Creation or Destruction? STEM OPT Extension and Employment of Information Technology Professionals

Xue Guo
Temple University, xueguo@temple.edu

Jing Gong
Lehigh University, jig319@lehigh.edu

Min-Seok Pang
Temple University, minspang@temple.edu

Creation or Destruction? STEM OPT Extension and Employment of Information Technology Professionals

Completed Research Paper

Xue Guo
Temple University
1801 N Broad St,
Philadelphia, PA 19122
xueguo@temple.edu

Jing Gong
Lehigh University
27 Memorial Dr W,
Bethlehem, PA, 18015
jig319@lehigh.edu

Min-Seok Pang
Temple University
1801 N Broad St,
Philadelphia, PA 19122
minspang@temple.edu

Abstract

Information technology (IT) professionals play an important role in the U.S. economy by facilitating IT investments, development, and innovation. The use of temporary work visas and related immigration policies that import foreign IT professionals has attracted significant policy debates. On the one hand, foreign IT professionals may *complement* domestic IT professionals by facilitating local innovation and expanding local employment. On the other hand, foreign professionals may *substitute* the domestic counterparts by intensifying labor-market competition and decreasing wage. This study focuses on Optional Practical Training (OPT) extension program for graduates in science, technology, engineering, and mathematics (STEM) from U.S. institutions, a policy change which greatly increases the supply of foreign IT professionals in local labor markets. Specifically, we explore (1) the effects of the OPT extension on the number and wage of domestic workers in STEM occupations and (2) how the effects may differ between IT and non-IT STEM occupations. We test the effects using a novel dataset that is merged from several sources and use a difference-in-differences model to bring identification. Our results demonstrate that an increase in the supply of foreign IT professionals as a result of the OPT extension boosts employment for domestic IT professionals. The unique characteristics of IT human capital differentiate the impacts on IT occupations from non-IT STEM occupations. This study contributes to the information systems, labor economics, and public policy literature by quantifying the impacts of a policy change on the supply and return of IT professionals and provides rich implications for policymakers.

Keywords: IT human capital; high-skilled immigration; OPT extension; STEM; local IT employment; sanctuary jurisdictions

Introduction

Skilled information technology (IT) professionals play a critical role in the U.S. economy by facilitating technology formation, development, and innovation (Bresnahan et al. 2002, Kleis et al. 2012, Mithas and Krishnan 2008). The growth in the information economy and digital business exacerbates the need for skilled IT professionals (e.g., Ang and Slaughter 2001, Mithas et al. 2011). To address the shortage of IT professionals (Ang et al. 2002), the U.S. government uses temporary work visa programs (e.g., H-1B) and related immigration policies to allow foreign high-skilled workers to enter the U.S. labor market. These working visas and related policies have been a controversial topic for policy debates (e.g., Kerr et al. 2015). On the one hand, the supply of foreign professionals may reduce the shortage for high-skilled workers, help firms gain competitive advantages, and promote overall economic growth (Peri et al. 2015). This may even generate a spillover effect by expanding the employment of domestic workers (e.g., Audretsch and Feldman 1996). On the other hand, foreign high-skilled workers may reduce firms' internal labor costs and potentially displace domestic workers (e.g., Hira 2010, Matloff 2013). Thus, it is important for policymakers to understand the impact of foreign high-skilled professionals on domestic labor markets.

Seeing that the supply of foreign high-skilled workers is highly dependent on federal immigration policies and legislative actions (Mithas and Lucas 2010), the goal of this study is to examine how one of these immigration policies—an extension in the Optional Practical Training (OPT) program for foreign students in science, technology, engineering and mathematics (STEM) majors—affects local labor markets. OPT is a temporary employment program that allows foreign students with F-1 student visas to work in the U.S. after completing their academic studies, so that they can get practical training related to their field of study.[1] Before 2008, eligible foreign students could apply for up to 12 months of OPT employment authorization. In 2008, this temporary employment period was extended to 29-month for foreign students in STEM-related majors and was further extended to 36-month in 2016.

The STEM OPT extension policy, which provides flexibility for foreign students to work in the U.S. and thus increases the supply of foreign high-skilled workers, is likely to significantly influence local labor markets. Hence, we aim to assess the effect of the STEM OPT extension on the employment of domestic workers in IT and other STEM occupations. We also examine whether IT occupations are affected by the policy differently from other STEM occupations. In particular, we ask the following research questions:

1) What are the effects of the STEM OPT extension on the employment (i.e., number and average wage) of domestic workers and all workers (domestic and foreign combined) in the local labor markets?
2) How do the above effects differ by occupations (IT versus non-IT STEM)?

To examine the effect of the STEM OPT extension, we build upon the literature on IT human capital (Ang and Slaughter 2001, Mithas and Lucas 2010) and labor economics (Boh et al. 2007, Borjas 1989, Friedberg and Hunt 1995). Specifically, we propose two opposing effects—*substitution* and *complementarity*—of the STEM OPT extension, an exogenous shock that increases the number of foreign STEM workers, on the employment of domestic workers. In particular, the effects of the STEM OPT extension on local employment depend on the relationship between foreign and domestic workers. On the one hand, if foreign and domestic workers possess similar skills and knowledge, it would be indifferent to employers to hire the two types of workers. As a result, the inflow of foreign workers may hurt the employment of domestic workers. On the other hand, if two types of workers possess different skill and knowledge sets, they may complement each other. As a result, the greater inflows of foreign workers may boost the demand for domestic workers. Our study further explores the unique characteristics of IT professionals as human capital and how these aspects come into play in the effect of STEM OPT extension. IT professionals have both technology and business competence, which can be applied to a majority of the firms (Bharadwaj 2000). Furthermore, IT professionals play a central role in innovation and entrepreneurial activities. Hence, the introduction of the STEM OPT extension may have different effects for IT and non-IT STEM workers.

To answer these research questions, we construct a novel dataset merged from various sources including the U.S. Census Bureau, the U.S. Citizenship and Immigration Service (USCIS), and the O*Net database. Our panel dataset is at the occupation-MSA-year level. It contains detailed information about workers' employment status, occupation, wage, birthplace, citizenship, education, and so on in 2005–2016. For identification, we exploit changes across occupations over the 2005-2016 period brought by the STEM OPT extension policy. We use a difference-in-differences (DID) model to explore the effect of the policy on the employment of domestic workers as well as total workers. In addition, we divide STEM workers into two

[1] For more information about OPT, please refer to the USCIS website: https://www.uscis.gov/opt (accessed March 26, 2019).

categories – IT and non-IT STEM – and explore the differential effects of the policy on these two categories. We also conduct a series of robustness checks including a relative time model, alternative measures for the dependent variables, alternative measures, subsample analyses, count models, and exclusion of outliers.

Our empirical analyses yield several notable findings. First, we find that the extension of STEM OPT significantly increases the number of all and domestic workers in the local labor markets, while there is little significant effect on the average wage. This suggests that foreign high-skilled workers complement the need for domestic workers in the local labor markets, rather than substituting them. Second, we find that the STEM OPT extension policy has a stronger positive effect on the number of workers in IT occupations than non-IT STEM occupations. In addition, the policy significantly increases the average wage for domestic workers in IT occupations, a finding that suggests a complementary relationship between high-skilled foreign and domestic professionals in IT occupations. We also explore the role of occupational characteristics in the impact of the STEM OPT extension. Our results suggest that the inflow of foreign workers with quantitative and analytic skills increases the number of domestic workers with communication and interactive skills, corroborating our argument that foreign IT professionals complement workers that possess different skills.

Our study makes several contributions. First, our study contributes to the IS literature by differentiating the human capital of IT and non-IT STEM workers. Our study demonstrates that the STEM OPT extension has a stronger complementary effect on IT workers than non-IT STEM workers, offering new insights into the unique aspects of IT human capital. Second, our study contributes to the literature on labor economics by theorizing and examining the effects of the new immigration policy—STEM OPT extension—on the local labor markets. Specifically, our study examines the heterogeneous effects of STEM OPT extension by occupational characteristics, which help us better understand the mechanism of the complementary effects.

Our findings have important managerial and policy implications. From an organization perspective, understanding the relationship between foreign and domestic high-skilled workers directly help firms evaluate the value of foreign IT professionals and how to leverage diverse human capitals to improve productivity and innovation capabilities. From a policy perspective, the finding that the STEM OPT extension policy has a complementary effect on local employment have direct implications for policymakers to design more effective immigration policies.

Background and Theory

Foreign STEM Workers in the United States

The globalization of work increases the international mobility of labor, and developed countries are more likely to attract foreign workers (Mithas and Lucas 2010). More than 1.5 million immigrants enter the U.S. every year (Salzman et al. 2013). While a large number of foreign workers have significantly lower skills than domestic workers (Borjas 2001), some immigrant workers are highly skilled (Kerr et al. 2015), a fact that is of critical importance to the U.S. (Kerr et al. 2015). In this study, we focus on the impact of foreign high-skilled (with a bachelor's degree or above) workers in STEM occupations.

One major path for high-skilled foreign workers to enter the U.S. labor market is through education and temporary work visas (Borjas 2005). Figure 1 outlines a typical path for foreign students to enter the U.S. labor market (Salzman et al. 2013). Foreign students graduating from U.S. institutions are eligible to apply for Optional Practical Training (OPT) to work in the U.S. The OPT program is a type of temporary employment authorization that allows foreign students with an F-1 student visa to work after completion of their academic studies, so that they get practical training related to their field of study. During the OPT period, employers could sponsor H-1B visas for foreign employees. Then, foreign workers with H-1B visas could apply for permanent residency ("green card"), which is a prerequisite for the U.S. citizenship application (Doran et al. 2014).

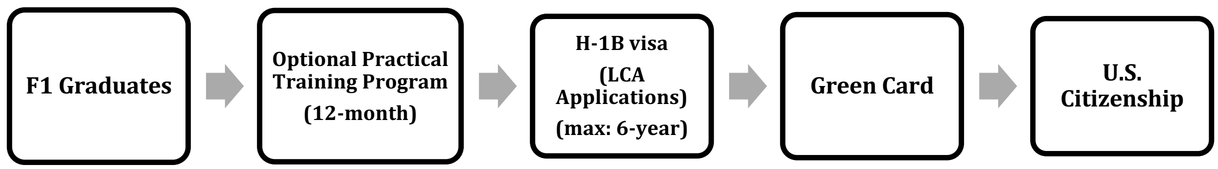


Figure 1. A Typical Path for Foreign Workers to Enter the U.S. Labor Market

Table 1 presents the detailed OPT extension changes and the affected occupations.[2] Before 2008, eligible foreign students could apply for up to 12 months of OPT employment authorization. Since 2008, this temporary employment period was extended to 29-month for those in STEM-related majors, and it was further extended to 36-month in 2016.

The STEM OPT extension has increased the supply of foreign workers in two ways. First, this policy provides foreign students more time and flexibility to look for jobs or work in the U.S. OPT does not require the graduates to have a job offer to apply, and they could work for different employers during the period. Hence, extending this temporary employment period increases their chance to find permanent jobs. Second, the OPT extension attracts a greater number of prospective foreign students to enroll in U.S schools. Figure 2 shows that the number of foreign students graduating from U.S. colleges and obtaining OPT to work in the U.S. has been consistently growing after the OPT period was extended, and this increase is more salient for STEM fields than it is for non-STEM fields.

Table 1. STEM OPT Extension Policy Change

OPT Extension	Before 2008	April 2008	2011	2012	March 2016
OPT Period	12-month	29-month	29-month	29-month	36-month
Occupations	All occupations	100 STEM occupations	147 STEM occupations	163 STEM occupations	163 STEM occupations

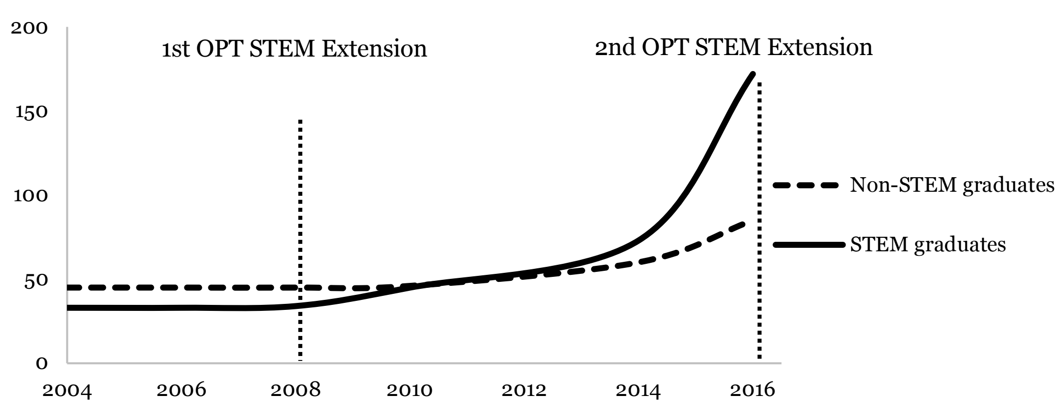


Figure 2. Number of OPT Approvals From 2004-2016, in Thousands

Foreign High-Skill Workers and Local Labor Market Outcomes

The labor economics literature has examined various effects of foreign high-skilled workers on local labor markets and the relationship between foreign and domestic workers (e.g., Kerr and Lincoln 2010, Peri et al. 2015). One stream of research argues that high-skilled foreign workers *substitute* domestic workers (e.g.,

[2] http://www.pewglobal.org/2019/01/22/majority-of-u-s-public-supports-high-skilled-immigration/

Card 1990, Friedberg and Hunt 1995, Matloff 2013). There are two possible explanations for this effect. First, an increase in the supply of foreign workers intensifies labor-market competition and reduces overall wage. For instance, Borjas (2006) finds that the increased supply of foreign workers reduces the wage for domestic workers. Second, the cost of hiring foreign workers is often lower than hiring domestic ones, allowing firms to minimize their internal labor costs (e.g., Hira 2010). For instance, Matloff (2004) finds that firms pay high-skilled foreign workers, on average, 15%-33% less than "comparable" U.S. professionals. Thus, an increase in incoming foreign high-skilled workers may "crowd out" domestic workers from the local labor market.

In contrast, another stream of literature argues that foreign workers *complement* the demand for domestic workers since they possess a different set of skills and knowledge. A number of studies demonstrate that an inflow of high-skilled foreign workers facilitates innovation and enhances productivity, expanding the size of labor markets (e.g., Kerr and Lincoln 2010, Peri et al. 2015). Kerr and Lincoln (2010) finds that a 10% growth in the H-1B workers is associated with a 0.3%-0.7% increase in the total number of inventions. In addition, studies show that labor diversity with different cultural backgrounds also leads to higher innovation activities locally (e.g., Parrotta et al. 2014). According to the view of agglomeration economies (e.g., Kerr 2010), the increased innovation and productivity growth in an area attracts more firms to locate nearby and expands the demand for local workers in the area (Kerr and Lincoln 2010).

Building on labor economics literature, our study theorizes the impact of foreign IT workers on the local labor markets in terms of the number of workers and average annual wage. While the majority in this stream of research focuses on high-skilled foreign workers in general (e.g., Borjas 2005), our study extends this literature by focusing on the unique aspects of IT human capital in the relationship between foreign and domestic workers.

Unique Value of IT Human Capital – How IT Workers Differ from Non-IT STEM Workers?

The information systems (IS) literature has demonstrated the crucial value of IT professionals in firm productivity and economic growth (e.g., Aral et al. 2012, Tambe and Hitt 2012). Prior IS studies (e.g., Bassellier and Benbasat 2004, Bharadwaj 2000) propose two types of unique competences of IT professionals—technical and business competences—that distinguish IT professionals from other STEM workers fundamentally (Josefek and Kauffman 2003). Technical competence refers to technical knowledge and skills that enable IT workers to design and maintain information systems Bharadwaj 2000). Business competence refers to business-specific knowledge and interpersonal skills that enable IT workers to understand business domains and communicate with their business partners (Bassellier and Benbasat 2004). Business domain knowledge enables IT workers to see the "big picture" of IT in an organization (Bassellier and Benbasat 2004), and interpersonal and management knowledge enables them to develop knowledge network and participate in social interactions (Gorgone et al. 2003). Hence, it is costly for firms to replace IT workers with strong technical and business competences, which makes IT human capital uniquely valuable (Barney 1991).

IT professionals are different from other non-IT STEM professionals in three ways. First, IT human capital can be utilized by almost all firms and is valuable to virtually all industries. IT workers have both general and firm-specific experience (Josefek and Kauffman 2003). General IT work experiences, which include knowledge of programming languages, database, and telecommunication technologies, are standard and valuable to the majority of firms. Firm-specific IT experiences, such as knowledge of a firm's control processes or specific software development methodology, are also valuable to other firms since IT professionals could bring diverse and new knowledge that the other firms do not have (Mithas and Krishnan 2008). Hence, IT professionals have higher flexibility to move among firms locally (Dahl and Sorenson 2010). By comparison, a labor market is less flexible for many non-IT STEM occupations (e.g., biochemists, aerospace engineers) than for IT professionals. For instance, biochemists mainly work in pharmaceutical or biotechnology industries. Aerospace engineers are unlikely to have much value to industries other than the aerospace. On the other hand, IT professionals could work in both IT (e.g., software and hardware) and non-IT industries (e.g., banking and insurance).

Second, IT human capital plays an important role in building the IT-business relationship (Bassellier and Benbasat 2004), which in turn helps firms grow and gain competitive advantages (Aral et al. 2012). IT workers with business competence can better understand business domains, partners in business units, and key strategic planning processes (Reich and Benbasat 2000) and build a successful relationship with business units (Gorgone et al. 2003). For instance, extant studies find that IT professionals' business competence significantly influences their intentions to develop and strengthen partnerships with their clients (Bassellier and Benbasat 2004, Reich and Benbasat 2000). Hence, a strong IT human capital that facilitates the business relationship building promotes firms' growth and expansion, which may in turn increase local employment. In other words, skilled IT professionals have greater opportunities to directly contribute to firms' bottom lines than other non-IT STEM professionals.

Third, IT human capital facilitates product and process innovations (e.g., Kleis et al. 2012), which lead firms to devote more resources to R&D that expand local employment (Kerr and Lincoln 2010). Prior literature contends that R&D capital of a firm's R&D capital is largely embodied by its human capital (e.g., Banker et al. 2008, Chan et al. 2007). High-skilled IT workers directly contribute to the firm's innovation capabilities and facilitates the innovation activities of other STEM workers (e.g., scientists, engineers) (Chan et al. 2007, Kleis et al. 2012).For example, IT professionals create infrastructures for capturing and sharing knowledge needed for innovation processes such as new search engines and data mining techniques (Bharadwaj 2000), help firms generate new product ideas through customer relationship management (CRM) systems (Mithas et al. 2005), and provide networks and communication applications to enable collaboration of geographically dispersed teams (Forman and Zeebroeck 2012). Particularly, rapid development in IT and the rise of the Internet and web-based business make the role of IT in the innovation process more important than before (e.g., Ang et al. 2002). For example, a study finds that a 10% increase in IT investments is associated with a 1.7% increase in innovation output (Kleis et al. 2012).

In sum, the unique aspects of IT professionals as a human capital distinguish them from other non-IT STEM professionals. Building on this line of the literature, our study explores the impact of unique human capital characteristics in foreign IT professionals. Based on economic theories that examine high-skilled human capital (e.g., Borjas 1989, Friedberg and Hunt 1995), we propose two opposing effects of the STEM OPT extension—substitution and complementary.

Substitution Effects of Increased Supply of New Foreign IT Workers

Foreign IT professionals substitute the need for domestic IT professionals if they possess similar skills, as it would be indifferent to employers to hire either type of workers for a given position (Mithas and Lucas 2010). The STEM OPT extension policy is a supply shock that brings a greater number of foreign IT professionals to local labor markets. However, it does not mean that it opens a door for U.S. employment for any foreign workers. Rather, the OPT program serves as a restrictive screening process that brings high-skilled workers (e.g., Kerr et al. 2015), as it only applies to foreign students who have earned a bachelor's degree or higher in U.S. institutions and can stay in the U.S. only if they find an employer in fields related to their majors in the U.S.[3] Hence, only skilled and capable foreign workers can be hired and work in the U.S. in this process (e.g., Mayda et al. 2017), while low-skilled foreign workers are unlikely to successfully go through this process. These foreign IT professionals are strong competitors to domestic IT workers in local labor markets. Therefore, the increase in the supply of high-skilled foreign IT professionals, brought by the STEM OPT extension, may reduce opportunities for domestic IT professionals and drive down wages for all in the IT occupations.

Complementary Effects of Increased Supply of New Foreign Workers

Foreign IT professionals complement the demand for domestic IT professionals if they possess different skills or if they increase the overall demand for IT professionals in the labor market. We here discuss the unique human capital characteristics of foreign IT professionals that play a role in expanding the labor market of IT professionals. In this way, the STEM OPT extension can increase the employment and wage of domestic IT professionals.

[3] https://www.uscis.gov/working-united-states/students-and-exchange-visitors/students-and-employment/stem-opt

First, foreign IT professionals possess knowledge and cultural backgrounds outside the U.S., which help firms build business relationships with oversea operations/partners for global expansion and competitive advantages (Bassellier and Benbasat 2004). Thanks to the strict screening process, these new foreign IT workers are highly skilled and can contribute to relationship building by developing, operating, and supporting enterprise systems that enable successful interactions with overseas operations (Bharadwaj 2000). Specifically, foreign IT professionals have advantages in understanding foreign clients or vendors requirements, which further facilitate the relationship with overseas partners. In addition, foreign IT professionals are often willing to travel and work overnight, providing flexibility for firms to manage their human resources (Krishna et al. 2004) and enhancing productivity (Gorgone et al. 2003). With expansion and growth, firms need more local IT professionals on site to transfer and connect to different geographic locations (Espinosa et al. 2007). Hence, foreign IT professionals can increase the need for domestic IT professionals.

Second, foreign IT professionals generate higher labor diversity, which promotes innovative activities by enlarging breadth of knowledge, fostering the diffusion of knowledge, and providing better problem-solving methods and valuable ideas (e.g., Bonin 2017). Foreign IT professionals can promote the role of IT in innovation activities by providing business and social knowledge outside the U.S. (e.g., Berliant and Fujita 2009). Thus, the increased number of foreign IT professionals can lead to the employment of more domestic IT professionals for collaboration in innovation activities. Furthermore, increased innovative activities in an area can generate spillover effects and attract more firms to locate nearby to benefit from the positive effects.

Third, foreign IT professionals are more likely to take risks, have stronger motivations, and can learn and adapt to new situations quickly (Bonin 2017), leading to more vibrant entrepreneur activities. Mithas and Lucas (2010) contents that people who choose to migrate need to overcome a series of challenges caused by differences in cultures and environment. Hence, migration to seek better work opportunities has been touted as an important aspect in human capital (Schultz 1961). Prior studies show that foreign high-skilled workers carry more skills necessary to become a successful entrepreneur such as the willingness to take risks and invest in new skills (Duleep et al. 2012). For startup entrepreneurs, IT human capital is an important investment to boost the chance of survival (Melville et al. 2004). A survey of high technology startups shows that 25% of the new high-tech companies founded between 1995 and 2005 have at least one immigrant founders in Silicon Valley (Wadhwa et al. 2008). Hence, the inflow of foreign IT workers may increase the entrepreneurial activities and in turn expand the demand for domestic IT workers.

In sum, our study theorizes two opposing effects of the STEM OPT extension on the local employment—substitution and complementary. In addition, we propose that owing to the unique human capital aspects of IT professionals, the effects of the STEM OPT extension may different for IT and other STEM workers. IT human capital can be leveraged by the majority of firms, and foreign IT workers facilitate business-IT relationship building, enable international expansion, promote innovation, and boost entrepreneurial activities. Hence, if the STEM OPT extension complements the number and wage of the domestic workers, the effects would be stronger for IT than other STEM workers.

Empirical Analysis

Data

We construct a longitudinal dataset (2005-2016) from four major sources. First, we acquire local employment information from the Integrated Public Use Microdata Series (IPUMS) from the U.S. Census Bureau, the largest publicly available census of individual-level microdata in the U.S. The dataset includes individual-level information about employment status, occupation, wage, income, location, birthplace, citizenship, education, and race. This micro-level dataset covers 1% of the U.S. population each year. This dataset has been widely used in the labor economics (e.g., Kerr and Lincoln 2010) and the IS literature (e.g., Burtch et al. 2018) to explore issues related to immigration and local employment. Second, we obtain MSA-level demographic data from the American Community Survey. Third, we obtain detailed information on the STEM OPT extension and associated STEM occupations (Table 1) from the USCIS. Lastly, we obtain data on occupational skills and abilities from O*NET Database.

In total, our dataset contains 490 occupations in 290 MSAs that has been consistently identified in the 12-year panel period (2005-2016). The unit of analysis is at the occupation-MSA-year level. We divide occupations into three groups – 1) non-STEM occupations as the control group, (2) IT and (3) non-IT STEM occupations as treatment groups. The categorization of STEM occupations is based on information provided on the USCIS website.[4] Following Mithas and Lucas (2010), we categorize 13 occupations[5] as IT occupations. We classify workers' nationality based on the country of birthplace. Specifically, we classify workers who are U.S. citizens at birth as domestic workers. All others who were not born as citizens are classified as foreign workers.[6]

Variable Definition

Dependent variables. The dependent variables are the number and average annual wage of all workers and domestic workers. We categorize all workers into domestic and foreign workers, the former of whom are those who were born as U.S. citizens. We are primarily interested in the effects of the STEM OPT extension on all and domestic workers. Following prior literature (e.g., Kerr and Lincoln 2010, Peri et al. 2015), we use the natural log to address the problem of non-normal distributions and interpret coefficients as a percentage change. The unit of annual wage is in the year 2016 inflation-adjusted dollars.

Independent variables. Our main independent variable is a dichotomous indicator, $OPTExtension_{it}$, indicating whether the OPT extension was applicable to occupation i in year t. Specifically, $OPTExtension_{it}$ equals one for STEM occupations in and after the implementation year of OPT extension. In other words, the STEM occupations are in a treatment group, and all the other occupations are in a control group. Further, we use the number of months for employment authorization by OPT as an alternative independent variable as a robustness check. Another independent variable is $ITOccupations$, a dichotomous indicator that equals one for IT occupations. We use this variable to estimate the differential effects of the STEM OPT extension on IT and non-IT STEM occupations.

Control variables. In addition to the above variables, we include a set of MSA-level demographic and economic factors as control variables. In particular, we include population, educational attainment, average income in 2016 adjusted dollars, the ratio of female in population, the ratio of the population not in the labor force, unemployment rates, and gross domestic product (GDP) for each occupation. Specifically, the control variable, GDP for each occupation, serves as a proxy for the MSA level demand for each occupation. The detailed definition and summary statistics for the key variables are presented in Table 2.

Specifically, the control variable, GDP Occupation, is generated by combining two datasets—annual GDP by MSA7 and the industry-occupation matrix.8 The annual GDP dataset provides the measure of GDP in the MSA-industry unit, and the industry-occupation matrix provides the percentage of employment of a specific occupation in each industry. We multiply these two measures to generate estimated GDP in the MSA-occupation-year unit. This variable calculates the weighted average GDP for each occupation in each MSA, which serves as a good proxy for the time-varying MSA-level demand for each occupation and enables us to control the time-varying occupation trends in the local labor markets.

Table 2. Summary Statistics of Key Variables

Variables	Definition	Mean	SD	Min	Max
Number workers	Total number of workers	1,841	6,751	1	375,725
Number domestic workers	Total number of domestic workers	1,425	4,661	1	276,513
Average wage	Average annual wage for all workers	43,562	36,139	1.01	773,021
Average wage domestic	Average annual wage for domestic workers	43,879	36,759	1.01	773,021

[4] https://www.uscis.gov/working-united-states/students-and-exchange-visitors/students-and-employment/stem-opt
[5] The 13 categories of IT jobs include computer and information systems managers, computer and information research scientists, information security analysts, computer programmers, software developers (applications), software developers (systems software), web developers, database administrators, network and computer systems administrators, computer network architects, computer user support specialists, computer network support specialists, computer occupations (all other).
[6] https://www.census.gov/topics/population/foreign-born.html
[7] https://www.bea.gov/data/gdp/gdp-metropolitan-area
[8] https://www.bls.gov/emp/tables/industry-occupation-matrix-industry.htm

OPT Extension	An indicator of whether the occupation is affected by the policy	0.10	0.30	0	1
IT Occupation	An indicator of whether the occupation is IT related occupation	0.02	0.15	0	1
Ln(Population)	Log transformation of the total population	13.23	1.15	11.41	16.82
ln(Income)	Log transformation of per capita income	10.65	0.19	10.00	11.69
Education	Percentage of population with an education above a bachelor's degree	0.27	0.08	0.10	0.55
Sex Ratio	Males per 100 females	96.79	3.88	86.60	140
Age Dependency Ratio	The ratio of the population not in the labor force to the population in the labor force (15-64)	60.19	7.62	34	107
Unemployment Rate	Percentage of the population unemployed	0.07	0.03	0.02	0.29
ln(GDP Occupation)	Log transformation of gross domestic product per occupation	11.24	1.58	0	16.21
Sanctuary Jurisdictions	Percentage of the areas have sanctuary laws, practices, and policies	0.05	0.20	0	1
Skill Content	The ratio of quantitative to interactive skill contents of the occupations	0.90	0.11	0.59	1.22

Empirical Model

We use a difference-in-differences (DID) model to empirically test the effect of STEM OPT extension on the number and average wage of local workers. The primary benefit of this method is that it can mimic a natural experiment to examine the treatment effect by comparing average changes in the number and average wage of local workers overtime for STEM occupations as compared to non-STEM occupations. Both economics and IS studies have extensively adopted this approach as an identification strategy (e.g., Angrist and Pischke 2008, Chan and Ghose 2013). Here, the STEM occupations are the treated group, while the non-STEM occupations are the control group. Equation (1) outlines our empirical model.

$$ln(Y)_{ijt} = \alpha_i + \gamma_j + \theta_t + \beta_1 OPTExtension_{it} + \beta_2 Controls_{jt} + \lambda_j t + \varepsilon_{ijt} \quad (1)$$

where $ln(Y)_{ijt}$ represents the log-transformed number or average wage of workers in occupation i, MSA j and year t. α_i, γ_j, and θ_t represent occupation, MSA, and year fixed-effects, respectively, to account for unobserved heterogeneities. $OPTExtension_{it}$ is our main treatment variable. β_1 captures the effect of OPT extension on the number and average wage of all and domestic workers. $Controls_{jt}$ is a group of control variables described above in MSA j and year t. Further, we include λ_j, MSA-specific linear trend of MSA j, to allow each MSA to have a different time trend in the sample period. We use robust standard errors clustered by MSA and occupation.

To empirically examine the different effects of the OPT extension on IT and non-IT STEM workers, we further include an interaction term between OPT extension ($OPTExtension_{it}$) and IT occupations ($ITOccupations$), as in Eq. 2. Specifically, β_4 captures the additional effects of OPT extension on IT workers compared with non-IT STEM workers.

$$ln(Y)_{ijt} = \alpha_i + \gamma_j + \theta_t + \beta_3 OPTPolicy_{it} + \beta_4 OPTExtension_{it} * ITOccupations_i + \beta_5 Controls_{jt} + \lambda_j t + \varepsilon_{ijt} \quad (2)$$

Identification Strategy

The DID model in Eq. 1 allows us to compare how the number and wage of workers in STEM occupations changes after the STEM OPT extension is implemented (as compared with non-STEM occupations). The treatment effect is estimated as the difference in the changes in the dependent variables across the two types of occupations. Specifically, we include occupation- and MSA-specific fixed-effects to control for any time-invariant unobservable factors. Further, the time fixed-effects control for unobserved temporal trends or shocks. In addition, we include MSA-specific linear time trends which allow for varying trajectories in employment across the MSAs.

Although our DID model includes a series of fixed-effects and MSA-specific linear time trends, several concerns need to be addressed. First, it is possible that STEM and non-STEM occupations may follow different trends before the OPT extension, which may bias the estimated effects. To address this issue, we present a leads-and-lags model (relative time model) as a robustness check, which is to check whether there are any pre-treatment differences in the dependent variables between the treatment and control groups. Second, in selecting STEM occupations, the U.S. government may have taken the expected increase in local employment for STEM occupations into account (e.g., self-selection bias). However, to the best of our knowledge, the USCIS chose the STEM occupation list[9] based on the Classification of Instructional Programs from the U.S. Department of Education.[10] This rule out the possibility that the USCIS chose occupations based on future labor market demands. In addition, in all of our estimations, we control for GDP Occupation, measured as GDP for each occupation in the MSA level, which enables us to control for time-varying local demands of each occupation. This alleviates any self-selection concern and assures that the treatment variable ($OPTExtension_{it}$) is orthogonal to the residuals. Section 3.6 presents further robustness checks that address the self-selection concerns. Third, the measurement errors of the dependent variables (e.g., number and average wage) may also lead to a biased estimation. It is worth noting that IPUMS contains consistent variable names, coding schemes, and documentation across all the samples, facilitating the analysis of long-term changes (Ruggles et al. 2019). It has been treated as a creditable source to examine issues related to local employment (e.g., Kerr and Lincoln 2010, Peri et al. 2015). In addition, we do not have a strong reason to believe that measurement errors in the number of workers and average wages from the Census Microdata are systematically different between STEM and non-STEM occupations. To further address the measurement error issue, we replicate the model using alternative data with occupation employment statistics from the Bureau of Labor Statistics.

Results

The main results are presented in Tables 3 and 4. Columns 1 and 3 of Table 3 present the effects of the STEM OPT extension on the number of all and domestic workers, respectively. As seen, the OPT extension is positively and significantly associated with the number of all and domestic workers in STEM occupations. The results suggest that compared to non-STEM occupations, the OPT extension increases the number of all and domestic workers in STEM by 2.5% and 2.2%, respectively. This finding provides credence to the complementary effect from an increase in the supply of high-skilled foreign STEM professionals. Columns 1 and 3 of Table 4 present the effects on the average wage. It appears that the STEM OPT extension does not have significant effects on the average wage of all and domestic workers.

Results also show that the effects of OPT extension differ by occupations—IT and non-IT STEM. First, as seen in Columns 2 and 4 of Table 3, the STEM OPT extension has stronger positive effects on the number of workers in IT occupations than in non-IT STEM occupations for all and domestic workers. The OPT extension increases the number of all and domestic workers by 7.2% and 6.8% in IT occupations compared with 1.6% and 1.4% in non-IT STEM occupations. Second, results in Columns 2 and 4 of Table 4 suggest that the STEM OPT extension has positive and significant effects on the average wage for workers in IT occupations but not for workers in non-IT STEM occupations. The OPT extension increases the average wage of all and domestic workers in IT occupations by 2.7% and 2.5%, respectively.

These effects are driven by the differences in human capital between IT and non-IT STEM workers that we explained in the section about complementary effects. Unlike non-IT STEM workers, IT human capital is valuable to the majority of firms in virtually every industry. Talented foreign IT professionals can contribute to greater firm performance by improving business processes, building stronger IT-business relationships, enabling global expansion, and facilitating innovation. This establishes IT as a strategic contributor to firm performance and competitiveness and leads firms to hire more domestic IT workers. This discussion explains the stronger impact of the STEM OPT extension on IT occupations than on non-IT STEM occupations.

Table 3. DID Estimation of STEM OPT Extension on Number of Workers

DV: ln(number of workers)	(1) All	(2) All	(3) Domestic	(4) Domestic
OPT Extension	0.025***	0.016***	0.022***	0.014**
	(0.004)	(0.005)	(0.004)	(0.005)
OPT Extension × IT Occupations		0.056***		0.054***
		(0.010)		(0.010)

[9] The is accessible at: https://www.ice.gov/sites/default/files/documents/Document/2016/stem-list.pdf

[10] Detailed description of the STEM list selection is provided at 8 CFR 214.2(f) Under 8 CFR 214.2(f)(10)(ii)(C)(2), accessible at: https://www.nafsa.org/_/file/_/amresource/8cfr2142f.htm

ln (Population)	-0.015+	-0.015+	-0.015+	-0.015+
	(0.008)	(0.008)	(0.009)	(0.009)
ln (Income)	-0.087**	-0.087**	-0.134***	-0.135***
	(0.033)	(0.033)	(0.035)	(0.035)
Education	0.227**	0.227**	0.140+	0.140+
	(0.078)	(0.078)	(0.080)	(0.080)
Sex Ratio	0.001+	0.001+	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Age Dependency Ratio	-0.003***	-0.003***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
Unemployment Rate	-0.354***	-0.354***	-0.542***	-0.543***
	(0.100)	(0.100)	(0.103)	(0.103)
ln (GDP Per Occupation)	0.080***	0.080***	0.076***	0.076***
	(0.002)	(0.002)	(0.002)	(0.002)
Observations	959,988	959,988	924,748	924,748
Adjusted R-squared	0.730	0.730	0.709	0.709
Occupation FE	Yes	Yes	Yes	Yes
MSA FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Linear Trend	MSA	MSA	MSA	MSA

Robust standard errors (cluster at MSA and occupation level) in parentheses *** p<0.001, ** p<0.01, * p<0.05

Table 4. DID Estimation of STEM OPT Extension on Average Wage

DV: ln(average wage)	(1) All	(2) All	(3) Domestic	(4) Domestic
OPT Extension	0.005	0.002	0.005	0.001
	(0.005)	(0.004)	(0.005)	(0.005)
OPT Extension × IT Occupations		0.025**		0.024*
		(0.010)		(0.010)
ln (Population)	-0.010	-0.010	-0.009	-0.009
	(0.008)	(0.008)	(0.008)	(0.008)
ln (Income)	0.205***	0.205***	0.205***	0.205***
	(0.035)	(0.035)	(0.036)	(0.036)
Education	0.345***	0.345***	0.344***	0.344***
	(0.082)	(0.082)	(0.085)	(0.085)
Sex Ratio	-0.000	-0.000	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Age Dependency Ratio	0.000	0.000	-0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Unemployment Rate	-0.582***	-0.582***	-0.603***	-0.603***
	(0.104)	(0.104)	(0.109)	(0.109)
ln (GDP Per Occupation)	0.023***	0.023***	0.022***	0.022***
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	917,097	917,097	889,743	889,743
Adjusted R-squared	0.460	0.460	0.459	0.459
Occupation FE	Yes	Yes	Yes	Yes
MSA FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Linear Trend	MSA	MSA	MSA	MSA

Robust standard errors (cluster at MSA and occupation level) in parentheses *** p<0.001, ** p<0.01, * p<0.05

Robustness Checks

Next, we perform a set of tests to establish the robustness of our main results. Table 5 summarizes the robustness checks. Because of the page limit, we only provide the detailed explanation for the relative time model.

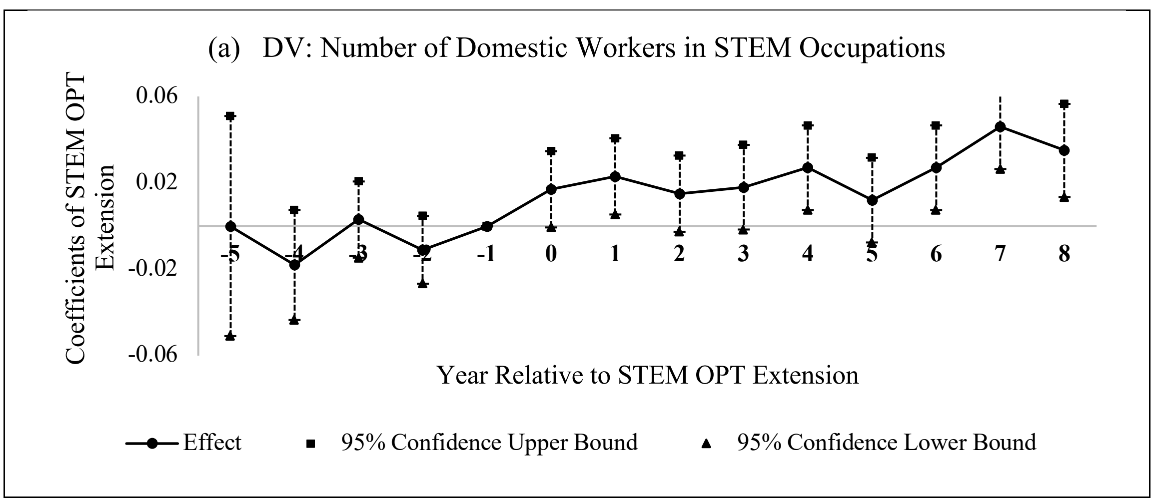
Table 5. Summary of Robustness Checks

Concern	Test	Finding
Parallel trends before the treatment	Relative time model	No clear pre-treatment trend of the OPT extension
Measurement errors in the independent variables	Alternative measures (months of OPT extension)	Consistent with the main analyses
Measurement errors in the dependent variables	Alternative measures of local employment from the BLS	Consistent with the main analyses
Financial crisis (2008-2009)	Excluding the sample in 2008 – 2009	Consistent with the main analyses
Bias in OLS due to heteroscedasticity	Count model (Poisson) for the number of workers	Consistent with the main analyses
Outliers of MSAs with large population	Excluding MSAs with large population	Consistent with the main analyses
Selection bias in STEM occupations	Only including STEM occupations treated in 2008	Consistent with the main analyses
MSAs may have different time trends before and after the OPT extension.	Including MSA quadratic time trends	Consistent with the main analyses
It takes time for the effect of OPT extension to materialize.	Using a lead dependent variable	Consistent with the main analyses
Employment of foreign workers	DID estimation for foreign workers	Consistent with the mechanism

Relative Time Model

A critical assumption required for the validity of a DID estimation is that the pre-treatment trends of the dependent variable must be parallel prior to the treatment (i.e., the STEM OPT extension policy). Following prior literature (e.g., Autor 2003), we include a series of dummy variables that indicate the relative time distance between an observation period, t, and the timing of the STEM OPT extension changes in occupation i. The detailed model is outlined in equation (3).

$$\ln(Y)_{ijt} = \alpha_i + \gamma_j + \theta_t + \sum_d \tau_d PreOPTExtension_{it}(d) + \sum_k w_k PostOPTExtension_{it}(k) + \beta_6 Controls_{jt} + \varepsilon_{it} \quad (3)$$



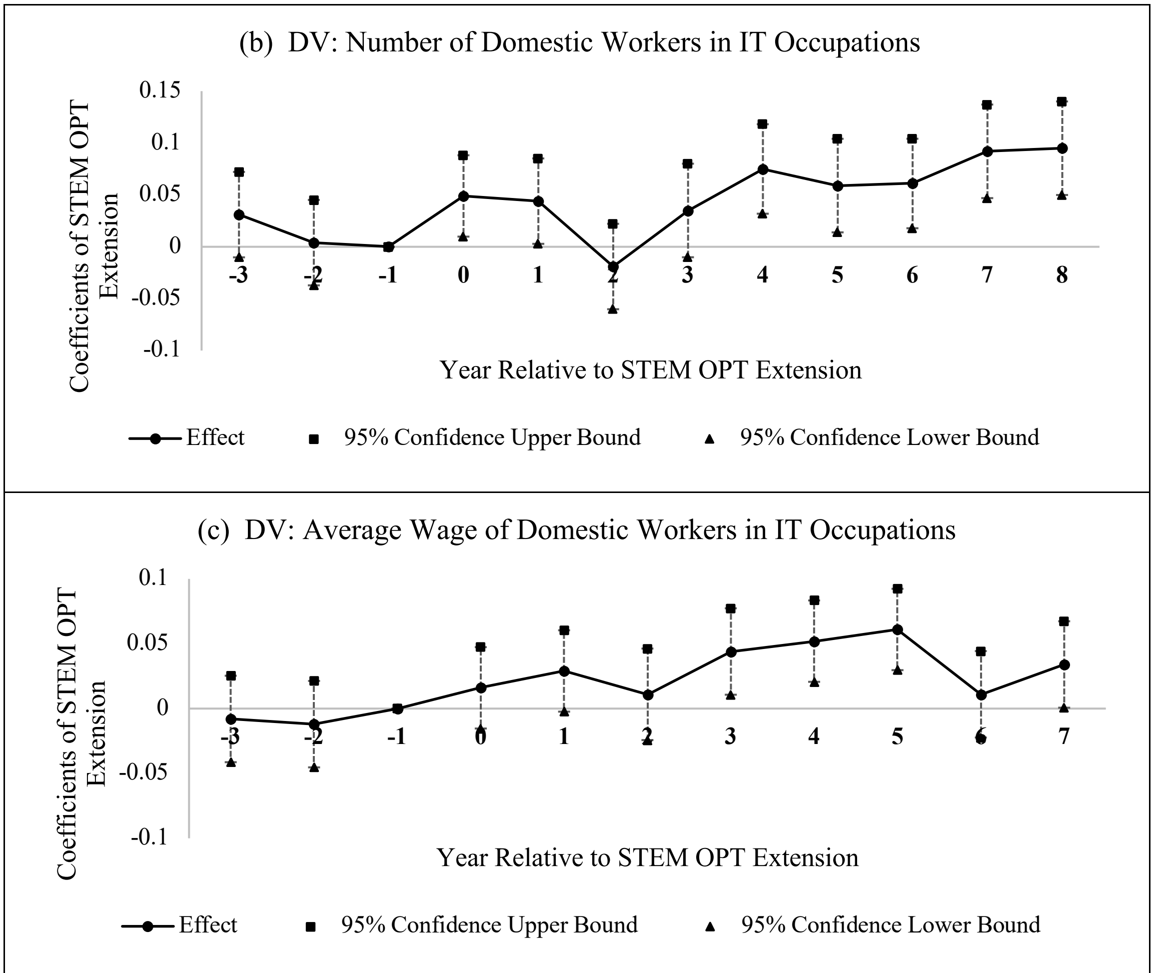


Figure 3. Effects of OPT Extension on Number and Average Wage of Domestic Workers

$PreOPTExtension_{it}$ is an indicator equal to one if year t is d years prior to the OPT extension for occupation i. $PostOPTExtension_{it}$ in an indicator equal to one if year t is k years post the extension. This model allows us to test whether there is a difference in pre-treatment trends across different occupations.

Figures 3(a) plots the coefficients of the pre- and post-treatment relative time dummies. As seen, none of the pre-treatment dummies are statistically significant, suggesting that there are no significant differences in pre-treatment trends across occupations. In addition, we see a significant increase in the number of all and domestic workers after the STEM OPT extension, which grows from 2% to 5% over the years. We also replicate Eq. 3 using IT occupations as the treatment group. The results are presented in Figure 3(b)-(c), which also support our results in the main model.

Empirical Extensions

Our analyses thus far have shown a complementary effect of the STEM OPT extension on local employment. We next examine heterogeneity in the observed effect to empirically demonstrate the underlying mechanisms for the complementary effects.

Skill Content

We further examine the occupation-related characteristic in the relationship between the STEM OPT extension and local employment. Specifically, we examine how the complementary effect of the STEM OPT extension varies for occupations with different skill content. Skill content refers to the types of skills and tasks required by occupations (Peri and Sparber 2009). Prior studies show that high-skilled foreign workers specialize in occupations demanding quantitative and analytical skills, whereas native-born counterparts specialize in occupations requiring interactive and communication skills (e.g., Peri and Sparber 2009). As we theorize above, if foreign and domestic workers possess different types of skills and knowledge, newly emigrated foreign workers with stronger quantitative and analytic skills compete with domestic workers who have similar skills and complement domestic workers who have different ones such as interactive and communication skills.

Empirically, we collected the skill content information for all occupations (IT, non-IT STEM, and non-STEM) in our dataset from the O*NET Database, which contains information on a range of occupations from job incumbent surveys. These surveys ask respondents to evaluate the importance of 52 abilities (skills) and 41 activities (tasks) required by his/her current job on a scale of 1 to 5. We construct the measures of occupational skill content by averaging the importance for the quantitative and interactive skills separately and generate the ratio of the two averaged measures (quantitative/interactive), an approach adopted by Peri and Sparber (2009). Among all IT occupations, computer programmers and database administrators have the highest quantitative/interactive ratio.

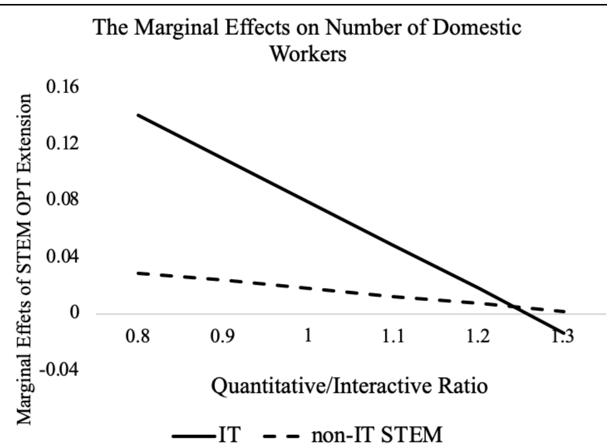


Figure 4. Marginal Effects of the STEM OPT extension by Different Levels of Skill Content

To explore the moderating effects of skill content, we add the interaction term of the OPT extension and skill content. Figure 4 plots the moderating effects of skill content on the number for domestic workers for workers in IT and non-IT STEM occupations. Specifically, the quantitative/interactive ratio negatively moderates the effects of STEM OPT extension on the number of IT workers, while it is not significant for non-IT STEM workers. The results suggest that the STEM OPT extension has a higher complementary effect on domestic workers whose occupations require higher interactive and communication skills than quantitative and analytic skills. On the other hand, the moderating effects of the skill content on the average wage are not significant for all and domestic workers.

Discussion and Contributions

Discussion

In this study, we examine the effects of the STEM OPT extension, which increases the inflow of foreign high-skilled workers, on the number of workers and the wage levels in local labor markets. First, our results suggest that the policy is positively associated with the total number of local workers (2.5%) and domestic workers (2.2%) in STEM occupations. This effect is not significant with respect to average wage (Table 4). More interestingly, these effects vary for workers in IT and non-IT STEM occupations. Specifically, the OPT extension has a stronger effect on the number of workers in IT occupations than in non-IT STEM occupations as well as a positive impact on their average wage. This finding illustrates that an increase in the supply of foreign IT professionals as a result of the STEM OPT extension boosts the demand for domestic IT professionals. The unique characteristics of IT human capital differentiate the impacts of STEM OPT extension on IT occupations from non-IT STEM occupations.

We also explore the heterogeneity occupational characteristics to identify the underlying mechanisms in the observed complementary effect. Our results further suggest that the complementary effects of the OPT extension are stronger for domestic workers in IT occupations with higher interactive (or communicational) skills than ones with higher quantitative (or analytical) skills, since high-skilled foreign workers specialize in occupations demanding quantitative and analytical skills. The results further support the underlying mechanisms for the complementary relationship between high-skilled foreign workers and domestic workers.

Contributions and Implications

Our study makes several contributions to the IS and related disciplines. First, it contributes to the IS literature by differentiating the human capital of IT and non-IT STEM workers. Our study theorizes the unique role of IT professionals in building business-IT relationship, increasing innovative and entrepreneurial activities, and increasing labor mobility, which contributes to complementary effects of OPT extension on domestic IT professionals. Empirically, we test the effects of the STEM OPT extension on the number and average wage of IT and non-IT STEM workers. Our findings suggest that the inflow of skilled foreign workers complements domestic IT workers locally, instead of replacing or "crowding out" them, providing new theoretical insights into the unique characteristics of skilled foreign IT labor. Second, our study contributes to the literature on labor economics by theorizing and examine the effects of a new immigration policy—STEM OPT extension—on the local labor markets. Our study finds that the effects of the STEM OPT extension are heterogeneous by occupational characteristics. We find that the complementary effects of STEM OPT extension are stronger for occupations that require higher interactive skills than quantitative skills.

Our study also provides important policy and managerial implications. Our study provides a better understanding of the impact of immigration policies for high-skilled workers. From a policy perspective, the findings suggest that the STEM OPT extension has a complementary effect on domestic employment, especially for IT professionals, which provide implications for policymakers to develop immigration programs that attract more high-skilled foreign workers. In doing so, it is necessary for them to leverage concrete empirical evidence on the substitution or complementary effect of immigration. Our findings that the effect of immigration policy varies by regions also provide implications for state and local officials. From a managerial perspective, our results demonstrate the unique role of the human capital of foreign IT workers. This provides guidelines for hiring decisions by evaluating the human capital of IT workers properly. For instance, the collaboration between foreign and domestic IT professionals may generate higher innovation activities and facilities the integration of IT-business relationship.

Our study is subject to several limitations. First, our identification strategy is based on a natural experimental design utilizing the variations in OPT periods across occupations (STEM vs. non-STEM) that the OPT extension brings over time. Although our analyses adopt a comprehensive set of control variables and several econometrics methods for the robustness of the results, further work is necessary to ensure that there are no confounding factors that influence the findings. Second, due to data limitations, we could not directly track the number and average wage of foreign OPT workers in each MSA. Hence, we cannot directly test the effects of STEM OPT extension on the number and wage of foreign OPT workers. Future researchers with access to such detailed data could gain better insights.

Our study has also spawned several research questions that provide opportunities for future research. First, besides the employment of local labor markets, future studies could explore the effects of STEM OPT extension on other aspects of the U.S. economy such as innovation and entrepreneur activities, which would help better understand the role of high-skilled foreign IT professionals in local labor markets and the relationship between foreign and domestic workers. Second, while the unit of analysis of our is within geographic areas (i.e. MSAs), future studies could explore the role of the policy in affecting the employment structures within firms. It would be interesting to conduct more in-depth analyses on how the employment of foreign IT professionals influences domestic workers at an individual level. Specifically, studies could explore the heterogeneous effects of the policy by employee characteristics such as education and skill sets. Finally, the present study focuses on the role of the OPT extension that applies to all STEM occupations. If there are future immigration policies that specifically apply to IT occupations, studies could examine their effects to help us better understand the role of the IT human capital.

References

Ang S., Slaughter S., Yee Ng K 2002. "Human capital and institutional determinants of information technology compensation: Modeling multilevel and cross-level interactions," *Management Science* (48:11), pp.1427–1445.

Ang, S., and Slaughter, S. A. 2001. "Work Outcomes and Job Design for Contract versus Permanent Information Systems Professionals on Software Development Teams," *MIS Quarterly* (25:3), pp. 321–350.

Angrist, J. D., and Pischke, J.S. 2008. Mostly Harmless Econometrics: An Empiricist's Companion, Princeton Univ Press

Aral, S., Brynjolfsson, E., and Wu, L. 2012. "Three-Way Complementarities: Performance Pay, Human Resource Analytics, and Information Technology," *Management Science* (58:5), pp. 913–931.

Audretsch, D. B., and Feldman, M. P. 1996. "R&D Spillovers and the Geography of Innovation and Production," *The American Economic Review* (86:3), pp. 630–640.

Banker, R., Wattal, S., Liu, F.-C., and Ou, C.-S. 2008. "Value Contributed by Education in IT Firms," in Proceedings of the 9th International Conference on Information Systems, pp. 116.

Barney J (1991) "Firm resources and sustained competitive advantage," *Journal of Management* (17:1), pp.99–120.

Bassellier, G., and Benbasat, I. 2004. "Business Competence of Information Technology Professionals: Conceptual Development and Influence on IT-Business Partnerships," *MIS Quarterly*, (28:4), pp. 673–694.

Berliant, M., and Fujita, M. 2009. "Dynamics of Knowledge Creation and Transfer: The Two Person Case," *International Journal of Economic Theory* (5:2), pp. 155–179.

Bharadwaj, A. S. 2000. "A Resource-Based Perspective on Information Technology Capability and Firm Performance: An Empirical Investigation," *MIS Quarterly*, (24:1), pp. 169–196.

Boh, W. F., Ren, Y., Kiesler, S., and Bussjaeger, R. 2007. "Expertise and Collaboration in the Geographically Dispersed Organization," *Organization Science* (18:4), pp. 595–612.

Bonin, H. 2017. "The Potential Economic Benefits of Education of Migrants in the EU. EENEE Analytical Report No. 31.," European Commission.

Borjas GJ (1989) "Economic theory and international migration," *International Migration Review* (23:3), pp.457–485.

Borjas, G. J. 2001. "Does Immigration Grease the Wheels of the Labor Market?," Brookings Papers on Economic Activity (2001:1), pp. 69–119.

Borjas, G. J. 2005. "The Labor-Market Impact of High-Skill Immigration," *American Economic Review* (95:2), pp. 56–60.

Borjas, G. J. 2006. "Native Internal Migration and the Labor Market Impact of Immigration," Journal of Human Resources (41:2), pp. 221–258.

Bresnahan, T. F., Brynjolfsson, E., and Hitt, L. M. 2002. "Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence," *The Quarterly Journal of Economics* (117:1), pp. 339–376.

Card, D. 1990. "The Impact of the Mariel Boatlift on the Miami Labor Market," *ILR Review* (43:2), pp. 245–257.

Chan, J., and Ghose, A. 2013. "Internet's Dirty Secret: Assessing the Impact of Online Intermediaries on HIV Transmission," MIS Quarterly (38:4), pp. 955–976.

Dahl, M. S., and Sorenson, O. 2010. "The Migration of Technical Workers," *Journal of Urban Economics* (67:1), pp. 33–45.

Doran, K., Gelber, A., and Isen, A. 2014. "The Effects of High-Skilled Immigration Policy on Firms: Evidence from H-1B Visa Lotteries," *National Bureau of Economic Research*.

Duleep, H. O., Jaeger, D. A., and Regets, M. C. 2012. How Immigration May Affect US Native Entrepreneurship: Theoretical Building Blocks and Preliminary Results.

Espinosa, J. A., Slaughter, S. A., Kraut, R. E., and Herbsleb, J. D. 2007. "Familiarity, Complexity, and Team Performance in Geographically Distributed Software Development," *Organization Science* (18:4), pp. 613–630.

Forman, C., and Zeebroeck, N. van. 2012. "From Wires to Partners: How the Internet Has Fostered R&D Collaborations within Firms," *Management Science* (58:8), pp. 1549–1568.
Friedberg, R. M., and Hunt, J. 1995. "The Impact of Immigrants on Host Country Wages, Employment and Growth," *Journal of Economic Perspectives* (9:2), pp. 23–44.
Gorgone, J., Davis, G. B., Valacich, J. S., Topi, H., Feinstein, D. L., and Longenecker, H. E. 2003. "IS 2002 Model Curriculum and Guidelines for Undergraduate Degree Programs in Information Systems," *Communications of the Association for Information Systems* (11:1), p. 1.
Hira, R. 2010. "Bridge to Immigration or Cheap Temporary Labor," *Economic Policy Institute. EPI Briefing Paper* (257).
Hummel, D. 2016. "Immigrant-Friendly and Unfriendly Cities: Impacts on the Presence of a Foreign-Born Population and City Crime," *Journal of International Migration and Integration* (17:4), pp. 1211–1230.
Josefek RA, Kauffman R (2003) "Nearing the threshold: An economics approach to pressure on information systems professionals to separate from their employer," *Journal of Management Information Systems* (20:1), pp. 87-122.
Kerr, S. P., Kerr, W. R., and Lincoln, W. F. 2015. "Skilled Immigration and the Employment Structures of US Firms," *Journal of Labor Economics* (33:S1), pp. S147–S186.
Kerr, W. R., and Lincoln, W. F. 2010. "The Supply Side of Innovation: H-1B Visa Reforms and US Ethnic Invention," *Journal of Labor Economics* (28:3), pp. 473–508.
Kleis, L., Chwelos, P., Ramirez, R. V., and Cockburn, I. 2012. "Information Technology and Intangible Output: The Impact of IT Investment on Innovation Productivity," *Information Systems Research* (23:1), pp. 42–59.
Krishna, S., Sahay, S., and Walsham, G. 2004. "Managing Cross-Cultural Issues in Global Software Outsourcing," *Communications of the ACM* (47:4), pp. 62–66.
Matloff, N. 2004. "Globalization and the American IT Worker," *Communications of the ACM* (47:11), pp. 27–29.
Matloff, N. 2013. "Immigration and the Tech Industry: As a Labour Shortage Remedy, for Innovation, or for Cost Savings?," *Migration Letters* (10:2), pp. 211–228.
Mayda, A. M., Ortega, F., Peri, G., Shih, K., and Sparber, C. 2017. "The Effect of the H-1B Quota on Employment and Selection of Foreign-Born Labor," *National Bureau of Economic Research*.
Melville, N., Kraemer, K., and Gurbaxani, V. 2004. "Information Technology and Organizational Performance: An Integrative Model of IT Business Value," *MIS Quarterly* (28:2), pp. 283–322.
Mithas, S., and Krishnan, M. S. 2008. "Human Capital and Institutional Effects in the Compensation of Information Technology Professionals in the United States," *Management Science* (54:3), pp. 415–428.
Mithas, S., and Lucas Jr, H. C. 2010. "Are Foreign IT Workers Cheaper? US Visa Policies and Compensation of Information Technology Professionals," *Management Science* (56:5), pp. 745–765.
Mithas S, Ramasubbu N, Sambamurthy V (2011) How information management capability influences firm performance. *MIS Quarterly* (35:1), pp. 237-256.
Parrotta, P., Pozzoli, D., and Pytlikova, M. 2014. "Labor Diversity and Firm Productivity," *European Economic Review* (66), pp. 144–179.
Peri, G., Shih, K., and Sparber, C. 2015. "STEM Workers, H-1B Visas, and Productivity in US Cities," *Journal of Labor Economics* (33:S1), pp. S225–S255.
Peri, G., and Sparber, C. 2009. "Task Specialization, Immigration, and Wages," *American Economic Journal: Applied Economics* (1:3), pp. 135–69.
Reich, B. H., and Benbasat, I. 2000. "Factors That Influence the Social Dimension of Alignment between Business and Information Technology Objectives," *MIS Quarterly* (24:1), pp. 81–113.
Salzman, H., Kuehn, D., and Lowell, B. L. 2013. Guestworkers in the High-Skill US Labor Market: An Analysis of Supply, Employment, and Wage Trends. Report, Retrieved from https://doi.org/doi:10.7282/T379469D
Schultz, T. W. 1961. "Investment in Human Capital," *The American Economic Review* (51:1), pp. 1–17.
Tambe, P., and Hitt, L. M. 2012. "Now IT's Personal: Offshoring and the Shifting Skill Composition of the US Information Technology Workforce," *Management Science* (58:4), pp. 678–695.
Wadhwa V, Saxenian A, Rissing BA, Gereffi G (2008) "Skilled immigration and economic growth," *Applied Research in Economic Development Journal*. (5:1), pp.6-14.