $\theta$ jobs in the services sector.

The demand for labor in the tradeables sector can be taken from (10) and is also decreasing in $w$ but is independent of $L$ because the tradeables sector does not depend on local demand. The two labor-demand relations (10) and (18) can be represented as downward-sloping curves in a diagram with $w$ on the vertical axis and employment on the horizontal axis, and summed horizontally to produce total labor demand. Now suppose that the total labor supply is composed of $L^N$ native-born workers and $L^I$ immigrants, and is denoted $L^{TOT} \equiv L^N + L^I$. The intersection of the labor-demand curve with the vertical labor-supply curve at $L^{TOT}$ units of labor defines the equilibrium wage.

## 1.4 The effects of immigration.

Immigration in this simplest version of the model then simply amounts to an increase in $L^I$, say $\triangle L^I$. From (18), this shifts labor demand to the right by an amount equal to $\theta \triangle L^I$. We will refer to this shift in labor demand as the 'shot-in-the-arm' effect, and is depicted in Figure 1. Since the labor-supply curve shifts to the right by more than labor-demand, the equilibrium wage $w$ must fall. Recall that this is the wage *in terms of tradeables*, not the real utility wage, because it does not reflect any change in the prices or variety of services. In addition, the equilibrium values for $L^T$ and $L^S$ will both rise compared to the case with no immigrants, with their combined increase equal to the rise in $L^I$.

Note that the shot-in-the-arm effect does not eliminate the drop in the wage in terms of tradables, but it does attenuate it. In Figure 1, the shift in labor supply without this effect would reduce the wage from $w^0$ to $w^1$, but the shot-in-the-arm effect pulls it up to $w^2$. This may help explain why researchers have consistently found modest if any effects of immigration on local wages. Indeed, since we will later argue empirically for a value of $\theta$ equal to about 83%, once this labor demand effect is taken into account it is hard to see a reason to expect anything else. Most of the new labor supply generates its own demand.

GDP in both sectors will rise as a result of the new immigrants. To see this, note first that, since $w$ has fallen but tradeables prices have not changed, each tradeable good will increase output and so GDP in the tradeables sector will rise. Now note that in equilibrium the value of tradeables production will be equal to the value of tradeables consumption (otherwise the town's consumers are not spending their whole income).[9] Therefore, the rise in tradeables GDP implies a rise in the value of tradeables consumption ($E^T$). But the value of tradeables consumption is equal to $(1-\theta)$ times total GDP, so total GDP must also have increased. Finally, since the value of services consumption $E^S$ is equal to $\theta$ times GDP, the value of services consumption and therefore services-sector GDP has also increased.

Now we can see that although the wage has fallen in terms of tradeables, it has increased in terms of services. To see this, note first that from (12) the price of each service has fallen exactly in proportion with the drop in the wage. Next, note that from (14) the number $n$ of services available has increased, both because the expenditure on services (the numerator) has gone up and because the wage (in the denominator) has fallen. Putting together these two effects, it is clear that the composite price of services (16) has fallen more than the wage.

To sum up, by shifting labor supply to the right, immigration has led to a fall in the wage relative to tradeables (that is, a fall in $w$). We might call this the 'labor glut' effect. However, immigration has also led to a rise in the number and variety of restaurants, shops, barbers, and the like, by expanding the customer base for those industries, in the process shifting labor demand to the right, which we have referred

[9] Formally, if $R^T$ is the total value of tradables output and $R^S$ is the value of nontradable services output, then local income is equal to $R^T + R^S$, which is also therefore the value of local consumption spending. If we write $E^T$ for local consumer spending on tradables and $E^S$ for spending on non-tradables, of course $E^S = R^S$ and consumer budget constraints yield $R^T + R^S = E^T + E^S$. It follows that $E^T = R^T$. Another way of putting this is to observe that trade must be balanced in equilibrium.

to as the 'shot in the arm' effect. This results in a drop in $P^S$ that exceeds the drop in $w$. Given our choice of units that makes tradables the numeraire, the real wage can be written:

$$w^{REAL} = \frac{w}{(P^S)^{\theta}}. \tag{19}$$

This real wage could go up or down as a result of immigration. If $\theta$ is small or labor and capital in tradables sectors are not very substitutable so that tradables labor demand is inelastic, the 'labor glut' effect will dominate and immigration will hurt native workers on balance. If $\theta$ is sufficiently close to 1 or capital and labor are sufficiently substitutable, so that tradables labor demand is elastic, then the 'shot in the arm to the local economy' effect will dominate and immigration will benefit native workers on balance. Indeed, from (18), if $\theta$ is close to 1, there will be no labor glut to speak of because each immigrant will produce close to 1 job and there will be almost no increase in net labor supply. These observations are formalized as follows:

**Proposition 1.** *Immigration will raise the real wage (19) for native-born workers if and only if:*

$$\theta > \frac{(\sigma - 1)}{\phi_{L,T}\epsilon_{L,T} + \sigma}, \tag{20}$$

*where $\phi_{L,T}$ is the share of labor in costs in the tradables sector and $\epsilon_{L,T}$ is the absolute value of the elasticity of labor demand in tradables.*

All results are derived in the appendix. Clearly, condition (20) holds if and only if $\theta$ is large enough, because that is what makes the 'shot-in-the-arm' effect strong. In addition, holding other parameters constant, (20) will hold if $\sigma$ is small enough (recalling that it is always greater than 1), since the smaller is $\sigma$ the more important is the diversity of local services. Holding other parameters constant, the condition will hold if the tradables sector is sufficiently labor-intensive and has sufficiently elastic labor demand, since these properties allow it to absorb additional labor easily. In the limiting case of Ricardian technology, $\epsilon_{L,T}$ will be infinite; in this case, there is no change in the wage in terms of tradables at all, and only the beneficial effect on local services diversity remains.

In this simple model with inelastic labor supply, the increase in total employment must be exactly equal to $\triangle L^I$. We can summarize this observation by saying that each immigrant generates one new job. (Of course, in practice not all immigrants will be workers – some will be dependents, and so in practice with inelastic labor supply each immigrant will generate less than one new job.)

Further, the effect of immigration on employment is not uniform across sectors. The shot-in-the-arm effect increases the demand for labor in the non-tradables sector but not in the tradables sector, and this skews increases in employment toward non-tradables. We can summarize and formalize the point as follows:

**Proposition 2.** *Immigration will increase the level of employment in both the tradables and non-tradables sectors. An additional immigrant will result in more than $\theta$ additional workers employed in non-tradables, and fewer than $(1-\theta)$ additional workers employed in tradeables. Precisely:*

$$\frac{dL^T}{dL^{TOT}} = (1-\theta)\left(\frac{\epsilon_{L,T}}{\epsilon_{L,T} + (1-\theta)\left(\frac{L^{NT}}{L^T}\right)}\right) < (1-\theta). \tag{21}$$

The reason that the increase in employment in the non-tradeables sector is greater than the non-tradables expenditure share $\theta$ is that additional immigrants increase the demand for local services, while they have no effect on the demand for tradeables. Note that if the tradeables sector has inelastic labor demand ($\epsilon_{L,T}$ is small), the increase in employment could be almost entirely concentrated in non-tradables. On the other hand, in the limit with the Ricardian case, as $\epsilon_{L,T} \to \infty$, the increase in employment is divided up between the two sectors just in the same proportions as the expenditure shares.[10]

## 1.5 Adding a Housing Market.

One unrealistic feature of the basic model presented above is that there is no housing market. This could be important in practice because new immigrants will need somewhere to live, and there is some evidence that immigrants tend to push local housing prices upward (Saiz (2007)), so it is worth incorporating these effects into the model. Augment the utility function as follows:

$$U(S,T) = \frac{S^{\theta^1} T^{\theta^2} h^{1-\theta^1-\theta^2}}{(\theta^1)^{\theta^1} (\theta^2)^{\theta^2} (1-\theta^1-\theta^2)^{1-\theta^1-\theta^2}}, \tag{22}$$

where $h$ denotes the consumption of housing services. Assume that there is a fixed stock of housing in the town, which can provide a total $H$ units of housing services to the local population. This stock of housing is homogeneous and perfectly divisible. The price of housing services is denoted $p^H$. We assume that the owners of the housing stock live in the town, and therefore spend their income from housing assets on locally-produces services, as well as on tradables and housing. With this

[10] In this case, there is no capital income, so GDP is equal to $wL^{TOT}$, with $w$ fixed by the Ricardian technology in the tradables sector together with world prices. A 10% increase in the local labor force due to immigration will therefore raise GDP by 10%, which will raise spending on both sectors by 10%, and therefore raise employment in both sectors by 10%.

specification, the real wage takes the form:

$$\frac{w}{\left(P^S\right)^{\theta^1}\left(p^H\right)^{1-\theta^1-\theta^2}}. \tag{23}$$

We can write the condition for labor-market clearing as follows:

$$\frac{\theta^1}{w}\left[wL^{TOT}+r(q,w,K)+p^H H\right]-r_2(q,w,K)=L^{TOT}. \tag{24}$$

The expression in the square brackets on the left hand side of (24) is the total GDP in the town; multiplying by $\theta^1$ yields the spending on local services; dividing by $w$ yields the labor demand due to the local services sector. The following term is labor demand in the tradables sector. These two labor demand sources must sum in equilibrium to the total labor supply.

In addition, the housing market must be in equilibrium:

$$\left(1-\theta^1-\theta^2\right)\left[wL^{TOT}+r(q,w,K)+p^H H\right]=p^H H. \tag{25}$$

Differentiating (24) and (25) with respect to $L^{TOT}$ yields the following result on the response of wages and the housing price to immigration.

**Proposition 3.** *In the model with housing, the response of the local wage to an increase in immigration is given by:*

$$\frac{dw}{dL^{TOT}}=\frac{-\theta^2 w}{\theta^2(L^{TOT}+r_2)+(\theta^1+\theta^2)wr_{22}}<0 \tag{26}$$

*and the response of the housing price is given by:*

$$\frac{dp^H}{dL^{TOT}} = \frac{(1-\theta^1-\theta^2)r_{22}w^2}{\left[\theta^2(L^{TOT}+r_2)+(\theta^1+\theta^2)wr_{22}\right]H} > 0. \tag{27}$$

When immigrants are added to the town labor force, the wage falls in terms of tradables, as in the basic model, and with the rise in local GDP and the drop in the wage, the number of varieties of local service rises, as in the basic model. However, the increase in local income also creates an increased demand for housing, driving up its price, which is a cost for local workers (but of course a benefit for owners of the local housing stock). In order to work out whether native-born workers benefit from the immigration or not, we need to trade off the drop in $w$ and the rise in $p^H$ against the drop in $P^S$. It is clear that there are cases in which real wages would rise but for the effect of the housing price. For example, consider the limiting case in which tradables technology is Ricardian (or in other words, let $r_{22}$, and thus the elasticity of labor demand in tradables, become arbitrarily large). In that case, from (26) the response of $w$ to immigration becomes vanishingly small, but from (27), the response of the price of housing does not. In this case, the portion of the real wage in (23) that applied in the basic model rises (in other words, (19) rises), but if $\theta^1$ and $\theta^2$ are small enough the rise in the housing price will nonetheless lower the overall real wage. Of course, that will not imply a reduction in welfare, because the increased income to the owners of the housing stock must be accounted for, but it will mean a reduction in the utility of native-born workers. These observations are formalized as follows:

**Proposition 4.** In the model with a housing market, immigration will raise the real wage for native-born workers if and only if:

$$\theta^1 > \left(\frac{\sigma - 1}{\sigma}\right)\left(\frac{1 + (1-\theta^2)\phi_{L,T}\epsilon^D_{L,T}}{1 + \phi_{L,T}\epsilon^D_{L,T}}\right). \tag{28}$$

Condition (28) shows that, as before, immigrants increase real wages if and only if the weight on non-tradables is large enough. Further, it shows that the housing market makes it more likely that immigrants will *lower* the real wage. To see this, consider the case in which housing consumption has a zero weight in the utility function, so that $(1-\theta^2) = \theta^1$; in this case it can easily be checked that (28) collapses to (20). Now, holding $\theta^1$ constant and raising the weight on housing above zero reduces $\theta^2$, which increases the right-hand side of (28). Clearly, this makes it less likely that (28) will be satisfied.

## 1.6 Adding worker mobility.

We have assumed to this point that native-born workers cannot relocate from this town, or new native-born workers from elsewhere in the country relocate to this town, once immigrants have chosen to enter. However, such relocation is an important part of the analysis of immigration. Borjas (2003) argues that because of mobility of native workers the whole country should be thought of as a single labor market; Saiz (2007) and Wozniak and Murray (2012), for example, examine various aspects of this mobility.

A really convincing account of intra-national mobility would require a dynamic model, such as for example Kennan and Walker (2011) or Artuç et al. (2010), but to capture the main idea here we accommodate intra-national mobility of native-born workers in a very simple way. Suppose that there are $\bar{L}$ native-born workers initially living in the town, and each one can move to another part of the country, receiving a real wage $\widehat{w}$ but paying a relocation disutility cost equal to $\tau$, so that the net wage from moving is $\widetilde{w} \equiv \widehat{w} - \tau$. These opportunity wages and moving costs are idiosyncratic; a measure $G(\widetilde{w})$ of local workers have an outside net wage of less than or equal to $\widetilde{w}$, with $G(0) = 0$ and $\lim_{\widetilde{w}\to\infty} = \bar{L}$. At the same time, workers elsewhere in the country can come to the town if they wish; a worker's opportunity real wage in his or her home town is denoted $\widehat{w}^*$, with a moving cost of $\tau^*$, so that the worker will move to the town we are focussing on if the real wage $w^{REAL}$ thereby obtained satisfies $w^{REAL} - \tau^* > \widehat{w}^*$, or $w^{REAL} > \widetilde{w}^*$, where $\widetilde{w}^* \equiv \widehat{w}^* + \tau^*$. Again, the opportunity wages and moving costs are idiosyncratic; a measure $G^*(\widetilde{w}^*)$ of non-local workers have an outside net wage of less than or equal to $\widetilde{w}^*$, with $G^*(0) = 0$.

Now, the total labor supply in the town is endogenous, and can be written as the increasing and continuous function $L^{TOT}(w^{REAL}) \equiv G(w^{REAL}) + G^*(w^{REAL}) + L^I$, where $L^I$ is the number of immigrants. (We ignore here the possibility that immigrants may themselves move to other towns after immigrating.) It should be emphasized that the size of the local labor force responds to a decline in the local real wage not only because a portion of local workers may choose to move elsewhere but because a portion of workers elsewhere in the country who otherwise may have chosen to move to this town instead choose to stay where they are.

All of the model up to now has been analyzed with an exogenous value of $L^{TOT}$, and has returned an equilibrium value of $w^{REAL}$. This relationship can be summarized in the curve $DD$ in Figure 2. Panel (a) shows the case in which the 'labor glut' effect dominates the 'shot in the arm' effect, so a rise in $L^{TOT}$ reduces the local real wage (precisely, condition (20) in the basic model or (28) in the housing model is *not* satisfied), and therefore the curve is downward-sloping. Panel (b) shows the opposite case in which the 'shot in the arm' effect dominates. Now, the possibility of labor mobility creates a new relationship between $w^{REAL}$ and $L^{TOT}$ summarized in the labor-supply function $L^{TOT}(w^{REAL})$ derived just above. This is represented by the curve $SS$ in Figure 2, which must be upward-sloping. In each panel, the initial equilibrium is marked as point $a$ and the equilibrium following increased immigration is marked as point $b$. Note that in the case of panel (b) there could be multiple equilibria; we will focus on the case of a stable equilibrium, which requires the $SS$ curve to be steeper than the $DD$ curve.

Now a rise in immigration creates a rightward shift in the $SS$ curve. In Panel (a), this lowers the local real wage, which induces a net outflow of native-born workers from the town. In Panel (b), the shift *raises* the real wage, which induces a net *inflow* of native-born workers to the town. Therefore, the mobility of workers can be a way of testing the direction of the overall change in the local real wage.

In addition, note that in panel (a) the increase in employment that results from the immigration is less than $\triangle L^I$, while in panel (b) it is greater than $\triangle L^I$. It may seem paradoxical that the arrival of 1,000 immigrants will shift the local demand for labor curve to the right by only $(\theta)(1,000) < 1,000$ (as seen in Figure 1 and (18) for the version with no housing sector, or (24) for the version with a housing sector), and yet result in a new equilibrium with an increase in employment greater than 1,000. One way of understanding this outcome is that when the shot-in-the-arm effect is strong, immigrants create a virtuous circle: The immigrants induce greater demand for local services, causing entry and creating a greater variety of local services; this makes the town a more attractive place to live, causing workers to move there from other locations; this in turn feeds local services demand again, amplifying the effect. We can summarize by saying that *when the shot-in-the-arm effect is weak, each immigrant creates less than one new local job, but when it is strong, each immigrant creates more than one new job.* (Of course, as before, this needs to be qualified by the fact that a portion of immigrants in practice will be dependents and not workers.)

To summarize:

**Proposition 5.** *In the model with worker mobility, if*

$$\frac{dw^{REAL}}{dL^I} < 0, \tag{29}$$

(precisely, if condition (20) in the basic model or (28) in the housing model is *not* satisfied), then immigration to a town will induce a net outflow of native-born workers from the town, and the increase in local employment will be less than $\Delta L^I$. Otherwise, immigration will induce a net inflow, and the increase in local employment will exceed $\Delta L^I$.

These findings can naturally be useful for empirical work. The real wage (23) is not observable, because consumer price data will not normally include information on how many local restaurants there are in a neighborhood, for example, and how much they differ in menu and style. Therefore, although the wage in terms of tradables can be observed and correlated with movements in immigration, the theoretically grounded real wage, which is needed for welfare evaluation, cannot (and of course, it would need to be observed in each town, over time). But Proposition 5 tells us that we can see in what direction the real wage is moving simply by observing movements in aggregate employment or internal migration of workers.

## 1.7 Labor complementarities and other complications.

The stylized model presented above has been simplified to clarify the effects of immigration on local labor demand. A number of features that have been emphasized by other authors could be incorporated as well, which we may need to keep in mind while analyzing the empirics.

*(i) Labor Complementarity.* We have assumed throughout that immigrant labor is a perfect substitute for native-born labor. Some authors have emphasized the possibility that immigrants tend to have different skills than native-born workers and are hired to do different tasks (Ottaviano and Peri (2012) and Peri and Sparber (2009)). This can be accommodated in our model by assuming a production function in (9) for tradable industry $i$, for example, that is a function of the two kinds of labor separately as well as capital, with imperfect substitutability between the two. Without working out the details, it is clear that such a specification will dampen and perhaps reverse negative effects of immigration on $w$, and make the case of Panel (b) of Figure 2, with an upward sloping $SS$ curve, more likely. Similar effects could result from allowing for immigrants to substitute for offshore workers as in Ottaviano et al. (2012), or allowing for adoption of labor-saving technology to respond endogenously to immigration as in Lewis (2011).

*(ii) Local non-tradable inputs.* Brezis and Krugman (1996) show that the presence of local non-traded inputs (including local parts producers and local services used

by firms, such as repair, construction, couriers, catering, and the like) can affect the relationship between immigration and labor market outcomes dramatically. In that model, an increase in immigration expands the local labor force, making entry into the non-traded input sector profitable, which increases productivity and encourages capital inflows, ultimately raising local wages. This could be added to the model as well, producing the same sorts of effects as (i), but with a lag to allow for capital inflows.

*(iii) Industry-switching costs.* We have assumed for simplicity that any worker in a given town can move costlessly from one industry to another, so that in each town all workers receive the same wage. Obviously, this is not realistic, and it would imply that wage effects from immigration are identical in all industries within a given town. A full incorporation of industry-switching costs would add a great deal of complexity (as in Artuç et al. (2010)), so we will simply acknowledge that a full model would have such costs and so a rise in demand for labor in one industry relative to another would generally result in both a movement of workers and a rise in that industry's relative wage.[11] This is important to acknowledge in examining the empirical results.

With these theoretical points in hand, we now turn to empirics. We will be able to check for clues as to the strength of the shot-in-the-arm effect: (i) The effect of immigrants on overall local employment; (ii) the effect of immigrants on employment in non-tradable services relative to tradeables; (iii) the sign and magnitude of the effect on local wages; (iv) and movements of workers into or out of a location that has received an influx of immigrants.

[11] It should be noted as well that, as Artuç et al. (2010) show, part of the shift in inter-industry wage differentials is permanent if the shift in labor demand is.

# 2 Empirical approach.

To check on the strength the the 'shot-in-the-arm' effect, we check on the overall effect of immigration on the size of local employment; on the number of jobs created in the non-traded sector compared to the traded sector; and on wages.

## 2.1 The total employment effect.

The most straightforward method to assess the total employment effect would be to estimate:

$$\Delta E_{m,t+1} = \alpha_0 + \alpha_1 N_{m,t} + \psi_m + \lambda_t + \epsilon_{m,t}, \tag{30}$$

where $\Delta E_{m,t+1}$ is employment growth in location $m$ between years $t$ and $t+1$, $N_{m,t}$ is the flow of immigrants into location $m$ over the same period; $\psi_m$ and $\lambda_t$ are location and time fixed effects; and $\epsilon_{m,t}$ is an i.i.d error term. We will measure $N_{m,t}$ in two different ways: The change in the number of immigrants residing in $m$ between years $t$ and $t+1$ ("change in immigrant population"), and the number of immigrants living in $m$ at date $t+1$ who have entered the country between those two dates ("new immigrant population"). A value of $\alpha_1$ in excess of unity would indicate a strong shot-in-the-arm effect. However, this approach is vulnerable to two major econometric problems, scale effects and the likely endogeneity of $N_{m,t}$, which we discuss in turn.

*(i) Scale effects and heteroskedasticity.* One reason equation (30) could provide misleading results is the presence of scale effects, a problem analyzed at length by Peri and Sparber (2011). Even if there is no causal connection between immigration

and local employment, if each location's employment grows at 1% per year and each location receives immigrants equal to 1% of its initial population, large towns will show large numbers of immigrants entering and large numbers of new jobs compared to small towns, and $\alpha_1$ will be estimated to have a positive value. At the same time, city size could be correlated with other factors relevant for employment growth, such as import competition afflicting local industries, which has been a dramatic feature of the experience of some of the largest US cities in recent years. For example, the second-largest city in our sample, Los Angeles, with the second-largest immigrant inflow, had negative employment growth over the 1990's, due to the loss of $200,000$ manufacturing jobs clearly caused by the rise of manufactured exports from low-wage economies and not by the expansion of the Los Angeles labor force. If we are unable to control adequately for these other factors and they are correlated with city size, specification (30) can be biased.

In regressions with the size of the labor force as the dependent variable, Peri and Sparber (2011) examine various solutions to this problem and find, with simulated data, that the most reliable solution is to normalize both the dependent variable and immigrant inflows by initial population. This is also used in similar situations by Card (2001) and Wright et al. (1997). Accordingly, our preferred specification for the total employment effect is:

$$\Delta E_{m,t+1}/P_{m,t} = \alpha_0 + \alpha_1 N_{m,t}/P_{m,t} + \psi_m + \lambda_t + \epsilon_{m,t}, \tag{31}$$

where $P_{m,t}$ is the population of location $m$ in year $t$. Again, $\alpha_1$ is the main parameter of interest, and in accordance with Proposition 5, our interest is in whether or not it is greater than unity.

An additional reason for normalizing by initial population is heteroskedasticity (indeed, more important, since with the location fixed effects, the scale-effect problem persists only to the extent that city sizes change significantly over the data period). As suggested by Wozniak and Murray (2012) in an analogous situation, we have run regression (30) and then regressed the square residuals on initial city population and its square. Both variables were highly significant, suggesting that weighting the regression by the reciprocal of city size would be desirable. Normalizing by initial population is similar in its effect.

(ii) *Endogeneity of immigrant inflows.* Immigrant flows are likely to respond to local labor-market conditions. It is natural to surmise that immigrants will be attracted to locations with booming labor markets or avoid areas with falling labor demand (a point confirmed by Cadena and Kovak (2013)), in which case $N_{m,t}$ will be positively correlated with $\epsilon_{m,t}$. On the other hand, Olney (2012) finds evidence that in his data immigrants, surprisingly, are attracted to locations with high unemployment, perhaps because of the availability of low-cost housing, which could generate the opposite correlation. Either way, an instrument for immigrant inflows is called for.

A well-known instrument is the 'supply-push' instrument developed by Card (2001), which is based on the initial distribution of immigrants of various nationalities across the country. In our case, the instrument takes the form:

$$\hat{N}^{CARD}_{m,t} = \frac{1}{P_{m,t}} \sum_{s=1}^{S} N^{AGG}_{s,t} \left( \frac{P_{s,m,t}}{\sum\limits_{m'=1}^{M} P_{s,m',t}} \right), \tag{32}$$

where $N^{AGG}_{s,t}$ is the aggregate inflow of new immigrants from source country $s$ between $t$ and $t+1$ and $P_{s,m,t}$ is the size of initial immigrant population from country $s$ in location $m$. The term in parentheses is location $m$'s initial share of immigrants from $s$, and the Card instrument is the predicted total inflow of new immigrants to location $m$ assuming that all new immigrants will be allocated nationwide in the same proportions as their initial distribution (and normalized by location $m$'s initial population).[12]

## 2.2 Non-traded share of employment effect.

While informative in assessing the *mean* effect of immigration across all the industries, the above specification does not account for the possibility of a *differential* effect on employment in the traded and non-traded sectors, as predicted by Proposition 2. To test this hypothesis, we need to develop an index of tradability to compare across industries. We defer details to the next section, but in brief we conjecture that employment in non-tradeable industries will be highly correlated with local income, since local non-traded output must be equal to local demand, while traded industries need show no such correlation. We therefore compute the correlation, *corr*, between

[12] This instrument can fail in the face of long-run persistent shocks to local labor demand. We explore this issue in Section 4.4.

local GDP and local employment of each industry and use this as a proxy for non-tradedness. Using this measure, we replace equation (31) with an equation in which each observation is an industry-location combination:

$$\Delta E_{j,m,t+1}/P_{m,t} = \beta_0 + \beta_1 N_{m,t}/P_{m,t} + \beta_2 corr_j N_{m,t}/P_{m,t} + \phi_j + \lambda_t + \psi_m + \epsilon_{j,m,t}, \quad (33)$$

where $j$ indexes industries and $\phi_j$ is an industry fixed effect. The employment change in industry $j$ caused by one more immigrant can be expressed as $(\beta_1 + \beta_2 corr_j)$. If we choose a cutoff value of $corr_j$, say, $corr^*$, such that we will call an industry $i$ non-traded if and only if $corr_j \geq corr^*$, then we can compute the effect of a marginal immigrant on non-traded employment as $\Delta_{NT} \equiv \sum_{j \ni corr_j \geq corr^*} (\beta_1 + \beta_2 corr_j)$, and the marginal effect on traded-industry employment as $\Delta_T \equiv \sum_{j \ni corr_j < corr^*} (\beta_1 + \beta_2 corr_j)$. To the extent that more immigrants lead to a larger increase in non-tradables employment than tradables employment because immigrants increase local consumer demand for non-tradables – an outcome predicted by Proposition 2 provided that $\theta \geq \frac{1}{2}$ – we will observe $\Delta_{NT} > \Delta_T$. The larger is $\beta_2$, the stronger is the implied shot-in-the-arm effect.

## 2.3 Wage effects.

Finally, in order to measure the impacts of immigration on local wages, we move to data on individual workers. In our data, each worker is observed at most once, so for each worker $i$ we can write that worker's location, industry of employment and date of observation as functions of $i$, $m(i)$, $j(i)$, and $t(i)$ respectively. Consider the following regression:

$$
\begin{aligned}
log(w_i) \;=\; & \gamma_0 + \gamma_1 X_i + \gamma_2 yr2000_i + \gamma_3 yr2000_i corr_{j(i)} \qquad (34)\\
& + \gamma_4 yr2000_i N_{m(i),t(i)-1}/P_{m(i),t(i)-1} + \gamma_5 yr2000_i corr_{j(i)} N_{m(i),t(i)-1}/P_{m(i),t(i)-1}\\
& + \psi_{m(i)} + \phi_{j(i)} + \epsilon_i,
\end{aligned}
$$

where $X_i$ is a vector of worker $i$'s demographic characteristics including age, age squared, immigrant status, marital status, race and education; $yr2000_i$ is a dummy variable equal to one if worker $i$ is observed in year 2000. (More generally, we would have dummies for each year, but, as we discuss in the next section, we will use wage data from 1990 and 2000 so only a 2000 dummy is needed.) Therefore, the inclusion of $yr2000_i$ and $yr2000_i corr_j$ in the regression controls for the time trend over the 1990s and its interaction with industry tradability. Any unobserved, time-invariant location- or industry-specific variables are controlled for by $\psi_m$ and $\phi_j$.

The dependent variable, $w_i$ is the nominal wage; dividing by the CPI would make no difference because the trend in measured CPI will be common to all workers and will be absorbed in $\gamma_2$. Since the true cost-of-living index depends on the price index for services (4) which is not observed (since it depends on the number of varieties of service available locally and on $\sigma$), the wage $w_i$ on the left-hand side of (34) corresponds to the wage in terms of tradables in the theory model, rather than the real wage of (19) or (23).

The parameters of interest are $\gamma_4$ and $\gamma_5$, which would inform us of how immigration affects the wage in traded and non-traded industries. In the simple theory model presented earlier, we would have $\gamma_4 < 0$ and $\gamma_5 = 0$, because immigration lowers the wage in terms of tradeables,[13] and in that model labor is costlessly mobile across sectors so the wage would move in the same way in both traded and non-traded industries. If we allowed for costs of switching sectors, then to the extent that immigrants increase local services demand, we would expect $\gamma_5$ to be positive. If $\gamma_4$ and $\gamma_5$ are both close to zero, then immigration has only a small effect on the tradables wage (implying that $\phi_{L,T}$ or $\epsilon_{L,T}$ is large, from Proposition 1), and the effect of immigration on the real utility wage is likely to be positive.

# 3 Data.

Our main data set is extracted from the 5% samples from the 1980, 1990 and 2000 US Censuses provided by the IPUMS project at the Minnesota Population Center of the University of Minnesota (Ruggles et al. (2010)).[14] The variables employed in the empirical analysis include year, age, gender, marital status, race, place of birth, year of immigration, educational attainment, employment status, industry, and income.

In order to investigate the local economic impacts of immigration, we need a definition of location. Two main candidates are available in IPUMS, the "CONSPUMA" variable and the "METAREA" variable. CONSPUMA's are a division of the entire United States into 543 similarly-sized units, which are consistently defined from 1980 to 2000. METAREA's are metropolitan areas with boundaries drawn in such a way as to contain both employment and residence for a typical worker in the city. By contrast, CONSPUMA's in many cases divide a city, so that immigrants

[13] In a model such as presented by Brezis and Krugman (1996), it is possible to have $\gamma_4 > 0$ because immigration improves productivity and induces capital inflows, which increase wages after a lag. A similar point applies to Ottaviano and Peri (2012).

[14] The Census data are publicly available at https://usa.ipums.org/usa/.

to one CONSPUMA could cause employment effects that spill over to an adjacent CONSPUMA, and movement of residence of a worker from one neighborhood to another would show up as an employment loss from one CONSPUMA and a gain to the other even if the worker's job does not change. Therefore, although it does not cover the entire area of the U.S. and, therefore, it costs a significant number of observations, we prefer METAREA for our purpose.[15] We limit our attention to the metropolitan areas that are consistently defined from 1980 to 2000 census, which results in 219 METAREA's.

Following the convention in the literature, we define an immigrant as a person who is either a noncitizen or a naturalized U.S. citizen. Then an immigrant is considered a 'new' arrival in the Census year $t$ if his or her year of immigration is reported to be between $t-9$ and $t$.

Table 1 presents summary statistics for the 9,861,622 individual workers who are included in the estimation.[16] The average sample person is a 39-year-old, likely to be married. The sample is 80% white and 54% male. A fraction of 14% of the sample are identified as immigrants. About 53% of the sample are observed to have college experience, while high-school dropouts account for 25% of the total. The two main outcome variables we consider are employment status and salary income. The employment status used in the regressions are based on the variable "EMPSTAT," which indicates whether the respondent was a part of the labor force and, if so, whether the person was working or searching for employment. We count the number of employed workers to compute the changes in employment level for each metarea in

[15] Approximately 31% of the sample observations in both Census years are missing "METAREA" information.

[16] See Table 1 for details of the sample selection criteria.

the employment regressions. In our sample, after excluding armed forces, about 70% of the sample are employed, while 25% report to be out of labor force. "INCWAGE" reports the pre-tax nominal wage or salary income received during the previous calendar year. We exclude observations with $400,000 or more and zero income in the wage regressions.

One important requirement for studying the impacts of immigration on the local economy is an operable measure of 'tradability.' In order to identify the existence and magnitude of the shot-in-the-arm effect of immigration, we must make a clear distinction between non-traded industries, whose demand is likely boosted by immigration, and traded industries, whose demand is not. Despite the growing importance of the non-tradable service sector in the U.S. economy,[17] little scholarly attention has been paid to it empirically, perhaps because of the lack of reliable measure of 'non-tradedness.'[18] We develop a new measure of industry 'tradability' by looking at, for each industry, the correlation between local demand and supply across different locations in the U.S. For a non-traded service, local demand must equal local supply, while for a traded good supply can be located where production cost is minimized, regardless of where consumers reside, so the geographic correlation between supply and demand should be stronger for a non-traded than for a traded industry. To

[17] See Buera and Kaboski (2012).

[18] One notable exception is Gervais and Jensen (2012). Our approach to measuring non-tradedness is inspired by their approach, but is much simpler and less ambitious. Considering a spatial mismatch between production and consumption as evidence of trade, they provide industry-level estimates of trade costs from a structural equilibrium model. However, because their estimates were obtained from microdata on U.S. service establishments and do not cover other important industry categories such as agricultural, mining, utilities and construction, they could not be directly applied to this study. Our measure is also closely related to the measure of geographic concentration used by Jensen and Kletzer (2006), but is simpler because we do not need the input-output patterns that they employ.

implement this idea, we first construct GDP for each location (computed as the sum of incomes of all persons living there) as a proxy for local demand; and employment for every industry/location cell as a proxy for local supply. Then, we simply compute the correlation coefficient between the two variables across regions for each industry (of course, we are implicitly assuming that demand patterns for non-tradables do not vary too much from place to place).[19] Table 2 lists the top 10 most/least tradable industries according to our measure, which seems to conform to our priors regarding the degree of 'non-tradedness.' For example, retail bakeries or child day care services are widely perceived as non-traded service industry. On the other hand, mining or tobacco manufacturers are well-known examples of geographically concentrated, tradeable industries.

# 4 Results

## 4.1 Employment regressions

Table 4 presents estimates of the local employment effects of immigration. The first four columns report the results from measuring immigrant flows as the change in immigrant population, and the last four from measuring only newly arrived immigrants (as discussed in Section 2.1). The first two columns within each group report

[19] Here, we use "CONSPUMA," instead of "METAREA," as the unit of geography, because production establishments for some industries are geographically concentrated outside of metropolitan areas. For example, a tiny fraction of workers employed in coal mines are located within metropolitan areas, and those who do are not a representative sample of coal miners nationwide. The correlation between local GDP and coal mining employment is 69% by METAREA, suggesting a fairly non-traded industry, but the correlation is -0.2% by CONSPUMA, suggesting a traded industry. Of course, coal mining is a traded industry, with production concentrated outside of major population centers and consumption concentrated within them.

the results from the standard OLS regression of equation (31), first the effect on employment in the full sample and then the effect on employment of native (non-immigrant) workers. The next two columns show the results using the Card IV. The bottom two rows report the Angrist-Pischke first-stage tests for identification of the endogenous variable, which passes in each case.

The results vary widely with the estimation method; instrumental variables reduce the size of coefficients a great deal, as does using new immigrants as the flow measure instead of the change in immigrant population. However, the results consistently indicate a strong positive effect of immigrants on employment. Focussing on IV results for the full sample, an inflow of immigrants amounting to a one-percent rise in the local population relative to the initial metropolitan area population is predicted to provide an increase in total employment amounting to 3.5% or 1.2% of the initial population and an increase in native employment amounting to 2.5% or 0.9% depending on the measure, providing initial evidence of the 'shot-in-the-arm' effect of immigrant inflows. If we take the 'new immigrant' measure as the preferred one, both because it is a more plausibly exogenous shock and because it passes the Angrist-Pischke test much more strongly, then 1,000 new immigrants are associated with an increase of 1,200 new local jobs, most of which go to native-born workers.[20]

While informative in gauging the net impacts of immigration on regional employment change, this approach has its limitations because it masks substantial variation across industries. Therefore, we re-estimate the model employing the measure of 'non-tradedness,' $corr$, as illustrated in equation (33) in order to account for the dif-

[20] Although the best estimate of the coefficient in column 7 is 1.2, the standard error is large enough that we cannot reject the possibility that the true value is 1. However, the positive effect on native employment in the adjacent column is significant at the 1% level, implying a strong local labor demand effect.

ference in industry tradability. Table 5 presents IV results from estimating equation (33). The first six columns show the effect on full-sample employment, employment of native workers, and employment of immigrants, measured by the change-in-immigrant-population measure of immigrant flow. The columns alternate between results with and without industry fixed effects. The second six columns do the same for the new-immigrant measure of the flow.

The first row contains estimates of $\beta_1$, the coefficient in the immigrant inflow, and the second row estimates of $\beta_2$, the coefficient on the interaction with $corr_j$. For the full sample, with either measure of immigrant flow we find a positive and significant $\beta_1$ and small and insignificant $\beta_2$ with industry fixed effects; with industry fixed effects omitted, we have $\beta_1 < 0$ and $\beta_2 > 0$, both significant. On the other hand, $\beta_2$ is consistently positive and strongly significant for immigrants themselves: New immigrant jobs tend to be concentrated in non-traded services.

As seen in the third row of results, the implied total employment effect, $\Delta \equiv \sum_{i=1}^{228}(\beta_1 + corr_i\beta_2)$, is roughly in line with results from Table 4, but the breakdown between traded and non-traded industries is of more interest to us. We can compute the share of jobs created in non-traded industries as $\Delta_{NT}/\Delta$. Of course, we need to choose a threshold value for $corr^*$, below which we will call an industry 'tradable' and above which we will call it 'non-tradable.' There is necessarily some arbitrariness in such a choice. We use a threshold value of $corr$ equal to 0.6; the results change little if the threshold is perturbed around this value.[21] Focussing again on the results

[21] We follow the following reasoning. (i) We expect most, but not all, services to be non-traded, and most goods industries to be traded. (ii) If we classify each industry as a good or a service on the basis of the Census description of the industry, any threshold choice results in some services below the cutoff and some goods industries above it; any increase in the cutoff increases the former and decreases the latter. (iii) At the value $corr = 0.6$, the the number of non-traded goods industries

from the 'new-immigrants' measure of immigrant flows, and using the results with industry fixed effects, we compute the non-traded share of jobs as 62% for the full sample, 57% for native workers, and 75% for immigrants.

It is instructive to note the relationship between these results and Moretti (2010), who studies the multiplier effect of one new tradables job on local non-tradables employment. Moretti finds that each tradables job generates 1.5 local non-tradables jobs on average. According to our results, if the only variation in the data came from immigration, then there would be 62 non-tradables jobs generated for each 38 tradables jobs, implying a Moretti multiplier of $62 \div 38 = 1.63$, quite close to the 1.5 value. However, there is no reason to expect that immigration is the only (or even the largest) source of local employment variation in the data; Moretti has in mind, for example, terms-of-trade improvements that raise labor demand in a given manufacturing industry; the Moretti multiplier from such a shock could presumably be quite different compared to that from an immigration shock.

Recall that Proposition 2 predicts that the non-tradeable sector's share of the employment increase exceeds $\theta$, the share of non-tradeables in expenditure – or, in the extreme case of high tradables labor-demand elasticity or a small tradables sector, it will be equal to $\theta$. Now, in equilibrium, the share of non-tradables in expenditure must equal their share in income, so we can estimate $\theta$ by adding up the income of all individuals in our sample who work in the non-tradables industries; doing the same for tradeable industries; and finding what fraction the former sum is of the total. We do this both with labor income (the IPUMS variable INCWAGE) and total income (the variable INCTOT), which presumably includes capital and rental

and the number of traded service industries are equal at 22, out of a total of 228 industries. This cutoff yields 138 non-traded industries and 90 traded industries.

income as well, which may or may not derive from the same industry as the labor income. Either way, the share of non-tradables in income, and therefore our estimate of $\theta$, is 0.83.[22]

The overall message of Table 4 is that *on average, each immigrant generates about 1.2 jobs in the city in which he or she locates, about* 62% *of which are in the non-traded industries.* From Proposition 4, this can be taken as evidence of a strong shot-in-the-arm effect. However, since 62% is less than our estimated $\theta$ of 83%, Proposition 2 fails, and we may ask which piece of the model is the cause. Examining wage evidence in the next section will provide a suggestion that it may be our assumption that workers face no costs in switching industries.

To explore the composition of labor-demand effects further, in Table 6, we control for the national trend and global shocks for the tradeable industries. For this, we first compute for the projected employment change in each industry-metarea cell assuming that local industry employment growth will follow the national trend for that industry:

$$ProjE_{j,m,t} = trend_j E_{j,m,t}, \tag{35}$$

where $trend_j$ is the nation-wide employment growth rate between years $t$ and $t+1$ in industry $j$ and $E_{j,m,t}$ is initial employment in industry $j$ in location $m$. In Table 6, this is the variable 'National employment growth trend,' entered as a control in the employment change regression, in place of an industry fixed effect. Then we interact the variable with a dummy variable for 'tradable' industry to allow for the possibility that traded goods follow national trends since they are hit by global shocks, but

[22]If we raise the cutoff for tradability to $corr = 0.65$, non-tradables' share of employment gains becomes 53% and $\theta$ becomes 75%. If we lower it to $corr = 0.55$, non-tradables' share of employment gains becomes 68% and $\theta$ becomes 86%.

non-traded industries are affected only by local variables. This provides the control variable called 'National employment growth trend, traded industries' in Table 6. In either form, these controls for industry-specific national trends enter strongly in the regression with a coefficient close to unity. When the regression is run in this way, the coefficient on the interaction between $corr_j$ and the immigrant inflow is always strongly positive and significant, reinforcing the conclusion that non-traded labor demand is disproportionately affected by immigrants. The $\beta_1$ and $\beta_2$ from the last two columns imply a share for non-traded industries in employment gains of 67% and 89% respectively.

## 4.2 Wage regressions

Table 7 presents the results from equation (34). Looking at the full sample, using either measure of immigration inflows (first and third columns), we see that the effect of new immigrants on wages in traded industries is modestly negative (first row; $\gamma_4 < 0$), while the effect on wages in non-tradable industries is positive (second row; $\gamma_5 > 0$ and in fact $\gamma_4 + \gamma_5 > 0$). Focussing on the 'new immigrants' measure of immigrant inflows, we see that the effect is modest. The arrival of immigrants amounting to 10% of the local labor force would lead to a drop in local wages of approximately 1.7% in a completely traded industry ($0.1 \times 0.172$), while the same event would raise wages approximately 4% in a completely non-traded industry ($0.1 \times (0.576 - 0.172)$). Since this would be a huge immigration event, larger than the Mariel boatlift, these are quite modest wage effects. Note as well that the aggregate wage effects are driven entirely by immigrant wages; the effects are positive but small and insignificant.

Note that the positive estimate of $\gamma_4$ implies costs to switching industries. This is consistent with abundant evidence (see Artuç et al. (2010)), and can help explain the finding in Section 4.1 that the non-traded share of employment gains is less than $\theta$.[23] Proposition 2, which predicts that the non-traded share of the increase in employment will exceed $\theta$, was derived under the assumption of perfect mobility across sectors. When the demand for labor in a sector rises, realistic labor switching costs will lead to a smaller shift in employment share and also a rise in that sector's relative wage, as seen here.

The finding that some local wages are increased by immigration is at odds with the simplest version of the theory model presented in Section 1, but it can easily be rationalized by adding non-traded inputs or labor complementarity as discussed in Section 1.7, together with some worker mobility costs to allow wages to differ across industries. More importantly, the result contrasts with most of the empirical literature, which mostly finds wage effects "small and clustered near zero" (Kerr and Kerr (2011), p.12). Part of the reason may be our distinction between tradable and non-tradable industries, which, as we have seen, differ sharply in their response to immigration. In addition, some other studies that have examined large-scale immigration events have looked at a much shorter time horizon than our 10-year horizon (Card (1990) and Friedberg (2001), for example). As emphasized in Giovanni et al. (2015), the mechanism of new firm formation may take time to respond to new immigrants (although Olney (2012) finds surprisingly quick firm entry in response to immigration), and both Ottaviano and Peri (2012) and Brezis and Krugman (1996) emphasize that capital flows may respond to immigration with a lag.

[23]It is important to underline that once industry-switching costs have been added to the model in a realistic way, a permanent shock to labor demand in one industry tends to lead to a *permanent* change in inter-industry wage differentials, as discussed at length in Artuç et al. (2010).

Moreover, some studies that have found negative wage effects, such as Borjas (2003), Aydemir and Borjas (2011) and Borjas et al. (2010) are actually asking a different question: These studies divide up the labor force into, say, 32 skill-experience cells and ask what is the effect of an increase in immigration within cell $i$ on wages for native workers within cell $i$. This approach is more focussed on the effect of the *composition* of immigration on the *relative* native wages, rather than on the *total number* of immigrants on *absolute* wages. If a rise in total immigration changes all wages in some direction, that will be absorbed in the year fixed effects; holding the total number constant, a rise in immigrants within cell $i$ then implies a change in that cell's *share* of the immigrant inflow, which can affect its wages relative to wages in other cells. Thus, the same data-generating process could generate both our results and the results in those papers.[24]

Crucially, note that the rising wages associated with immigration inflows for non-traded industries indicated in Table 7 make it clear that the expansion of non-traded employment documented in the previous two tables cannot simply be a result of the supply-side forces that are the focus of Cortes (2008) and Olney (2012). The wages move in the wrong way for that; only a rise in labor demand in non-traded industries can rationalize a simultaneous rise in non-traded wages plus a rise in non-traded employment.

To sum up, we find that incoming immigrants tend to raise the wages of workers

[24]Put differently, suppose that the actual data-generating process follows $\log(w_{ct}) = \alpha_0 + \alpha_1 \log(N_t) + \alpha_2 \log(\frac{N_{ct}}{N_t})$, where $w_{ct}$ is the wage in skill-experience cell $c$ at date $t$, $N_t$ is total immigration at date $t$, and $N_{ct}$ is total immigration of workers in cell $c$ at date $t$. There is nothing logically preventing $\alpha_1$ from being positive and at the same time $\alpha_2$ from being negative. The Borjas (2003) regression and others of that type, with time fixed effects, would estimate $\alpha_2$, while the sort of regression we are running would be aimed at estimating $\alpha_1$.

in non-tradable services and push down the wages of workers in tradables, modestly in both cases. This is consistent with a rise in the demand for labor in services that accompanies the increase in local labor supply, although this wage effect is small and limited to immigrants themselves. However, given that the nominal price index does not account for the change in the diversity of local services, the *real* wage could still go up in response to an increase in the immigrant population provided that the real price of services falls. Although no direct method is available to estimate the impacts of immigration on the real wage, Proposition 5 provides an alternative approach to check the direction of the change in real wage by focusing on the pattern of internal migration.

## 4.3 Do immigrants crowd out native workers?

The immigration literature has provided mixed evidence regarding the impact of immigration on the internal migration of the native workforce. While Butcher and Card (1991) and Card (2001) find that native out-migration and immigrant inflows are largely unrelated, Borjas (2006) argues that immigration is associated with higher out-migration rates; Peri and Sparber (2011) survey work on this question. The simple empirical framework described above allows us to examine the differential impacts of immigration on the movements of workers by employment status.

More specifically, we employ the metarea-level employment regression equation in (31) but consider two additional dependent variables: change in the number of unemployed and change in the size of not-in-labor-force (NILF), reporting the results in Table 8. The top half of the table reports results using the 'change in immigrant population' measure of immigrant inflows, and the bottom half reports the 'new immigrants' measure. We will focus on the latter. Columns 1 through 6 present regression results separately for natives and established immigrants who arrived more than 10 years prior to the Census year. The results are striking. The point estimates in the first three columns imply that 1,000 new immigrants are predicted to increase native employment by 865, native unemployment by 102, and native NILF by 359, which amounts to a net increase of 1,326 in the native population of the town. At the same time, the next three columns in the table show that $1,000$ newly arriving immigrants are expected to increase the established immigrant population by 192 (that is, 0.169 + 0.0576 - 0.0348).[25] However, care must be taken before concluding that higher immigrant populations *attract* workers *into* the town, because population increases could also be explained by decreases in outflows from affected metropolitan areas (Wozniak and Murray (2012)). In order to address this issue, we next limit the sample to include only those native-born US workers who moved from a different metropolitan area during the 5 years prior to the Census year using the "MIGMET5" variable available in IPUMS and run the regressions.[26] The estimated coefficients in the last three columns of the table suggest that 1,000 new immigrants induce 360 workers (that is, 0.212 + 0.104 + 0.0438) to move into the town from elsewhere in the United States during the five years leading up to the Census year. This provides strong evidence against the native displacement hypothesis of immigration: US workers are actually moving from elsewhere in the country into the city that

[25] In unreported results, we ran the same regressions for other various sub-groups in US Census and found that the same pattern holds for female, black, and Hispanic population. The results are available upon request.

[26] "MIGMET5" reports the metropolitan area the respondent lived 5 years ago. Therefore, it allows us to compute the number of in-migrants during the 5 years prior to the Census year in each metro area.

receives the immigrant inflow. Therefore, according to Proposition 5, we conclude that immigration appears to be raising the real wage through increased product diversity in the service industries.

## 4.4 Robustness

One concern with the instrumentation strategy employed in this study is that the 'supply-push' instrument may still be correlated with long-run trends in local labor demand. To the extent that earlier immigrants chose the U.S. locations based on persistent location-specific employment prospects, the historical settlement patterns of those groups used in predicting the current immigrant flows will be correlated with past local labor-demand shocks, and if those shocks are persistent over time, the instrument may fail to satisfy the exclusion restriction. In order to address this critique, we re-estimate the main regression equations controlling for the rate of location-specific population growth in the previous decade (1970-1980 and 1980-1990 respectively) as a proxy for pre-existing trends in local labor demand. The results in Columns 1-2 and 5-6 in Tables 9 and 10 show that the point estimates become slightly smaller in magnitude across different specifications with the additional control variable, but results also confirm that controlling for the population trends did not alter the main results qualitatively. In particular, the effect on total employment is still estimated to exceed 1, and the effect on native employment is still positive and significant.

In addition, there may be concerns regarding some other trends that would affect both employment growth and immigrant inflows in a systematic manner, thereby generating a spurious correlation between them. One potential omitted variable in this context may be technology shocks. For example, Autor and Dorn (2013) show how technological progress in the form of automation and computerisation would substitute low-skill labor and increase demand for non-routine service occupations. If immigrants have tended to locate in cities that are more exposed to this type of technology shocks, then the main results may be subject to omitted variable bias. To check the validity of this concern, we follow Autor and Dorn (2013) and create a location-specific measure of exposure to computerisation. In particular, we compute for each MSA the share of local employment that falls in 'routine task-intensive occupations' that are considered to be more vulnerable to technology shocks[27] and check whether the estimates are robust to the addition of the new control variable. Comparing the results in Columns 3-4 and 7-8 in Tables 9 and 10 with the results found in 4 and 5, we note that the technology proxy variable hardly changes the magnitudes of the point estimates. As a result, we conclude that the main results are not driven by the technology shocks.

# 5 Conclusions.

We have studied the effect of immigration on local labor markets, emphasizing the effect of immigration on local labor *demand* as opposed to merely labor *supply*. We have first studied a stylized model of a local labor market that shows how the arrival of immigrants increases local aggregate income and thus the labor demand by the non-traded services sector. This effect, which we have labelled the 'shot-in-the-arm' effect, dampens the downward pressure the extra labor supply places on local wages,

[27] Data on the routine task intensity of each occupation are available at http://www.ddorn.net/data.htm.

and also increases the variety of non-traded services available, which confers a benefit on all local consumers, native-born and immigrant. Consequently, even in a model in which immigration always lowers local wages in terms of tradeables, it *raises* real wages in terms of non-tradables, and depending on how strong the shot-in-the-arm effect is, it may raise real wages in terms of the overall consumer price index, raising utility for all local workers.

In that case, immigration into a town will tend to attract other native workers from elsewhere in the country, who will then create an additional 'shot in the arm' of their own, resulting in a virtuous cycle in which employment in the town has increased by more than the direct rise in the local labor force due to the immigrants. In that case, we can say that each immigrant generates more than one job. On the other hand, if the shot-in-the-arm effect is weak, real wages will fall, and native workers will flow out of the town; each immigrant can then be said to generate less than one job. Since real wages that take full account of diversity of services are difficult to measure, net flows of workers in response to immigration can be a useful indicator of the local net effects of immigration on the welfare of local workers.

We examine these effects empirically with a five-percent sample from the US Decennial Census. We use a novel method to divide industries into non-traded and traded, and find that the non-traded portion of the economy generates 83% of total income, which creates the potential for a large shot-in-the-arm effect. We find that $1,000$ new immigrants to a US Metropolitan Area generate approximately $1,200$ new local jobs, about 62% of which are in the non-traded sector. Further, we find that new immigrants tend to raise local wages slightly even in terms of tradeables for jobs in the non-traded sector while they push wages down slightly in the traded sector, and that new immigrants seem to attract native workers into the metropolitan area. Thus, the evidence appears to favor a strong shot-in-the-arm effect, and support the idea that workers in a given metropolitan area benefit from the arrival of more immigrants to that metropolitan area.

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# Appendix

**Proof of Proposition 1.** From (10) and (18), labor market equilibrium can be written as:

$$wL^{TOT} = -wr_2(q, w, K) + \theta wL + \theta r\left(q, w, K\right). \tag{36}$$

The left-hand side is total labor income and the right-hand side terms are, respectively, income to labor employed in tradables followed by two terms representing labor income in non-tradables. Differentiating with respect to $L^{TOT}$ yields and solving for $dw/dL^{TOT}$:

$$\frac{dw}{dL^{TOT}} = \frac{-(1-\theta)w}{(1-\theta)(L^{TOT}+r_2)+wr_{22}} < 0. \tag{37}$$

Note that $(L^{TOT}+r_2)$ is just the amount of labor employed in the non-traded sector, and is therefore positive. Therefore the denominator of $dw/dL^{TOT}$ is positive. This implies that the change in local income is:

$$\frac{dI}{dL^{TOT}} = \frac{d}{dL^{I}}\left[w(L^{N}+L^{I})+r(q,w,K)\right] = \frac{w^2 r_{22}}{(1-\theta)(L^{TOT}+r_2)+wr_{22}} > 0. \tag{38}$$

From (14), the effect on the equilibrium value of $n$ is:

$$\frac{d\log n}{dL^{TOT}} = \frac{d\log E^{S}}{dL^{TOT}} - \frac{d\log w}{dL^{TOT}} = \frac{d\log I}{dL^{TOT}} - \frac{d\log w}{dL^{TOT}}. \tag{39}$$

Putting this together with (19) and (4), we can derive the effect of immigration on the local real wage:

$$\begin{aligned}
\frac{d\ln(w^{REAL})}{dL^{TOT}} &= \frac{d\ln(w)}{dL^{TOT}} - \theta\frac{d\ln(P^S)}{dL^{TOT}} \\
&= \frac{d\ln(w)}{dL^{TOT}} - \left(\frac{\theta}{1-\sigma}\right)\frac{d\ln(n)}{dL^{TOT}} - \theta\frac{d\ln(w)}{dL^{TOT}} \\
&= \frac{d\ln(w)}{dL^{TOT}} - \left(\frac{\theta}{1-\sigma}\right)\frac{d\log I}{dL^{TOT}} + \left(\frac{\theta}{1-\sigma}\right)\frac{d\log w}{dL^{TOT}} - \theta\frac{d\ln(w)}{dL^{TOT}} \\
&= \left[-\left(\frac{1-\sigma+\theta\sigma}{1-\sigma}\right)(1-\theta) - \left(\frac{\theta}{1-\sigma}\right)\frac{w^2 r_{22}}{L^{TOT}}\right]\frac{1}{(1-\theta)(L^{TOT}+r_2)+wr_{22}}.
\end{aligned}$$

Given that

$$\frac{w^2 r_{22}}{I} = \left(\frac{w|r_2|}{r}\right)\left(\frac{r}{I}\right)\left(\frac{wr_{22}}{|r_2|}\right) = \phi_{L,T}(1-\theta)\epsilon^D_{L,T}, \tag{40}$$

where $\phi_{L,T}$ is labor's share of costs in the traded sector and $\epsilon^D_{L,T}$ is the elasticity of labor demand in the traded sector, the stated condition follows mechanically. *Q.E.D.*

**Proof of Proposition 2.** Since $-r_{22}$ is the derivative of tradables labor demand with respect to the wage, clearly

$$\frac{dL^T}{dL^{TOT}} = -\frac{dw}{dL^{TOT}} r_{22}. \tag{41}$$

Using the expression for $dw/dL^{TOT}$ derived in the proof of Proposition 1, the result follows immediately. *Q.E.D.*

**Proof of Proposition 3.** The derivative of equilibrium condition (24) with respect to immigrant labor is:

$$-[(1-\theta^1)(L^{TOT}+r_2)+wr_{22}]\frac{dw}{dL^{TOT}} + \theta^1 H\frac{dp^H}{dL^{TOT}} = (1-\theta^1)w \tag{42}$$

The derivative of equilibrium condition (25) with respect to immigrant labor is:

$$-(1-\theta^1-\theta^2)(L^{TOT}+r_2)\frac{dw}{dL^{TOT}}+(\theta^1+\theta^2)H\frac{dp^H}{dL^{TOT}}=(1-\theta^1-\theta^2)w \tag{43}$$

These two equations can be written in matrix form as:

$$A\begin{pmatrix}\frac{dw}{dL^{TOT}}\\ \frac{dp^H}{dL^{TOT}}\end{pmatrix}\equiv\begin{pmatrix}-[(1-\theta^1)(L^{TOT}+r_2)+wr_{22}] & \theta^1 H\\ -(1-\theta^1-\theta^2)(L^{TOT}+r^2) & (\theta^1+\theta^2)H\end{pmatrix}\begin{pmatrix}\frac{dw}{dL^{TOT}}\\ \frac{dp^H}{dL^{TOT}}\end{pmatrix}=\begin{pmatrix}(1-\theta^2)w\\ (1-\theta^1-\theta^2)w\end{pmatrix} \tag{44}$$

The inverse of the matrix $A$ is:

$$\frac{1}{D}\begin{pmatrix}(\theta^1+\theta^2)H & -\theta^1 H\\ (1-\theta^1-\theta^2)(L^{TOT}+r_2) & -[(1-\theta^1)(L^{TOT}+r_2)+wr_{22}]\end{pmatrix}, \tag{45}$$

where $D\equiv-[\theta^2(L^{TOT}+r_2)+(\theta^1+\theta^2)wr_{22}]H<0$ is the determinant. The result follows mechanically. *Q.E.D.*

**Proof of Proposition 4.** First, note that because $(1-\theta^1-\theta^2)I=p^H H$,

$$\begin{aligned}\frac{d\log(I)}{dL^{TOT}} &= \frac{d\log(p^H)}{dL^{TOT}}\\ &= \left(\frac{1}{p^H}\right)\frac{(1-\theta^1-\theta^2)r_{22}w^2}{[\theta^2(L^{TOT}+r_2)+(\theta^1+\theta^2)wr_{22}]\,H}\\ &= \frac{r_{22}w^2}{[\theta^2(L^{TOT}+r_2)+(\theta^1+\theta^2)wr_{22}]\,I}\\ &= \left(\frac{w|r_2|}{r}\right)\left(\frac{r_{22}w}{|r_2|}\right)\left(\frac{r}{I}\right)\frac{1}{[\theta^2(L^{TOT}+r_2)+(\theta^1+\theta^2)wr_{22}]}\\ &= \frac{\phi_{L,T}\epsilon^D_{L,T}\theta^2}{[\theta^2(L^{TOT}+r_2)+(\theta^1+\theta^2)wr_{22}]}.\end{aligned}$$

Second, note that because of free entry in nontraded services, $\frac{d\log(n)}{dL^{TOT}} = \frac{d\log(I)}{dL^{TOT}} - \frac{d\log(w)}{dL^{TOT}}$ as implied by (14). These yield:

$$\begin{aligned}
\frac{d\ln(w^{REAL})}{dL^{TOT}} &= \frac{d\ln(w)}{dL^{TOT}} - \theta^1 \frac{d\ln(P^S)}{dL^{TOT}} - (1-\theta^1-\theta^2)\frac{d\ln(p^H)}{dL^{TOT}} \\
&= \frac{d\ln(w)}{dL^{TOT}} - \frac{\theta^1}{1-\sigma}\frac{d\ln(n)}{dL^{TOT}} - \theta^1 \frac{d\ln(w)}{dL^{TOT}} - (1-\theta^1-\theta^2)\frac{d\ln(p^H)}{dL^{TOT}} \\
&= \frac{d\ln(w)}{dL^{TOT}} - \frac{\theta^1}{1-\sigma}\frac{d\ln(I)}{dL^{TOT}} + \frac{\theta^1}{1-\sigma}\frac{d\ln(w)}{dL^{TOT}} - \theta^1 \frac{d\ln(w)}{dL^{TOT}} - (1-\theta^1-\theta^2)\frac{d\ln(p^H)}{dL^{TOT}} \\
&= \left(1 + \frac{\theta^1}{1-\sigma} - \theta^1\right)\frac{d\log(w)}{dL^{TOT}} - \left(\frac{\theta^1}{1-\sigma} + 1 - \theta^1 - \theta^2\right)\frac{d\log(I)}{dL^{TOT}}
\end{aligned}$$

This can be combined with Proposition 3 to derive the effect of immigration on the real wage as follows:

$$\frac{d\ln(w^{REAL})}{dL^{TOT}} > 0 \iff -(1-\sigma+\theta^1\sigma) - (1-\theta^2-\sigma(1-\theta^1-\theta^2))\phi_{L,T}\epsilon^D_{L,T} < 0.$$

Rearranging gives the desired result. *Q.E.D.*

# Tables.

Table 1: Sample Selection Criteria

| Selection Criterion | Number Rejected | Number Remaining |
|---|---|---|
| Keep if in the 1980, 1990, or 2000 U.S. Censuses. | 0 | 37,925,632 |
| Keep if INCWAGE$<400,000$. | 8,761,439 | 29,164,193 |
| Drop if age$<20$ or age$>65$. | 7,038,233 | 22,125,960 |
| Keep if in a consistently defined metarea. | 7,489,516 | 14,636,444 |
| Keep if IND1990$<900$. | 772,486 | 13,863,958 |
| Keep if employed. | 4,002,336 | 9,861,622 |

Table 2: Summary Statistics

| | Mean | Std. Dev. | Min | Max | N |
|---|---|---|---|---|---|
| ***Individual-level*** | | | | | |
| Year | 1990.9 | 8.132 | 1980 | 2000 | 9,861,622 |
| Age | 38.79 | 11.77 | 20 | 65 | 9,861,622 |
| Male | 0.542 | 0.498 | 0 | 1 | 9,861,622 |
| Married | 0.620 | 0.485 | 0 | 1 | 9,861,622 |
| High school dropouts | 0.247 | 0.431 | 0 | 1 | 9,861,622 |
| High school graduates | 0.187 | 0.390 | 0 | 1 | 9,861,622 |
| Some college | 0.294 | 0.456 | 0 | 1 | 9,861,622 |
| College graduates | 0.236 | 0.425 | 0 | 1 | 9,861,622 |
| Immigrant | 0.139 | 0.345 | 0 | 1 | 9,861,622 |
| Salary income | 25119.9 | 31833.7 | 0 | 354000 | 9,861,622 |
| ***Metropolitan area-level*** | | | | | |
| Metarea | 459.6 | 276.9 | 4 | 932 | 219 |
| Employment growth in the 1980s | 1887.7 | 5546.0 | -8838 | 46347 | 219 |
| Employment growth in the 1990s | 2417.8 | 3916.9 | -5993 | 28706 | 219 |
| New immigrants in the 1980s | 2708.5 | 11602.2 | 12 | 126154 | 219 |
| New immigrants in the 1990s | 1590.9 | 5359.1 | 8 | 56491 | 219 |
| Change in the immigrant population in the 1980s | 889.1 | 3814.6 | -578 | 45650 | 219 |
| Change in the immigrant population in the 1990s | 974.0 | 2481.4 | -314 | 25769 | 219 |

Table 3: 10 Most and Least Tradable Industries

| IND1990 | Industry description | Corr. |
|---|---|---|
| 772 | Beauty shops | 0.855 |
| 412 | U.S. Postal Service | 0.851 |
| 610 | Retail bakeries | 0.846 |
| 731 | Personnel supply services | 0.838 |
| 862 | Child day care services | 0.837 |
| 623 | Apparel and accessory stores, except shoe | 0.836 |
| 812 | Offices and clinics of physicians | 0.835 |
| 890 | Accounting, auditing, and bookkeeping services | 0.834 |
| 471 | Sanitary services | 0.827 |
| 510 | Professional and commercial equipment and supplies | 0.826 |
| 312 | Construction and material handling machines | 0.180 |
| 42 | Oil and gas extraction | 0.153 |
| 31 | Forestry | 0.145 |
| 220 | Leather tanning and finishing | 0.115 |
| 132 | Knitting mills | 0.098 |
| 311 | Farm machinery and equipment | 0.090 |
| 130 | Tobacco manufactures | 0.054 |
| 40 | Metal mining | 0.039 |
| 380 | Photographic equipment and supplies | 0.025 |
| 41 | Coal mining | -0.002 |

Table 4: Metarea–level Employment Regression Results

| Dependent Variable: Normalized employment change | **Changes in immigrant population as immigrant flow** | | | | **New immigrant population as immigrant flow** | | | |
|---|---|---|---|---|---|---|---|---|
| | Full sample | Natives | Full sample | Natives | Full sample | Natives | Full sample | Natives |
| | (OLS) | (OLS) | (IV) | (IV) | (OLS) | (OLS) | (IV) | (IV) |
| Normalized immigrant flow | 5.109*** | 4.109*** | 3.456*** | 2.456*** | 2.143*** | 1.704*** | 1.218*** | 0.865*** |
| | (0.561) | (0.561) | (0.646) | (0.646) | (0.333) | (0.305) | (0.431) | (0.329) |
| Metarea FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 438 | 438 | 438 | 438 | 438 | 438 | 438 | 438 |
| Angrist-Pischke $\chi^2$-statistics | | | 6.17 | 6.17 | | | 51.90 | 51.90 |
| Angrist-Pischke F-statistics | | | 3.05 | 3.05 | | | 25.65 | 25.65 |

Notes: Robust standard errors in parentheses are clustered by metarea; *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively; The Angrist-Pischke $\chi^2$ and F statistics report the first-stage test statistics of underidentification and weak identification, respectively, of the endogenous regressor.

## Table 5: Metarea-industry-level Employment Regression Results (IV)

| Dependent Variable: Normalized employment change | **Changes in immigrant population as immigrant flow** | | | | | | **New immigrant population as immigrant flow** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Full sample | Full sample | Natives | Natives | Immigrants | Immigrants | Full sample | Full sample | Natives | Natives | Immigrants | Immigrants |
| Normalized immigrant flow | 0.015*** | -0.015*** | 0.018*** | -0.013*** | -0.004*** | -0.002** | 0.005*** | -0.007*** | 0.006*** | -0.006*** | -0.000 | -0.000 |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.001) | (0.000) | (0.002) | (0.002) | (0.001) | (0.002) | (0.000) | (0.000) |
| Normalized immigrant flow×Corr | 0.004 | 0.053*** | -0.007 | 0.043*** | 0.011*** | 0.008*** | 0.001 | 0.021*** | -0.002 | 0.017*** | 0.003*** | 0.003*** |
| | (0.004) | (0.005) | (0.005) | (0.005) | (0.002) | (0.001) | (0.001) | (0.002) | (0.001) | (0.002) | (0.000) | (0.000) |
| Total employment effect ($\Delta$) | 3.961 | 3.751 | 3.157 | 2.854 | 0.576 | 0.626 | 1.275 | 1.245 | 1.097 | 0.932 | 0.406 | 0.406 |
| Metarea FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry FE | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 80,199 | 80,199 | 79,474 | 79,474 | 28,094 | 28,094 | 80,199 | 80,199 | 79,474 | 79,474 | 28,094 | 28,094 |
| Angrist-Pischke $\chi^2$-statistics | 8.02/45.58 | 7.60/89.37 | 8.54/46.43 | 7.94/91.36 | 10.66/25.05 | 9.74/70.54 | 48.14/94.00 | 48.27/159.25 | 48.64/99.20 | 48.67/167.92 | 33.41/59.30 | 32.62/118.62 |
| Angrist-Pischke F-statistics | 7.94/45.12 | 7.54/88.71 | 8.45/45.96 | 7.88/90.69 | 10.44/24.54 | 9.62/69.67 | 47.66/93.04 | 47.91/158.09 | 48.15/98.19 | 48.31/166.69 | 32.73/58.09 | 32.22/117.15 |

Notes: The full sample was used for all regressions; Robust standard errors in parentheses are clustered by metarea; *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively; Total employment effect of one additional immigrant is computed as $\Delta \equiv \sum_{i=1}^{228}(\beta_1 + corr_i\beta_2)$, where $\beta_1$ is the intercept and $\beta_2$ is the coefficient on the interaction; The Angrist-Pischke $\chi^2$ and F statistics report the first-stage test statistics of underidentification and weak identification, respectively, of the two endogenous regressors.

Table 6: Metarea-industry-level Employment Regression with Additional Industry Controls (IV)

| Dependent variable: Normalized employment change | **Changes in immigrant population as immigrant flow** | | | | | **New immigrant population as immigrant flow** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Normalized immigrant flow | -0.015*** | 0.008** | -0.012*** | 0.008** | -0.011*** | -0.006*** | 0.002 | -0.005** | 0.002 | -0.005** |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| Normalized immigrant flow×corr | 0.053*** | 0.009*** | 0.046*** | 0.009*** | 0.043*** | 0.021*** | 0.003*** | 0.018*** | 0.003*** | 0.017*** |
| | (0.005) | (0.003) | (0.004) | (0.003) | (0.004) | (0.002) | (0.001) | (0.002) | (0.001) | (0.002) |
| National industry employment growth trend | | 0.969*** | | 0.967*** | | | 0.969*** | | 0.967*** | |
| | | (0.058) | | (0.059) | | | (0.058) | | (0.058) | |
| National industry employment growth trend, traded industries | | | 1.042*** | | 1.043*** | | | 1.037*** | | 1.039*** |
| | | | (0.118) | | (0.119) | | | (0.119) | | (0.119) |
| High school dropouts, per cent | | | | 0.000 | -1.87e-06 | | | | 0.000* | 3.07e-05 |
| | | | | (7.61e-05) | (7.19e-05) | | | | (8.71e-05) | (8.38e-05) |
| College graduates, per cent | | | | 0.000* | 0.001*** | | | | 0.000** | 0.001*** |
| | | | | (0.000) | (0.000) | | | | (0.000) | (0.000) |
| Total employment effect ($\Delta$) | 3.751 | 3.042 | 3.488 | 3.042 | 3.310 | 1.473 | 0.862 | 1.295 | 0.862 | 1.160 |
| Metarea FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry FE | No | No | No | No | No | No | No | No | No | No |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 79,054 | 79,054 | 79,054 | 79,054 | 79,054 | 79,054 | 79,054 | 79,054 | 79,054 | 79,054 |
| Angrist-Pischke $\chi^2$-statistics | 7.64/89.78 | 7.66/87.69 | 7.65/89.58 | 7.68/86.48 | 7.67/88.20 | 47.99/158.43 | 48.18/154.81 | 48.06/157.94 | 48.42/152.77 | 48.31/155.65 |
| Angrist-Pischke F-statistics | 7.59/89.12 | 7.61/87.04 | 7.59/88.52 | 7.62/86.48 | 7.62/87.55 | 47.64/157.27 | 47.82/153.67 | 47.71/156.78 | 48.06/151.65 | 47.96/154.50 |

Notes: The full sample was used for all regressions; Robust standard errors in parentheses are clustered by metarea; *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively; Total employment effect of one additional immigrant is computed as $\Delta \equiv \sum_{i=1}^{228}(\beta_1 + corr_i \beta_2)$, where $\beta_1$ is the intercept and $\beta_2$ is the coefficient on the interaction; The Angrist-Pischke $\chi^2$ and F statistics report the first-stage test statistics of underidentification and weak identification, respectively, of the two endogenous regressors.

Table 7: Wage Regression Results (IV)

| Dependent variable: Log Wage | **Changes in immigrant population** Full sample | Natives | **New immigrant population** Full sample | Natives |
|---|---|---|---|---|
| Normalized immigrant flow | -0.803*** | 0.262 | -0.172*** | 0.126 |
| | (0.187) | (0.207) | (0.0621) | (0.0786) |
| Normalized immigrant flow×Corr | 1.892*** | 0.206 | 0.576*** | 0.0639 |
| | (0.288) | (0.256) | (0.0776) | (0.0772) |
| | | | | |
| Metarea FE | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Observations | 6,467,192 | 5,466,920 | 6,467,192 | 5,466,920 |
| Angrist-Pischke $\chi^2$-statistics | 33.13/133.66 | 22.96/125.74 | 127.15/494.70 | 112.72/659.94 |
| Angrist-Pischke F-statistics | 32.97/113.13 | 22.85/125.16 | 126.56/492.40 | 112.20/656.88 |

Notes: The regressions include other control variables such as age, age squared, immigrant status, marital status, race and education; Robust standard errors in parentheses are clustered by metarea, industry and year ; *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively; The Angrist-Pischke $\chi^2$ and F statistics report the first-stage test statistics of underidentification and weak identification, respectively, of the two endogenous regressors.

Table 8: Population Change Regression Results (IV)

| Dependent variable: Normalized employment change | Natives | | | Pre-existing immigrants | | | Moved from other metareas (prev. 5 yrs) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Emp. | Unemp. | NILF. | Emp. | Unemp. | NILF. | Emp. | Unemp. | NILF. |
| **Panel A: Changes in immigrant population as immigrant flow** | | | | | | | | | |
| Normalized immigrant flow | 2.456*** | 0.289*** | 1.017*** | 0.481*** | 0.158*** | -0.0986 | 0.603** | 0.0296** | 0.124** |
| | (0.646) | (0.0957) | (0.259) | (0.142) | (0.0552) | (0.307) | (0.281) | (0.0131) | (0.0586) |
| Metarea FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 438 | 438 | 438 | 438 | 382 | 438 | 438 | 438 | 438 |
| Angrist-Pischke $\chi^2$-statistics | 6.17 | 6.17 | 6.17 | 6.17 | 6.17 | 6.17 | 6.17 | 6.17 | 6.17 |
| Angrist-Pischke F-statistics | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 | 3.05 |
| **Panel B: New immigrant population as immigrant flow** | | | | | | | | | |
| Normalized immigrant flow | 0.865*** | 0.102*** | 0.359** | 0.169* | 0.0576** | -0.0348 | 0.212*** | 0.0104 | 0.0438* |
| | (0.329) | (0.0361) | (0.149) | (0.101) | (0.0253) | (0.0976) | (0.0773) | (0.0063) | (0.0243) |
| Metarea FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 438 | 438 | 438 | 438 | 382 | 438 | 438 | 438 | 438 |
| Angrist-Pischke $\chi^2$-statistics | 51.90 | 51.90 | 51.90 | 51.90 | 51.90 | 51.90 | 51.90 | 51.90 | 51.90 |
| Angrist-Pischke F-statistics | 25.65 | 25.65 | 25.65 | 25.65 | 25.65 | 25.65 | 25.65 | 25.65 | 25.65 |

Notes: Robust standard errors in parentheses are clustered by metarea; *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively; The Angrist-Pischke $\chi^2$ and F statistics report the first-stage test statistics of underidentification and weak identification, respectively, of the endogenous regressor.

Table 9: Sensitivity Analysis, Metarea-level (IV)

| | **Changes in immigrant population as immigrant flow** | | | | **New immigrant population as immigrant flow** | | | |
|---|---|---|---|---|---|---|---|---|
| Dependent Variable: Normalized employment change | Full sample | Natives | Full sample | Natives | Full sample | Natives | Full sample | Natives |
| Normalized immigrant flow | 2.609*** | 1.609*** | 3.469*** | 2.469*** | 1.082*** | 0.667*** | 1.225*** | 0.872*** |
| | (0.524) | (0.524) | (0.653) | (0.653) | (0.210) | (0.205) | (0.428) | (0.328) |
| Decadal population growth, per cent | -0.007 | -0.007 | | | -0.019 | -0.014 | | |
| | (0.018) | (0.018) | | | (0.019) | (0.019) | | |
| Share of employed in routine occupations | | | 0.465 | 0.465 | | | 0.672 | 0.612 |
| | | | (1.246) | (1.246) | | | (1.619) | (1.493) |
| Metarea FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 335 | 335 | 438 | 438 | 335 | 335 | 438 | 438 |
| $\chi^2$-statistics | 12.83 | 12.83 | 6.23 | 6.23 | 16.87 | 16.87 | 51.56 | 51.56 |
| Angrist-Pischke F-statistics | 4.32 | 4.32 | 3.07 | 3.07 | 5.68 | 5.68 | 25.37 | 25.37 |

Notes: Robust standard errors in parentheses are clustered by metarea; *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively; The Angrist-Pischke $\chi^2$ and F statistics report the first-stage test statistics of underidentification and weak identification, respectively, of the endogenous regressor.

Table 10: Sensitivity Analysis, Metarea-industry-level (IV)

| Dependent Variable: Normalized employment change | **Changes in immigrant population as immigrant flow** | | | | **New immigrant population as immigrant flow** | | | |
|---|---|---|---|---|---|---|---|---|
| | Full sample | Natives | Full sample | Natives | Full sample | Natives | Full sample | Natives |
| Normalized immigrant flow | -0.017*** | -0.014*** | -0.015*** | -0.013*** | -0.007*** | -0.006*** | -0.006*** | -0.006*** |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.001) | (0.001) | (0.002) | (0.002) |
| Normalized immigrant flow×Corr | 0.050*** | 0.038*** | 0.053*** | 0.043*** | 0.021*** | 0.016*** | 0.021*** | 0.017*** |
| | (0.005) | (0.005) | (0.005) | (0.005) | (0.002) | (0.002) | (0.002) | (0.002) |
| Decadal population growth, per cent | -3.06e-05 | -2.92e-05 | | | -9.15e-05 | -6.91e-05 | | |
| | (9.45e-05) | (9.48e-05) | | | (0.000) | (0.000) | | |
| Share of employed in routine occupations | | | 0.002 | 0.002 | | | 0.003 | 0.003 |
| | | | (0.006) | (0.006) | | | (0.009) | (0.009) |
| Total employment effect ($\Delta$) | 2.889 | 1.949 | 3.751 | 2.854 | 1.245 | 0.796 | 1.473 | 0.932 |
| Metarea FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry FE | No | No | No | No | No | No | No | No |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 62,559 | 62,076 | 79,054 | 78,397 | 62,559 | 62,076 | 79,054 | 78,397 |
| Angrist-Pischke $\chi^2$-statistics | 75.39/83.15 | 79.52/95.86 | 94.67/95.21 | 101.32/107.19 | 193.63/215.45 | 223.88/291.8 | 182.17/167.41 | 199.55/179.84 |
| Angrist-Pischke F-statistics | 8.78/33.54 | 12.97/33.87 | 7.26/46.31 | 9.48/46.87 | 33.17/94.58 | 59.1/97.33 | 26.09/94.13 | 27.46/98.19 |

Notes: The full sample was used for all regressions; Robust standard errors in parentheses are clustered by metarea; *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively; Total employment effect of one additional immigrant is computed as $\Delta \equiv \sum_{i=1}^{228}(\beta_1 + corr_i\beta_2)$, where $\beta_1$ is the intercept and $\beta_2$ is the coefficient on the interaction; The Angrist-Pischke $\chi^2$ and F statistics report the first-stage test statistics of underidentification and weak identification, respectively, of the two endogenous regressors.

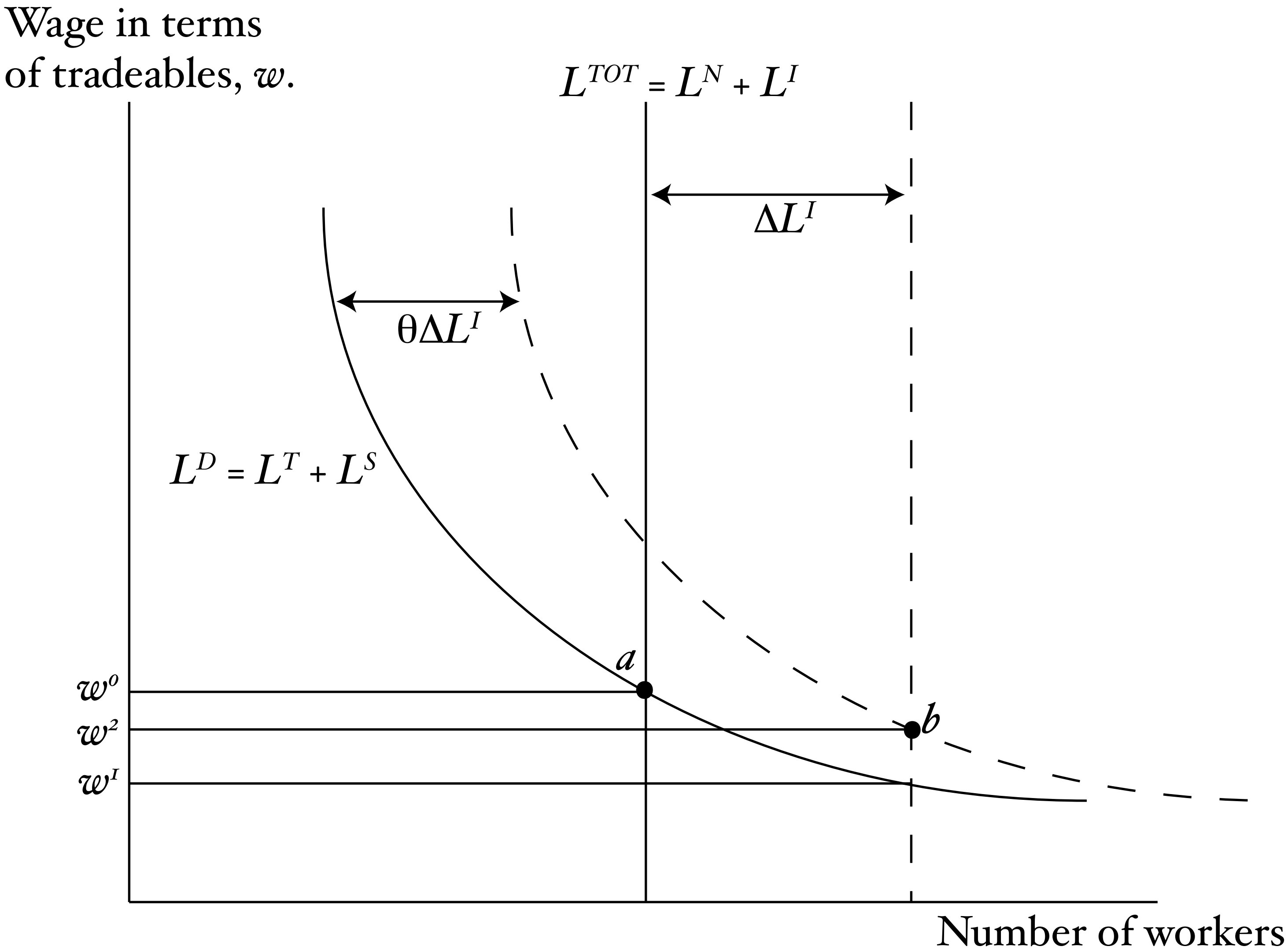


Figure 1: The effect of immigration with inelastic and immobile labor supply.

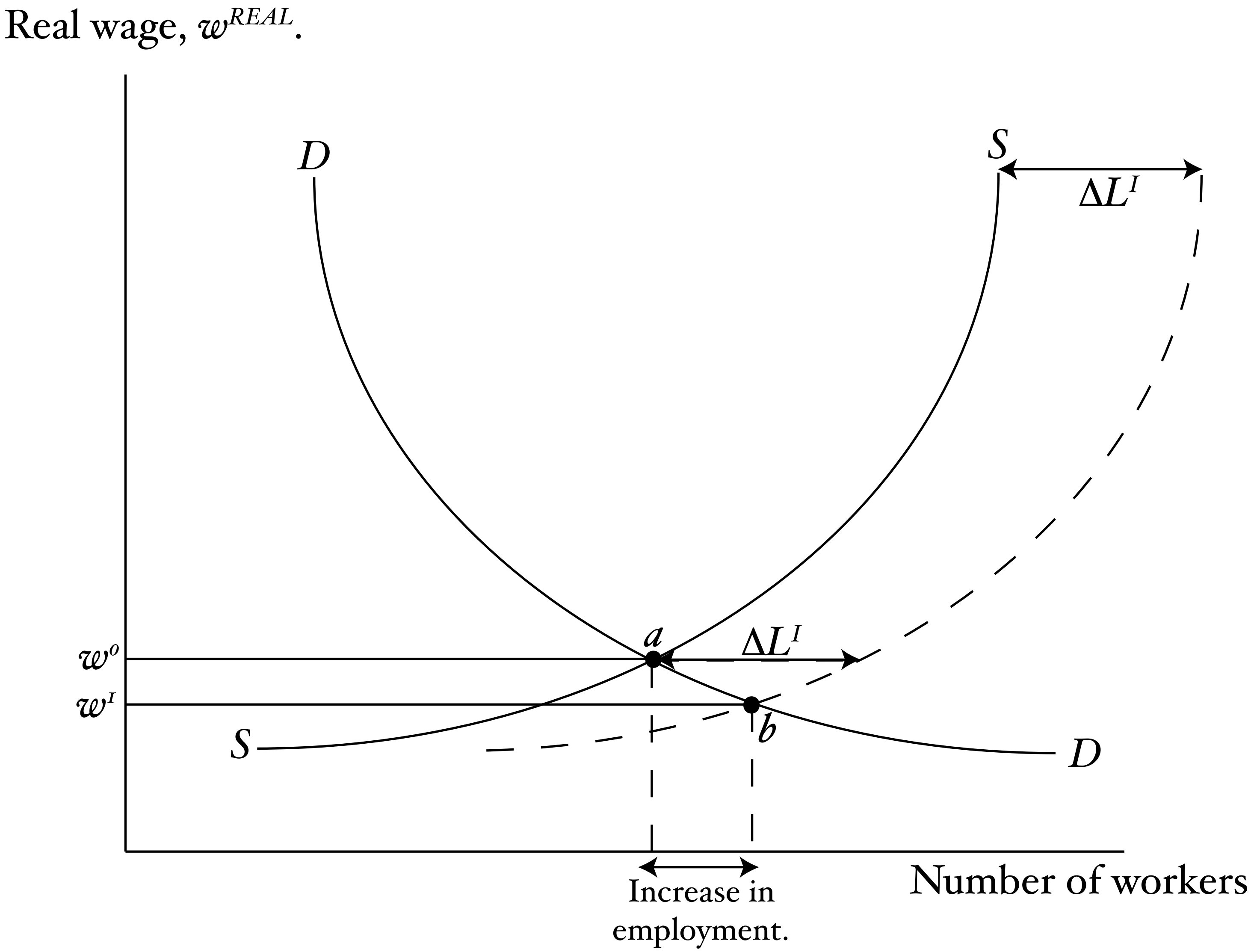


Figure 2(a): The effect of immigration when the 'shot-in-the-arm' effect is weak.

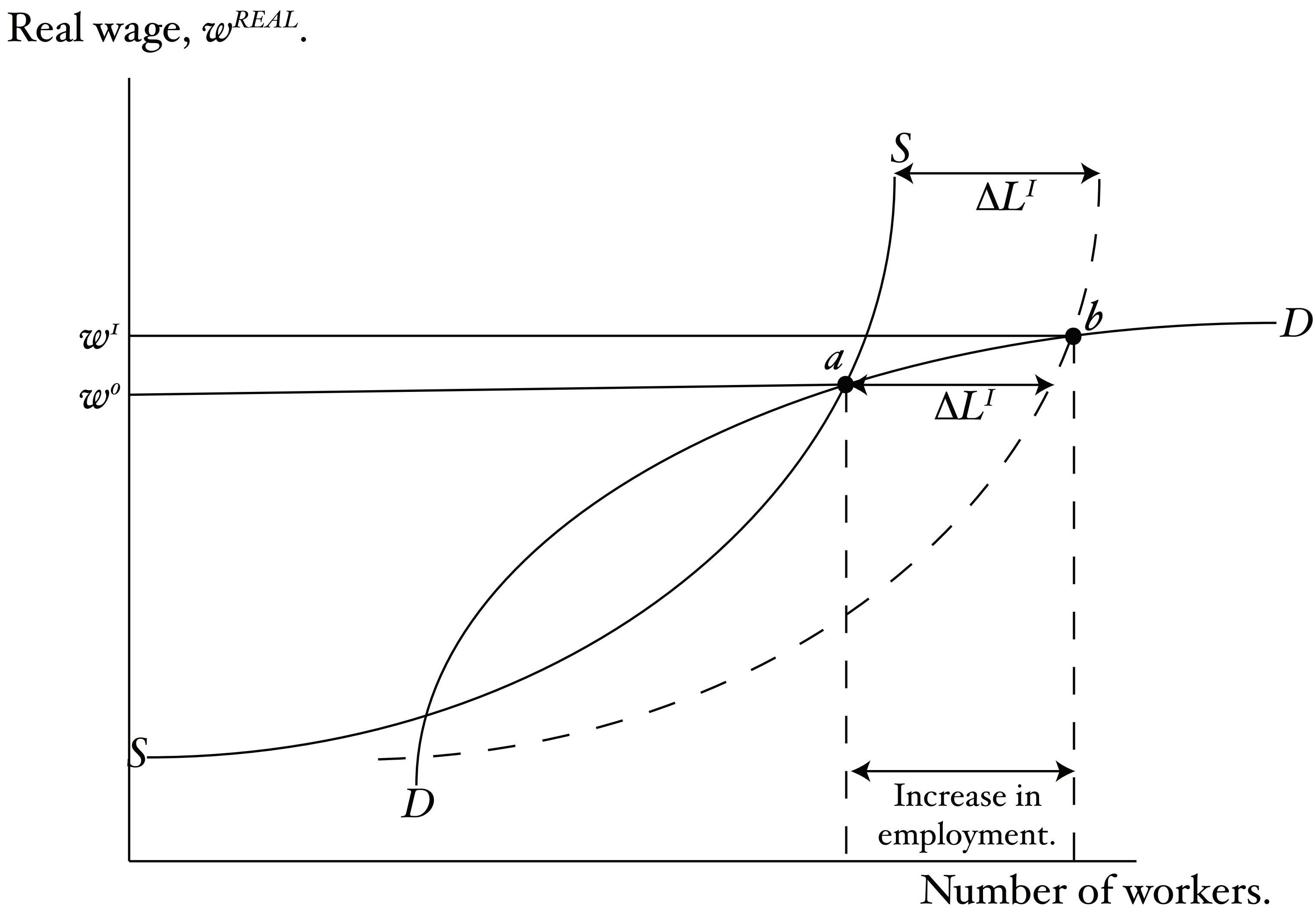


Figure 2(b): The effect of immigration when the 'shot-in-the-arm' effect is strong.