7-31-2015

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July 2015

Studies estimating the consequences of immigration on wages paid to native-born workers often uncover small to nonexistent effects when using cross city or state variation (the "spatial approach") but large deleterious effects when using variation across education-by-experience cells (the "national approach"). One mechanism of labor market adjustment emphasized in the spatial approach is that native-born workers respond to immigration by specializing in occupations demanding skills in which they have a comparative advantage, thereby helping to protect themselves from labor market competition and wage losses. This paper examines whether the national approach also identifies this skill response. We find evidence that such a response does occur, which reduced the magnitude of within-cell wage effects by more than 20%.

JEL: F22, J24, J61, J31
Keywords: Immigration, Occupational Skills

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1. Introduction

Academic debate on the wage consequences of immigration is extensive and well documented. On the one hand, standard textbook models of wage determination argue that if the demand curve is downward sloping, then an immigration-induced rise in labor supply should cause wages to fall. This intuitive theory finds empirical support in Borjas (2003, 2013, 2014), Borjas and Katz (2007), Aydemir and Borjas (2007), and Borjas, Grogger, and Hanson (2010). On the other hand, labor markets might be capable of absorbing new waves of migrants through alternative mechanisms so that wage losses are small or nonexistent. Such channels might include technological change, capital adjustment, or imperfect substitutability between foreign and native-born workers. Empirical evidence that wage losses from immigration are small or nonexistent can be found in Grossman (1982), Card (1990, 2001, 2009a, 2009b), Peri and Sparber (2009), Lewis (2011), Ottaviano and Peri (2012), and Manacorda, Manning, and Wadsworth (2012).

Immigration is a topic of major policy importance, so it is disconcerting that such a large body of prominent work has delivered starkly conflicting results. Much of the recent immigration literature has turned to discussion about why such disparities exist. One likely source is methodological: Spatial analysis exploiting cross-region variation tends to find few negative consequences of immigration. Critics, however, note that if native-born workers respond to immigration by moving to new regions, then spatial analysis will be biased. Alternatively, national-level analysis exploiting variation across groups of labor with similar educational attainment and work experience tend to find wage losses due to immigration. However, critics of this approach argue that incorrect groupings of workers and/or poor assumptions regarding elasticities of substitution across groups lead to unreasonably large wage loss estimates.[1]

This paper does not contribute to the debate on the strengths and weaknesses of methodological approaches or the extent to which elasticities of substitution drive general equilibrium results. Instead, we seek to identify common ground by adopting the partial-equilibrium, within-cell, estimation strategy of the national approach to explore relationships between immigration, skills, and wages that are more commonly examined using the spatial approach.

We begin our analysis by carefully replicating wage estimates in Borjas (2014), which uses a national-approach that defines five education groups by eight experience groups in each decade from 1960-2010. Regressions using his resulting 240 cells find that a one percentage point increase in the

[1]Thorough coverage of these issues can be found in Borjas (2006), Borjas, Grogger, and Hanson (2011, 2012), and Card (2009, 2012).

foreign-born share of the labor force decreases wages paid to native-born men by 0.53%. Using the Borjas methodology and selection criteria, we are able to replicate this result. This – like all estimates in the paper – is a partial equilibrium effect. It measures the wage response to immigration within a cell, but does not take into account cross-group complementarities that might exist in a general equilibrium setting. It can therefore be seen as an upper-bound estimate of the magnitude of wage losses generated by immigration. Next, we illustrate that losses identified by the national approach are concentrated among groups with little educational attainment. This partial equilibrium result is important because the general equilibrium identified in Borjas (2003, 2013, 2014) identifies large losses among all groups. If highly-educated workers experience no within-group losses, however, then they will experience no wage loss overall.

We then turn to the central focus of our paper. Studies employing spatial analysis have argued that native and foreign-born workers specialize in performing unique occupational skills.[2] When immigrants arrive, native-born workers respond rationally by further specializing in occupations in which they have a comparative advantage, thereby helping to protect themselves from labor market competition and wage losses. This paper examines whether a similar effect can also be found using the national-level approach. Interestingly, we find that workers with little educational attainment respond in a way consistent with findings from previous studies. Namely, they use fewer manual skills but perform more communication work, which leads to better wage outcomes than would be seen if native and foreign-born workers perform the same skills. Specialization mitigates the within-cell, partial equilibrium, wage losses by about 20%. In contrast, results for the college-educated workers are harder to reconcile. Manual skills increase in response to immigration as college-educated workers move to health and therapy-related occupations. More troubling is evidence that communication skills used by college-educated native-born workers decline in response to immigration. Though the within-cell wage effects of immigration are positive for college-educated workers, they would be higher if natives exhibited no occupational skill response.

We believe this exercise is important for several reasons. First, it provides an alternative method for uncovering suggestive evidence about the substitutability of foreign and native-born labor. Whereas a typical approach would assess the relationship between relative wages and employment across units of analysis, we instead ask whether foreign and native-born groups are performing different types of work. Second, by recognizing the skills used by different groups, we can identify areas in which native-born

[2] See Peri and Sparber (2009), Amuedo-Dorantes and de la Rica (2011), and De Arcangelis, Di Porto, and Santoni (2015), for example.

workers are most susceptible to competition with immigrants. Policy can be designed to help vulnerable groups adjust more easily. Third, the model will measure whether native-born workers exhibit a skill response within narrowly-defined education groups. This contrasts with previous work identifying a skill response that conflated occupational changes within education group with those occurring through increased educational attainment (for example, a new job that was acquired after immigration encouraged native-born high school dropouts to obtain a GED). Finally, by using the national-level approach to assess a question previously in the domain of spatial analysis, we can learn whether qualitative answers are sensitive to methodology. That is, we can ask whether the national-level approach concurs with spatial analysis in finding that immigration induces an occupational skill response among native-born workers that helps to protect them from labor market competition.

Altogether, the results suggest that it is inaccurate to argue that immigration reduces wages for all workers, even when using the national-approach. Among those who are most at risk of experiencing wage loss, workers respond by moving to occupations less prone to competition with immigrants, thereby helping to reduce negative effects.

2. Literature

Spatial analysis of the effects of immigration regress wage or employment outcomes of native-born workers on the foreign-born share of employment (or some related immigration variable) across regions (such as states or cities). Such work tends to find that immigration generates small wage effects for native-born workers. For example, Card (2001, p.23) notes that the literature typically finds that a 10-percentage-point increase the fraction of immigrants in a city reduces native wages "by no more than 1 percentage point." He concludes his study (p. 57) by arguing that "it seems likely that immigrant inflows over the late 1980s reduced the relative wages of laborers and less-skilled service workers in high immigrant cities by no more than 3%. The effects in other cities, and for other occupation groups that were less affected by new immigrant arrivals, were probably much smaller." Card (2009a) argues that the effect of immigration may even be positive: "Even after controlling for city size effects, human capital spillovers, and the possibility that immigrants are drawn to cities with stronger local economies, the evidence suggests a positive effect. Taken together with the rather small magnitude of the relative wage effects, it appears that immigration exerts a modestly positive effect on the labor market outcomes of most natives."

Borjas (2003) notes that nonexistent (or positive) wage effects from immigration violate textbook models of labor markets that assume downward sloping demand curves. One problem with the spatial

approach is that if natives respond to immigration by moving to low immigration cities, then the effects of immigration dissipate across the country. Cross-region analysis will fail to identify wage losses. To solve this problem, he developed a new national-level "approach for thinking about and estimating the impact of immigration (p. 1336)." His central idea is that the national labor market can be dividing into cells defined by education and experience. If a cell experiences an influx of immigration, the effects will not dissipate via spatial arbitrage.

Ultimately, Borjas (2003) finds large losses. For example, his Table III results suggest that a one percentage point increase in the foreign-born share of the labor force will reduce within-cell wages by 0.572%. When converted into an elasticity, this implies that an immigration-induced 10% labor supply shock will reduce weekly earnings of native-born men by about 4%. Note, however, that these direct within-cell wage estimates represent partial equilibrium effects that do not take into account potential complementarities across groups. To do so requires specification of a structural model with assumed elasticities across education and experience groups. Borjas (2003, Table IX) completes this exercise and finds that the immigration influx in the 1980s and 1990s reduced wages in the US by 3.2%, with the largest effects felt by high school dropouts (8.9%) and college graduates (4.9%). Importantly, Borjas's subsequent work using updated data and a slightly different definition of cells finds concurring evidence: Borjas (2013, Table 4.5) and Borjas (2014, Table 1) uncovers a qualitatively equivalent -0.529 within-cell wage estimate, while Borjas (2013, Table 3) calculates that the influx of immigrants between 1990 and 2010 generated a 3.2% wage loss, with the largest effects among high school dropouts (6.2%) and workers holding advanced college degrees (4.1%).

Unfortunately, the national approach faces its own challenges. Most notably, work by Card (2009b, 2012), Ottaviano and Peri (2012), and others have argued that the general equilibrium results in Borjas's work crucially depend upon the assumed elasticities in the structural model. For example, Borjas assumes a common elasticity of substitution across narrowly-defined education groups (e.g., high school dropouts, high school graduates, college graduates, etc.), whereas most of the labor literature recognizes a high level of substitutability within broader groups (e.g., high school dropouts and high school graduates can be grouped together as high school equivalents), but a low level of substitutability across broad groups (e.g., between high school equivalents and college equivalents). Similarly, Borjas's structural model assumes that native and foreign-born workers are perfectly substitutable within cells, whereas Ottaviano and Peri (2012) argue that imperfect substitutability greatly diminishes the possibility that immigrants generate wage losses for natives. The net result of these structural assumptions is that Borjas's within-cell wage loss estimates will be high and responsible for driving most

of the general equilibrium wage effect. In light of this information, it is not surprising that Borjas's general equilibrium wage losses are concentrated at the extreme ends of the educational attainment spectrum: those are precisely the groups that have the largest shares of foreign labor.

This paper will not explore the role of elasticities in estimating general equilibrium results. Instead, we are more interested in the partial-equilibrium within-cell estimate in two ways. First, we discuss some of the sensitivity of the estimate, and highlight a result also found in Borjas (2003) but absent in later work: the within-cell wage effect is not uniform across educational groups. This is an important result to emphasize. If within-cell effects are small (or even positive) for some education groups, then single estimates will greatly overstate general equilibrium wage losses. Some groups might not experience any wage loss at all, even when using the national approach to estimation.

Second, we return to the idea posed in Ottaviano and Peri (2012) that immigrants and natives are imperfectly substitutable within cells. Rather than estimate elasticities directly, however, we measure how the occupational skills used by native workers respond to immigration flows. Peri and Sparber (2009) used the spatial approach to illustrate that such occupational adjustment plays a role in protecting native-born workers from labor market competition with immigrants. It is worth exploring whether such an effect also exists when employing the national approach. For example, under Peri and Sparber (2009), a native-born high school dropout might respond to immigration by returning to school, earning a GED, and securing a higher-paying job. The national level approach, in contrast, will measure whether native born workers find alternative occupations without returning to school.

Using the national approach to estimate a skill response presents a unique challenge in that occupational skills vary across educational attainment. The spatial approach in Peri and Sparber (2009) focuses on the communication and manual skills used by workers with a high school degree or less education. They find that natives have a comparative advantage in higher paying communication skills. When immigrants arrive into a state, natives respond by choosing new occupations with more communication and less manual content. In a world of perfect substitution between native and foreign labor, immigration between 1990 and 2000 would have caused less-educated native-born American wages to fall by 1.2%. Occupational adjustment reduced that figure to 0.3% (a 75% decline in magnitude). Peri and Sparber (2011), in contrast, focused on workers with advanced degrees. At this education level, natives continue to perform communication work, whereas immigrants focus on quantitative skills. When highly-educated immigrants arrive to the US, highly-educated natives further specialize in communication work.

This paper will combine these approaches and examine how manual, communication, and quantitative skills respond to immigration. The results are likely to vary across educational attainment, thus necessitating interaction terms to explore potential heterogeneity in the effects of immigration. These results, combined with other wage estimates, will help us determine whether the national approach identifies occupational skill adjustment as a channel through which the US labor market absorbs immigration and potentially protects native workers from competition.

3. Wage Data and Estimation

Wage Data and Regression Specification

We start our analysis by replicating the Borjas (2013) national-level, within-cell, partial equilibrium wage effect of immigration. Data come from the IPUMS 1960, 1970, 1980, 1990 and 2000 U.S. Census samples.[3] We also use the collective 2007-2011 ACS sample for our representation of the year 2010. We exclude people living in group quarters, and include only those who are 18-64 years of age (inclusive).

The unit of analysis is an education-by-experience group cell. We consider five education groups: high school dropouts, high school graduates, those with some college, college graduates, and people with advanced degrees. We use eight experience groups, which are determined by the difference between a person's current age and his/her age at the assumed age of entry into the labor force. In particular, we assumed that high school dropouts enter the labor market at the age of 17, high school graduates at 19, those with some college at 21, college graduates at 23, and people with advanced degrees at 24. We drop individuals with less than one or more than 40 years of experience. We then divide people into five-year experience groups (e.g., 1-5 years of experience, 6-10 years, … 36-40 years).

Our main empirical specification for exploring wage outcomes is in Equation (1).

$$(1) \quad logw_{ijt} = \beta P_{ijt} + fe_i + fe_j + fe_t + fe_{it} + fe_{jt} + fe_{ij} + \varepsilon$$

The variable $logw_{ijt}$ represents the mean log weekly wages paid to native-born men in year *t* for education group *i* and experience group *j*. Our main explanatory variable of interest, P_{ijt}, measures the foreign-born share of the labor force. $fe_i, fe_j \; and \; fe_t$ are fixed effects of education, experience, and year respectively. The terms $fe_{it} \; and \; fe_{jt}$ interact education and experience fixed effects with year dummies to control for wage trends correlated with variation in educational attainment and experience over time. The term fe_{ij} controls for joint education-by-experience cells and ensures that the effects of

[3] See Ruggles et al. (2015).

immigration will be identified by changes within cell. All regressions cluster standard errors by education-by-experience cell.

Importantly, Borjas (2013) employs subtly different selection criteria in constructing the dependent and explanatory variables (see Table A1 in the Appendix). The "count" sample is the least restrictive, eliminating just those who live in group quarters, those who are not 18-64 years of age, and those who are outside the range of 1-40 years of experience. The explanatory variable measures the share of total hours that immigrants contribute to the labor force, where immigrants are defined as noncitizens and naturalized citizens.

Borjas's "wage" sample uses more restrictive selection criteria to construct the dependent variable. In addition to the criteria stated above, he included only men with positive hours worked, weeks worked, and wages earned. Individuals enrolled in school are omitted. Thus, his regression is identifying the effect of immigrant hours in the overall labor force on a more narrowly-defined group of native-born male workers.

Finally, we also employ a third and most restrictive set of selection criteria. We limit the sample to the civilian labor force by omitting military occupations and industries. All individuals are in the labor force and in identifiable states, industries, and occupations. Those with undefined or zero sample weights are also removed. In part, our additional criteria are necessary for the analysis examining variation in occupational skills, so we refer to this sample as the "skill" sample.

Wage Regression Results

The wage estimation results are in Table 1. The top panel uses the Borjas wage selection criteria to construct the dependent variable; the bottom panel uses the skill defined criteria. Column (1) attempts to perfectly replicate the Table 4.5 estimate of Borjas (2014). Our -0.528 figure is off by just one one-thousandth of a point. This is attributable to two unavoidable causes: First, IPUMS randomly allocates sample weight values of 99 or 100 to individuals in the 1960 census whenever that sample is updated. Borjas's data download occurred before the most recent update, so our counts in that year are slightly different. Second, IPUMS made slight wage adjustments in the 2007-2011 ACS sample between our respective downloads, thus altering some of the 2010 wage data. Despite these differences, our estimates are remarkably close. A 1 percentage-point increase in the foreign-share of employment decreases within-cell native-born male wages by 0.53%.

Since Borjas' count selection criteria includes many individuals who are not included in the wage selection criteria, Column (2) adopts the more restrictive skill defined criteria. Whether wages continue

to be constructed according to the Borjas wage or skill defined criteria, the results are quite comparable to baseline estimates. A 1 percentage-point increase in the foreign-share of employment decreases within-cell native-born male wages by 0.43-0.55%.

Columns (3) and (4) begin to explore heterogeneous effects across educational attainment level. Borjas (2003, p.1351) argues that "the sample of high school dropouts is not the group that is driving much of the analysis." Nonetheless, when removing high school dropouts from the dataset (Column 3), the coefficient becomes insignificant. Point estimates remain close to those in baseline results, however, so the larger standard errors and decreased significance could be attributable to noise in the estimation. That said, when eliminating all workers without college experience (Column 4), the coefficient is near zero or positive. These results are suggestive of an unequal impact of immigrants on native wages across the education groups – a result we will explore further.

4. Skill Data and Estimation

Skill Data

To measure the skills people use in their occupations, we follow Peri and Sparber (2009, 2011) and modify information provided by the National Center for O*NET Development's O*NET database. The O*NET ability dataset records the importance of 52 separate abilities (or skills) required for each occupation defined by Standard Occupational Classification (SOC) codes. We take the average of these skills for each census occupation code (using the IPUMS-provided occ1990 variable), and then group these abilities into three aggregate categories: Manual, Communication, and Quantitative skills.[4] We then rank occupations according to the relative importance of each skill and create percentile values based upon the 2010 occupational distribution of workers.

This procedure results in three (Manual, Communication, and Quantitative) skills for each occupation. Economists, for example, have values of (0.02, 0.70, 0.94) indicating that they use more manual skills than just 2% of the workforce, more communication skills than 70% of workers, and more quantitative skills than 94% of labor. Sales demonstrators, promoters, and models use less than the median level of all three skills (0.35, 0.19, 0.08). In contrast, construction supervisors (0.54, 0.63, 0.83) are above the median in all dimensions.

[4] Manual skills include Arm-Hand Steadiness; Manual Dexterity; Finger Dexterity; Control Precision; Multilimb Coordination; Response Orientation; Rate Control; Reaction Time; Wrist-Finger Speed; Speed of Limb Movement; Static Strength; Explosive Strength; Trunk Strength; Stamina; Extent Flexibility; Dynamic Flexibility; Gross Body Coordination; and Gross Body Equilibrium. Communication skills include Oral Comprehension; Written Comprehension; Oral Expression; and Written Expression. Quantitative skills include Mathematical Reasoning and Number Facility.

Not surprisingly, skill use varies by education level and nativity. Figure 1 illustrates these differences in 2010.[5] The left panel displays average skill use by education level for native and foreign-born workers. High school dropouts tend to work in occupations requiring very little communication or quantitative skill. However, the average high school dropout uses more manual skills than 70% of the labor force. Communication and quantitative skill intensity tend to rise with educational attainment, while manual skill use falls. Occupations in which more than half of workers have a college degree but nevertheless perform a high level of manual skill include police officers (0.68, 0.67, 0.29) and medically-related jobs such as physical therapists (0.66, 0.71 0.28), nurses (0.64, 0.88, 0.76), and veterinarians (0.51, 0.71, 0.59). Occupations at the lower end of the educational attainment spectrum that require intense communication work include customer service representatives (0.16, 0.81, 0.41), managers of food-serving and lodging establishments (0.77, 0.80, 0.78), and secretaries (0.13, 0.72, 0.32). Similarly-educated workers performing quantitative work include bank tellers (0.38, 0.52, 0.94), cashiers (0.48, 0.42, 0.87), and electricians (0.95, 0.40, 0.80).

The left panel of Figure 1 also illustrates that native-born workers have an absolute advantage in communication skills, whereas foreign-born workers have an absolute advantage in manual work. The implied comparative advantage motivated the spatial analysis in Peri and Sparber (2009), who found that native-born workers with a high school degree or less education increasingly specialize in communication-based work as immigrants arrive to the US. Quantitative work is less clear. Natives have an absolute advantage through much of the educational spectrum, but foreign-born workers with advanced (graduate) degrees do far more quantitative work. This latter regularity motivated the analysis in Peri and Sparber (2011), who found that workers with advanced degrees move to occupations requiring communication-based work when similarly-educated immigrants arrive to the US.

The right panel of Figure 2 converts absolute skill levels into relative values for the purpose of ranking the comparative advantage of native-born (versus foreign-born) workers across skills. It is not surprising that communication skill intensity is higher for native-born workers than for foreign-born labor at all education levels – natives have a comparative advantage in communication skills relative to both manual and quantitative skills. Immigrants have a comparative advantage in manual work relative to other skills at most levels of educational attainment. The only nuance to these regularities is that in comparing manual to quantitative work among advanced degree holders, native-born workers have a comparative advantage in manual skills, whereas immigrants have a comparative advantage in quantitative work. This is driven, in part, by the relative tendency among native-born workers of high

[5] Figures for other years are very similar.

educational attainment to work in medical fields as opposed to fields of mathematic or scientific inquiry (e.g., physicists and mathematicians).

Skill use is important because it generates wage implications. The top panel of Figure 2 illustrates the average wage paid to workers by skill decile in 2010. Average annual wages increase from about $20,000 for the lowest communication and quantitative skill decile to more than $70,000 for the highest decile. Wages tend to decrease with manual skill intensity, in contrast. This simple summary clearly conflates wages driven by occupational skills and educational attainment. The middle and bottom panels of Figure 2 display wages by decile within education group (those with a high school degree and less education, and those with a bachelor's degree or more education, respectively). Wage variation is clearly less pronounced within education group.

To better understand the return to skill, we use the skill-defined data selection criteria to estimate the following regression across individuals (*k*) from 1960-2010.

$$(2)\quad logw_{kt} = \sum_{i=1}^{5} \gamma_i^{Man} \cdot Man_{kt} + \sum_{i=1}^{5} \gamma_i^{Com} \cdot Com_{kt} + \sum_{i=1}^{5} \gamma_i^{Quant} \cdot Quant_{kt} + \eta \cdot X_{kt} + fe_i + fe_j + fe_t + fe_{it} + fe_{jt} + fe_{ij} + \varepsilon_{kt}$$

The γ^{Man}, γ^{Com}, and γ^{Quant} values represent the marginal return to manual, communication, and quantitative skills specific to education group *i*. The vector X represents a series of indicator variables for nativity, race, age, state of residence, industry of employment, weeks worked per year, and hours worked per year. The *fe* variables are fixed effects for education group, years of experience (*j*), year of observation (*t*), and their two-way interactions. Regressions are weighted by sample weights.

Figure 3 displays the estimates for the education-specific returns to skill.[6] Note that the returns to each skill are positive. Coefficients for communication equal 0.25 for high school dropouts but increase to 0.81 for workers with an advanced degree. This implies that a one decile increase in communication skill use (roughly the equivalent of moving from a bookkeeper to a sales clerk, or from a real estate manager to a lawyer) translates to a 2.5-8.1% wage gain, ceteris paribus. Returns to manual and quantitative skills are between 0.08 and 0.19 for workers without a bachelor's degree. The return to manual skill plummets to zero for workers with more educational attainment. This again partly reflects the dominance of lower paying medically-related occupations (nursing, physical therapists) among manually-intense high-education occupations. The return to quantitative skills, however, rises to 0.25 to 0.30 for those with a bachelor's degree or more education.

[6] The regression includes over 10 million observations and has an R^2 value of 0.42.

Skill Regression Results

We now return to regression estimation across education and experience group cells to estimate the wage and skill response of native-born American men to immigration. Table 2 reports the results. Motivated by the findings of Table 1, we introduce model flexibility allowing the effects of immigration to differ between people with little educational experience and those with more education. The top panel includes people with some college but no bachelor's degree in the highly educated group. The bottom panel places them in the low education group.

Column (1) again returns to wage regressions. A one percentage point increase in the foreign-born share of the labor force decreases wages paid to less-educated native-born men by 0.52 to 0.67% within education-by-experience cells before accounting for any cross-group complementarities. These figures are close to the Borjas estimates. Importantly, however, the net effect for workers with college experience ranges from a significantly positive 0.44 to 0.49%. This suggests that the national approach to estimating the wage effects of immigration should account for variation across levels of educational attainment. Workers with high levels of educational attainment experience no wage losses and may even experience gains. Wage losses – if they occur – will be concentrated among workers with little educational attainment. The full extent of those losses can only be understood in the context of a general equilibrium model that imposes various assumptions on the substitutability of workers across education and experience groups. Previous literature has shown that if high school dropouts and high school graduates are highly substitutable, and if low-education groups complement highly-educated ones, then wages losses will be small or nonexistent even for workers who experience within-group wage losses.

Columns (2)-(4) explore the possibility for occupational skill adjustment. These results are important for establishing whether native-born workers rationally respond to immigration by increasingly moving into occupations in which they have a comparative advantage, thereby helping to protect themselves from labor market competition and identifying a channel through which the US economy absorbs new immigrants. In Column (2), we see a response previously discovered using spatial analysis. Less-educated native-born workers reduce the level of manual skill work, although at only marginal levels of significance. Interestingly, we also see that highly-educated workers perform more manual work. This makes sense in the context of Table 1. Among workers with a graduate degree, native-born workers have a comparative advantage over immigrants in performing manual work relative to quantitative work. Again, this is partly driven by the stylized fact that the manual-skill-intense occupations chosen by

highly-educated workers include many medically-related fields disproportionately represented by natives.

Column (3) explores the communication skill response. Results for less-educated workers again support past spatial work. A one percentage point increase in the foreign-born labor force share increases native-born communication skill intensity by 0.27 to 0.39%. More puzzling is that the same immigration shock is estimated to reduce native communication skill intensity by 0.66 to 0.82%. This is a surprise because native-born workers have a comparative advantage in communication skills regardless of education level and the alternative skill to which it is compared. It also conflicts with Peri and Sparber (2011), which argues that natives with graduate degrees respond to immigration by moving into occupations demanding more communication skill. Much of this difference arises due to the presence of controls for education group-specific trends – in the absence of these controls, communication skills increase for natives of all educational attainment levels. It also reflects a more troubling regularity that as immigrants arrive, some college-educated natives move into occupations typically associated with lower levels of educational attainment and communication skill.

Finally, Column (4) examines the quantitative skill response. A one percentage point increase in the foreign-born labor force share increases less-educated native-born quantitative skill use by 0.23 to 0.31%. This response reverses to a 0.46 to 0.66% decline among college-educated natives. Both responses are reconcilable given the skill ordering of comparative advantages among foreign versus native-born workers.

5. Discussion

Occupational skill responses among native born workers are important to understand because they illustrate that immigrants and natives do not simply perform the same types of perfectly substitutable work functions. Instead, native skills are affected by immigration. This response influences the within-group wage effects of immigration that are easily missed in wage regressions alone.

To see this effect, consider Table 3. The first column of data summarizes the average within-cell increase in the foreign-born share of labor by education group between 2000 and 2010. The foreign-born share of the average experience group among high school dropouts increased a massive 14.7 percentage-points during the decade. The share among high school graduates increased 6 percentage points. Each college-educated group saw a rise of about 3 percentage points. The second column multiplies these values by the relevant coefficients of the second panel of results in Column (1) of Table 2 to estimate the within-cell wage consequence of immigration. As previously noted, losses are limited

to groups with little educational attainment. High school dropouts saw a within-group wage loss of nearly 10% before accounting for any cross-group complementarities. In contrast, advanced degree holders saw wages rise by 1.8%. Such increases might be possible, for example, if highly-educated immigrants are responsible for technological developments that create productivity spillovers for college-educated workers.[7]

The third column provides a simulated estimate of wage changes due to occupational skill responses only. The previous discussion of Figure 3 noted that the return to communication skills is large and grows with educational attainment. Quantitative skills earn a mid-sized rate of return, whereas manual skills earn a significant rate of return only for workers without a bachelor's degree or more education. Shifts in skill use, therefore, will have wage consequences. The increase in high-paying communication and quantitative skills experienced by less-educated natives could compensate for losses in lower-paying manual skills in a way that helps protect such workers from competition with immigrants. Indeed, we see that the skill shift was responsible for a 2.4% wage gain for high school dropouts, a 1% rise for high school graduates, and a 0.6% increase for those with some college experience. In contrast, the puzzling decline in communication skills among highly-educated natives led to 1.9-2.5% wage losses that wage regressions alone fail to uncover.

The fourth column calculates the counter-factual wage outcomes that would have arisen in the absence of an occupational skill response. For each education group, we see that the magnitude of the wage effect would have been much greater in the absence of skill changes. Equivalently, this column records the within-group wage outcome that would have occurred if native and foreign-born workers were perfectly substitutable within groups. Losses for less-educated workers would have been more severe, whereas the technological gains generated by college-educated immigrants would have created greater wage growth for similarly-educated natives.

The final column describes the proportion of this wage effect that disappears due to skill reallocation. Changes in occupational skills mitigate 20% of the potential wage loss for workers with a high school degree or less education. This national-approach estimate is much smaller in magnitude than the 75% reduction found in Peri and Sparber (2009), but their figure results from a general equilibrium computation and also allows for educational upgrading. That the same qualitative effect exists when using the national-approach to estimation is an important confirmation that occupational skill responses do occur and help to protect natives from competition, and that the result is not just a result of differences in estimation methodology. It also helps to demonstrate that native workers who

[7] See Hunt and Gauthier-Loiselle (2010), Kerr and Lincoln (2010), or Peri, Shih, and Sparber (2015), for example.

possess manual skills could be helped by policy to adjust to immigration by moving toward occupations demanding more communication work.

Among workers with a bachelor's degree or more education, occupational changes reduced the potential wage gains by about 55%. This sizable reduction is due to the somewhat puzzling result that highly-educated natives reduce their communication skill use in response to immigration. Wage gains still occur, though they arise from technological spillovers or other channels not discussed in this paper.

6. Conclusions

This paper adopted a national-approach to estimating the partial equilibrium wage effects of immigration on native-born men within education and experience groups. Many papers have criticized assumed elasticities of substitution required for converting partial equilibrium estimates into general equilibrium effects. We steer away from that debate and instead focus on a narrow set of questions about the partial equilibrium results themselves. First, we reemphasize a point briefly discussed in Borjas (2003) but sometimes neglected elsewhere: The within-group wage effects vary by level of educational attainment. Losses only appear among workers with little educational attainment. Natives with a bachelor's degree or more education experience within-group wage gains from immigration. This implies that even within a general equilibrium setting that assumes no complementarities across groups, losses do not occur within the most educated sectors of the economy. Such results are conceivable in the context of work arguing that highly-educated immigrants contribute to productivity advancement and skill biased technological change, but contrast with Borjas (2003, 2013) findings that highly-educated native groups are among the groups most negatively affected by immigration.

Our second point of emphasis is on the native occupational skill response to immigration. Imperfect substitutability between native and foreign-born workers within education and experience cells can be manifested through differential representation across occupations demanding varied skills. Native-born workers disproportionately work in communication-intense jobs. For most education levels, immigrants provide more manual skills. Among the highest education levels, emphases shift, and natives have a comparative advantage in manual work versus quantitative work compared to immigrants.

Most of the skill response results corroborate existing evidence from spatial analysis. Immigration causes less-educated natives to perform more communication and quantitative work, but less manual work. Since the rate return of return paid to the former skills exceeds that of the latter, the skill response helps native-born workers protect themselves from labor market competition with immigrants. Within-cell wage losses are at least 20% lower than they would be in a world of perfect

substitution between foreign and native workers, even before accounting for potential complementarities across education and experience groups. Highly-educated workers, in contrast, demonstrate an anomaly: despite their comparative advantage in communication-based occupations, immigration causes them to provide fewer communication skills. This reduces their wage gains from what would otherwise be predicted to occur, though the partial equilibrium wage effects from immigration remain positive for college-educated workers.

Altogether, the paper provides important insight into the economic debate on the wage consequences of immigration. Despite the national-approach's increased likelihood of finding severe deleterious wage effects of immigration, we demonstrated that such effects do not exist among all education groups. Moreover, occupational skill response helps mitigate wage losses from native-born groups at low levels of educational attainment.

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Table 1

The Wage Effect of Immigration within Education*Experience Cells

	Dependent Variable: ln(Weekly Wage Paid to Men)			
	(1)	**(2)**	**(3)**	**(4)**
Excluded Cells:	*NA*	*NA*	*HS Dropouts*	*HS Dropouts & Graduates*
Selection for Independent Variable:	*Borjas Count*	*Skill Defined*	*Skill Defined*	*Skill Defined*
Selection for Dependent Variable:	*Borjas Wage*	*Borjas Wage*	*Borjas Wage*	*Borjas Wage*
Foreign Share of Labor Force	-0.528***	-0.545***	-0.551	-0.047
	(0.102)	(0.107)	(0.405)	(0.328)
Constant	6.686***	6.952***	6.971***	7.170***
	(0.048)	(0.041)	(0.017)	(0.064)
Observations	240	240	192	144
R-squared	0.998	0.998	0.997	0.997
Selection for Dependent Variable:		*Skill Defined*	*Skill Defined*	*Skill Defined*
Foreign Share of Labor Force		-0.434***	-0.293	0.116
		(0.139)	(0.327)	(0.253)
Constant		6.948***	6.971***	7.152***
		(0.051)	(0.017)	(0.063)
Observations		240	192	144
R-squared		0.998	0.997	0.997

Note: Unit of observation is 5 education group * 8 experience group * 6 decade cells. Table entries represent different estimates of the within-cell effect of the foreign-born labor share on the log-wage paid to men using alternative sample-selection criteria defined in the text. Column (1) replicates Borjas (2014). "Borjas Wage" selection criteria for the explanatory variable include men and women. "Skill Defined" selection criteria include men only. All models include a full array of fixed effects for education, experience, year, and their two-way interactions. Cluster robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 2

The Wage and Occupational Skill Effect of Immigration within Education*Experience Cells and Education Group

Dependent Variable:	(1) ln(Weekly Wage)	(2) ln(Manual)	(3) ln(Communication)	(4) ln(Quantitative)
Foreign Share of Male Labor Force	-0.515***	-0.089	0.267***	0.232**
	(0.148)	(0.107)	(0.087)	(0.090)
Foreign Share * Some College or More Education	0.955***	0.913***	-1.083***	-0.895***
	(0.184)	(0.141)	(0.108)	(0.092)
Foreign Share of Male Labor Force	-0.668***	-0.218*	0.387***	0.312**
	(0.146)	(0.123)	(0.113)	(0.116)
Foreign Share * Bachelors Degree or More Education	1.156***	1.019***	-1.047***	-0.771***
	(0.165)	(0.139)	(0.133)	(0.100)

Note: Unit of observation is 5 education group * 8 experience group * 6 decade = 240 cells. Table entries represent estimates of the within-cell effect of the foreign-born male labor share on the log-wage and occupational skills of men by educational attainment. All models include a full array of fixed effects for education, experience, year, and their two-way interactions. Cluster robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3

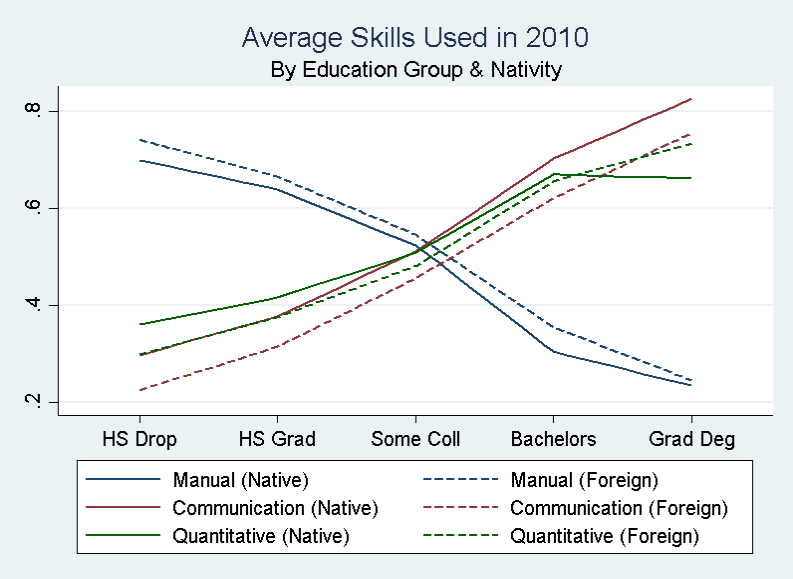
Average Within-Cell Changes due to Immigration: Observed, Estimated, and Simulated Figures

	Average Within-Cell Changes between 2000 and 2010 due to Immigration				
Education Group	**Foreign-Born Share**	**ln(Wage)**	**ln(Wage) from Skill Changes**	**Counterfactual ln(Wage) without Skill Changes**	**% Reduction in Skill Magnitude due to Skill Changes**
High School Dropouts	0.147	-0.098	0.024	-0.122	-0.197
High School Graduates	0.060	-0.040	0.010	-0.050	-0.203
Some College	0.027	-0.018	0.006	-0.024	-0.254
Bachelor's Degree	0.032	0.015	-0.019	0.034	-0.548
Advanced Degree	0.037	0.018	-0.025	0.043	-0.575

Note: Estimates computed using observed average changes in foreign-born share, estimated wage and skill changes from the bottom panel of Table 2, and the rates of return to skills displayed in Figure 3.

Figure 1

Average Skill Use by Education Group and Nativity in 2010



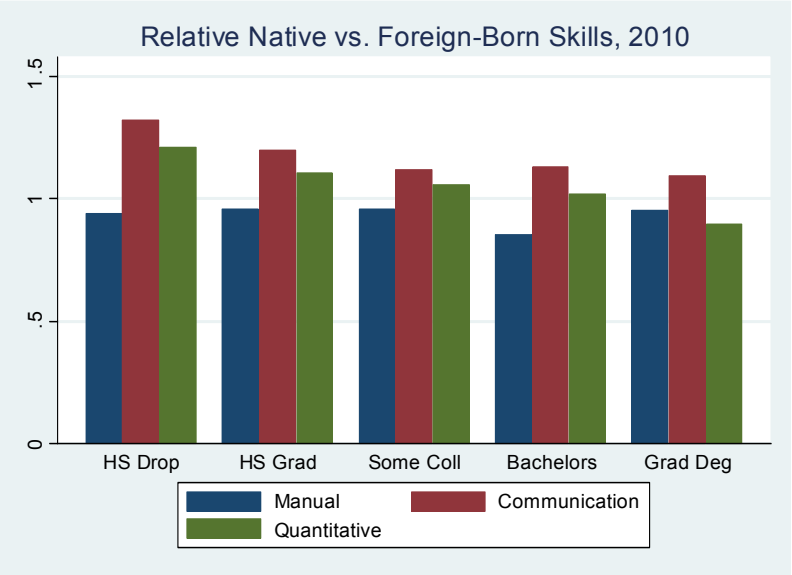


Figure 2

Average Wage by Skill Decile of Overall Workforce and within Education Group in 2010

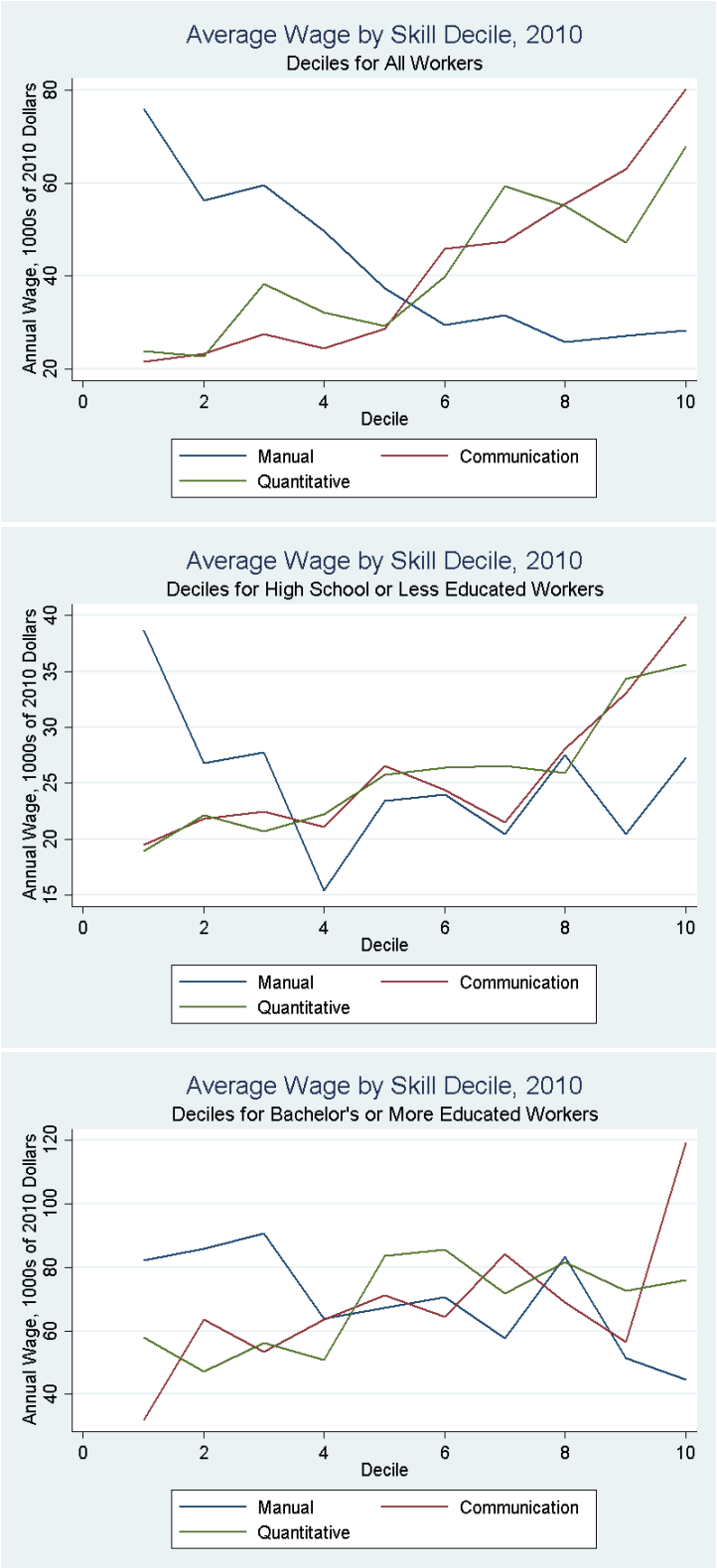
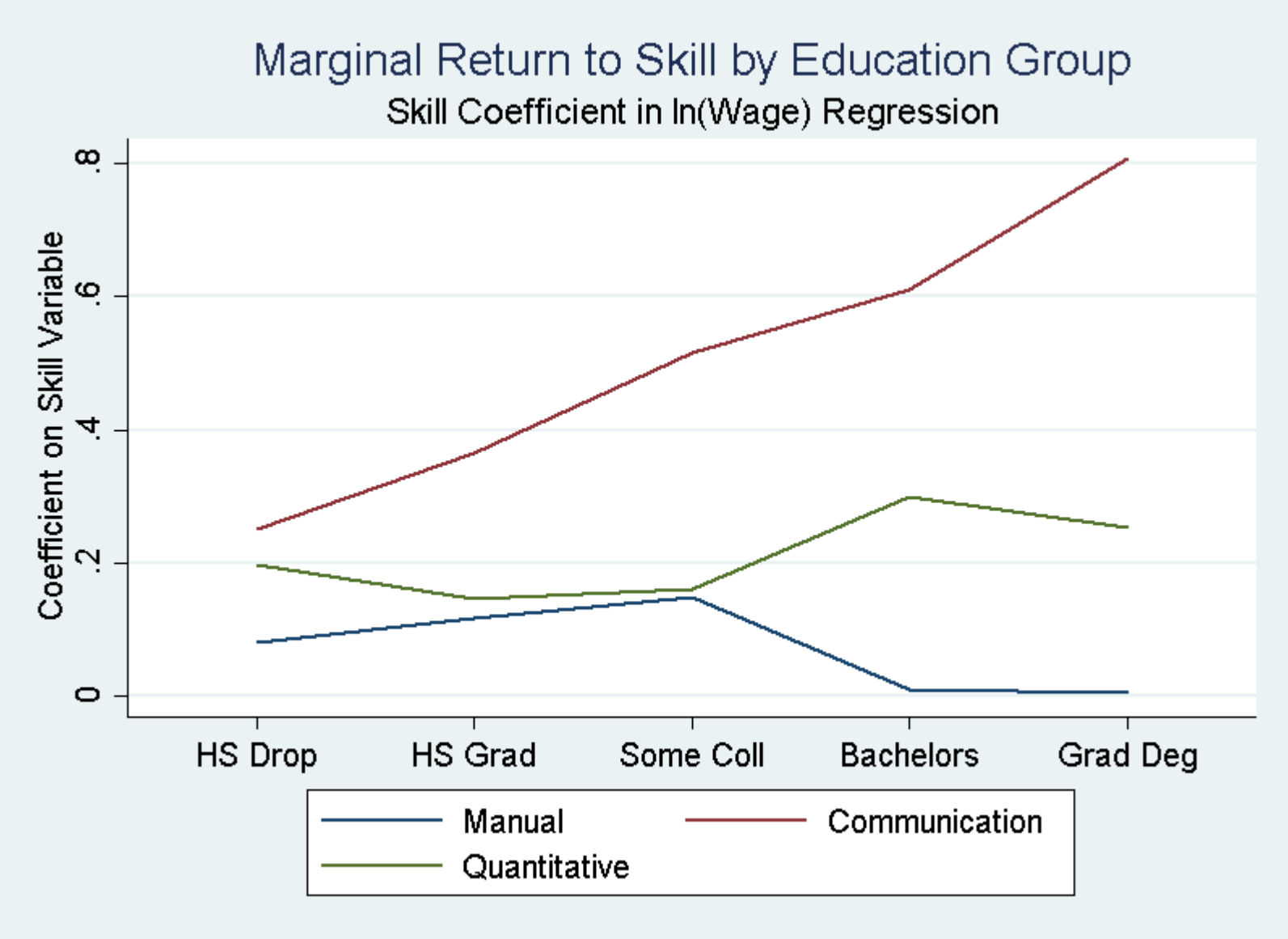


Figure 3

Marginal Return to Skills in ln(Wage) Regression



Appendix Table A1

Census Observations Included According to Various Sample Selection Criteria

Census Variable	**Borjas Count**	**Borjas Wage**	**Skill Defined**
Group Quarters	Not in GQ	Not in GQ	Not in GQ
Age	Age 18-64 (inclusive)	Age 18-64 (inclusive)	Age 18-64 (inclusive)
Experience	1-40 years (inclusive)	1-40 years (inclusive)	1-40 years (inclusive)
Gender	All	Male	Male
Hours Worked	All	Positive & Defined	Positive & Defined
Weeks Worked	All	Positive	Positive
School Attendance	All	Not Enrolled	Not Enrolled
Wage	All	Positive	Positive
Sample Weights	All	All	Positive & Defined
State	All	All	Identified
Employment Status	All	All	In Labor Force
Industry	All	All	In identified non-military
Occupation	All	All	In identified non-military with measured skills