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The Impact of Registered Apprenticeships on the Middle-Skills Gap in Virginia

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The Impact of Registered Apprenticeships on the Middle-Skills Gap in Virginia

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University.

by

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Dedication

This dissertation is dedicated to my mother, Geraldine Watkins Macklin, who I lost during this during this journey. Thank you for giving me the courage and inspiration to achieve my dreams and goals.

Table of Contents

List of Tables vi

List of Figures viii

Abstract ix

Chapter 1. Introduction 1

Background 4
Statement of the Problem 6
Purpose 9
Research Questions 10
Significance of the Study 11
Theoretical Framework 13
Research Methodology 14
Definition of Key Terms 15
Organization of the Study 19

Chapter 2. Review of Literature 20

Skills Gap 20
The Middle-Skills Gap and Middle-Skills Occupations 35
Overview and History of Registered Apprenticeships 41
Policy and Legislation 67
Virginia: Apprenticeships and the Middle-Skills Gap 76
Chapter Summary 85

Chapter 3. Methodology 87

Summary of Key Issues 88
Research Questions and Hypotheses 89
Research Design 90
Research Data and Methodology 92
Data Analysis Process 96
Threats to Validity 110
Limitations 111
Chapter Summary 112

Chapter 4. Results 114

RQ1: Is There a Middle-Skills Gap in Virginia 114
RQ2: How Many RA Positions Are Filling Middle-Skills Gap Occupations? 126
RQ3: What Is The Impact of Registered Apprenticeships on the MS Gap in Virginia 139

Chapter 5. Discussion and Implications 148

Discussion of Findings and Implications 149
Recommendations for Future Research 169
Conclusion 171

List of References 174

Appendixes 193

Vita……..... 257

List of Tables

Table

1. Top 11 Projected MS Job Vacancies in 2016 by Detail SOC Code 78

2. Top Projected Job Vacancies (Low, Middle, and High Skills) in 2016 by Major SOC Code 79

3. Top Five SOC Codes That Appeared the Most Often in the 2015 Virginia Job Vacancy Survey Report 80

4. VBWD Total Annual Openings for High-Demand Occupations by Occupational Field 83

5. Primary Variables, Scales of Measurement, Variable Type, and Operationalization 94

6. Data Sources for the 2018 and 2015 MS Gap Calculation 103

7. MS Gap Calculation Example 104

8. Hypotheses and Statistical Tests for Research Question 3 110

9. Number of MS Occupations By Education and Training 117

10. Number of MS Gap Occupations by the Size of the Gap 118

11. MS Gap Occupations Supply to Demand Ratio (Relative Demand Gap) 119

12. Virginia's 20 Occupations (6-Digit Detail) Most Impacted by the MS Gap in 2015 and 2018 123

13. RA Positions: Apprentice Characteristics and Demographics 128

14. Number of Registered Apprenticeships per RA Sponsor 130

15. RA Positions Compared to 2018 MS Gap Occupations (Top 10 RA Occupations Compared to the Largest MS Gap Occupations in 2018 133

Table

16. Number of RA Positions Filling MS Gap Occupations 134

17. Occupations With the Most RA Positions Filling MS Gap Occupations in 2015 and 2018 135

18. RA Positions in Virginia's Executive Order 49 Occupations 137

19. Summary of Virginia's RA Characteristics in 2015 and 2018 139

20. Binary Logistic Regression Model (2015 and 2018 Datasets) Predicting the Likelihood of a RA Position Filling a MS Gap Occupation 142

21. Binary Logistic Regression Predicting the Likelihood of a RA Position Filling a MS Gap Occupation in 2015 145

22. Binary Logistic Regression Predicting the Likelihood of a RA Position Filling a MS Gap Occupation in 2018 146

List of Figures

Figure

1. Data Analysis Implementation Steps 15

2. RA Programs and Apprentices in the United States 51

3. Active Apprentices in Virginia FY2013 to FY2018 84

4. Data Analysis Implementation Steps 96

5. Example of the U.S. Standard Occupational Classification (SOC) System Structure and SOC Code 98

6. Logistic Regression Equation 110

7. Frequency of MS Occupations by SOC Code Major Group 115

8. SOC Code Major Groups Most Impacted by the MS Gap by Frequency 121

9. SOC Code Major Groups Most Impacted by the MS Gap Based on Gap Size 121

Abstract

THE IMPACT OF REGISTERED APPRENTICESHIPS ON THE MIDDLE-SKILLS GAP IN VIRGINIA

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University.

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The skills gap debate has raged on among scholars and policymakers for the last few decades. The key questions are whether the gap exists, the extent of the gap and how to minimize the gap. Of particular concern is a shortage in filling middle-skills jobs—positions that require more than a high school diploma but less than a college degree. Since 2014, over $500 million has been invested in registered apprenticeships as a strategy to address the skills gap through federal grants and programs.

Likewise, Virginia has invested over $7.5 million in federal and state funds and implemented policies, such as VA Executive Order 49 in 2015, to expand registered apprenticeships as a workforce strategy to diminish the skills gap. While middle-skills jobs are projected to grow in Virginia, the Commonwealth ranks below the national average for the proportion of its workforce with the necessary credentials to fill those jobs. The goal of this

research was to determine if registered apprenticeships are filling the middle-skills gap in Virginia and whether VA Executive Order 49 was effective at increasing the likelihood of them doing so.

Using secondary data, this study first determined if Virginia had a middle-skills gap by calculating the gap between labor supply and labor demand of each middle-skills occupation. Next, by comparing the occupations of current registered apprenticeship positions to the list of occupations with a middle-skills gap, the study determined the extent to which registered apprenticeship positions in Virginia are being created in occupations that have a middle-skills gap. Finally, logistic regression was employed to compare the likelihood of a registered apprenticeship position being in an occupation with a middle-skills gap before and after the implementation of VA Executive Order 49.

Results confirm that there's a middle-skills gap in Virginia, albeit much smaller than expected. Most registered apprenticeship positions are created in middle-skill occupations with a skills gap. However, registered apprenticeships are less likely to fill middle-skill occupations after VA Executive Order 49 than they were before its implementation. Factors such as urban location and the unemployment rate influenced the likelihood of registered apprenticeships filling MS gap occupations. This study concludes that while registered apprenticeships are effective at filling the middle-skills gap, it appears policies and money put in place to encourage the relationship did not enhance their likelihood of doing so.

Chapter 1. Introduction

Recently, there has been a renewed focus on registered apprenticeships in the United States. In President Obama's 2014 State of the Union address, he made a call to action to double and diversify the number of apprenticeships to 750,000 by 2019 (U.S. Department of Labor [USDOL], 2015a) and made apprenticeships a priority by investing $265 million for an expansion of registered apprenticeships (White House Office of Press Secretary, 2016). In 2017, President Trump continued this investment in registered apprenticeship expansion by issuing Executive Order 13801, Expanding Apprenticeships in America (White House Office of Press Secretary, 2017). As of 2018, the USDOL announced over $245 million in grants toward this Executive Order, and news articles state President Trump wants to have five million apprentices by 2022 (USDOL, 2018a).

In view of the above events, why such a focus on apprenticeships? Why are our policymakers making apprenticeships a priority? Executive Order 13801 states that America's education and workforce development programs need reform to meet the challenges of today's rapidly changing economy, namely the "skills gaps" that result from a workforce that is insufficiently trained to fill existing and newly created jobs (USDOL, 2018b, p. 12). Policymakers are looking for solutions or strategies to address the skills gap because it impacts our economy—there are 6.2 million unemployed people and 7.6 million job openings as of February 2019 (USDOL, Bureau of Labor Statistics [BLS], 2017a, 2019a). The challenge of skills gap is further exemplified in the U.S. Bureau of Labor Statistics (USDOL-BLS) Jobs

Opening and Labor Turnover Summary April 13, 2018 report which states, "The disconnect between the capabilities offered by American job seekers and the skills demanded by the 21st century workplace, known as the 'skills gap,' contributes to the nation's 6.3 million open jobs" (USDOL, 2018b, p. 16).

Employers state they are having difficulty filling jobs. They cannot find an adequate supply of workers who possess the skills, experience, training, or education needed to fulfill these jobs (Carnevale, Smith, & Strohl, 2010; Hine, 2013; Levine, 2013). For example, according to a February 2019 report from the National Federation of Independent Business, 57% of small business owners reported they were hiring or trying to hire; 49% of those owners reported they had few or no qualified applicants for the positions they were trying to fill; and 37% of owners reported job openings they could not fill (National Federation of Independent Business, 2019; USDOL, 2018b). When there is a misalignment or gap between the workers' skills (supply) and the employers' job requirements of skills to perform the job (demand), it is known as a skills gap or skills mismatch (Hine, 2013).

Registered apprenticeships (RAs) are considered a solution for employers to find and retain skilled talent because it is a proven method of job preparation that helps people develop in-demand skills that meet the needs of business for a skilled workforce (Helper, Noonan, & Langdon, 2016; Lerman, Eyster, & Chambers, 2009; USDOL, 2017a). Per the White House Office of Press Secretary (2016) Fact Sheet, "Job-driven apprenticeships are among the surest pathways to provide American workers from all backgrounds with the skills and knowledge they need to acquire good-paying jobs and grow the economy" (p. 1). According to the USDOL performance outcomes, 91% of apprentices retain employment after completing their programs, with an average starting wage above $50,000 (USDOL, 2017a).

Registered apprenticeships are work-based learning career-training programs in which a participant receives on-the-job training in combination with job-related instruction in curricula (to master an occupational skill) that leads to a nationally recognized credential while being paid (Reed et al., 2012; USDOL, 2017a). The U.S. Registered Apprenticeship Program was established in 1937 under the National Apprenticeship Act and is overseen by the USDOL. In 2018, there were over 585,000 apprentices, which represents .3% of the U.S. workforce (USDOL, 2018c). Based on the Reed et al. (2012) study, apprenticeships are deemed an effective work-based learning training model that is cost-efficient and has significant benefits and return on investment for the employer, apprentice, and the government. Employers received a 38% return on their investment in the form of lower recruitment costs (Kochan, Finegold, & Osterman, 2012) and the tax return on every federal government dollar invested in RA programs is $27 (Reed et al., 2012).

Apprenticeships along with internships are types of work-based learning activities to help people gain experience in a field, industry sector, or organization. An apprenticeship is a formal paid employment or career program that trains an individual to do a specific job whereas an internship is more of an educational (exploratory educational experience) rather than a training role (Finch, 2018).

With apprenticeships, the apprentice signs a contract with an employer and is a paid full-time employee who participates in on-the job training (hands-on method of teaching skills or instruction to perform a specific job that occurs in the workplace) paired with formal job-related instruction in curricula that can take 1 to 6 years to complete (USDOL, 2017a). Whereas internships are short-term periods of temporary work experience that typically last a few weeks or months (e.g., a summer or semester) in which the intern may be paid, unpaid, or receive

college credit. One of the distinguishing differences between an apprenticeship and internship is the apprentice receives a nationally recognized credential at the end of the apprenticeship indicating they are certified to work in that job or industry.

Apprenticeship is one of the key solutions several states are using to address the skills gap. Policymakers and educators want to ensure workers obtain skills that align properly with the needs of the labor market. States such as Kentucky and Colorado are focused on skill development and apprenticeships as the way to increase labor participation, to attract mid- and high-wage jobs, and to address the skills gap (Leins, 2017; Whitehouse, 2017). In 2015, Virginia implemented initiatives (such as VA Executive Order 49) to expand registered apprenticeships as a way to address the skills gap and its workforce development needs. In the next section, the background and rationale of RA programs are described in order to contextualize the significance of the study.

Background

While major investments are being made in registered apprenticeships on a federal and state level, there has been minimal research on the effectiveness of RA programs in the United States and more information is needed on the returns of apprenticeships (Gunderson & Krashinsky, 2015; Lerman, 2013a). This study will help fill a void in this literature by examining the effectiveness and impact of Virginia's RA programs on the skills gap for middle-skill (MS) jobs (positions that require education or training beyond a high school degree but less than a 4-year college degree).

In previous studies on registered apprenticeships in the United States, researchers have assessed the effectiveness of RA programs by conducting cost-benefit analyses. Reed et al. (2012) assessed the effectiveness and performed a cost-benefit analysis of registered

apprenticeships in 10 states (Virginia was not one of the 10 states examined). Hollenbeck and Huang (2016) examined the net impact and cost-benefit evaluation of 12 workforce development programs (including apprenticeships) in the state of Washington. Hollenbeck (2008) also studied the net impact, social benefits, and costs of workforce development programs, including registered apprenticeships, in the state of Washington.

Those three studies examined the benefits of apprenticeships from a participant perspective and found that the benefits of RA programs significantly exceeded the costs and RA programs had a strong net social benefit, thus justifying the investment of resources into RA programs (Hollenbeck, 2008; Hollenbeck & Huang, 2016; Reed et al., 2012). From a business perspective, Case Western University and the U.S. Department of Commerce examined the costs and benefits of registered apprenticeships from the perspective of American businesses. In this study, Helper et al. (2016) reported that companies unanimously found value in registered apprenticeships. They indicated that RA programs resulted in: the benefits justifying the costs, reduced turnover and improved recruitment, improvement in employers' overall performance, and a competitive edge over other firms.

Researchers have also examined the perspectives of registered apprenticeship sponsors (employers) regarding RA program benefits, drawbacks and what employers value, apprenticeship completion rates, characteristics of sponsors and their programs, and the integration of registered apprenticeships with the public workforce investment system (i.e., one-stop centers) (Gunn & DeSilva, 2008; Lerman et al., 2009). Gunn and DeSilva (2008) and Lerman et al. (2009) both reported registered apprenticeship sponsors strongly supported the program; a majority (over 86%) would strongly recommend the RA program to others; and 65% of sponsors had completion rates over 70%).

According to Olinsky and Ayres (2013), better research is needed to help establish the credibility of the registered apprenticeship training model. This information would be beneficial for understanding the value of apprenticeships and recruiting stakeholders such as employers, apprentices, parents and educational practitioners. Additionally, Olinsky and Ayres (2013) state more advanced research is needed on the returns to investment for specific occupations and high growth (or in-demand) occupations; public information about the scope and completion rates of individual apprenticeship programs in states; and information regarding education attainment statistics, wages, gender and occupational breakdown beyond the historical state data would be useful to both prospective apprentices and researchers.

There is a gap in the literature regarding specific occupations and high growth (or in-demand) occupations. Occupational research could help efforts to increase participation in apprenticeships by directing resources to help with employer and participant outreach. This study will fill the gap in registered apprenticeship literature by examining the effectiveness or impact of Virginia's RA programs on MS gap occupations (MS occupations with a skills gap) and Virginia's in-demand occupations.

Statement of Problem

The Commonwealth of Virginia promotes itself as one of the best-educated and most productive workforces in the country; however, the state lags behind in providing workers for MS employment (Commonwealth of Virginia, 2017). According to Virginia Performs, Virginia has a low number of individuals with credentials (8.1% of Virginia's workforce had an associate's degree, ranking the state below the national average of 9.0% and 39th among other states) that are suitable for MS positions (Commonwealth of Virginia, 2017). This is important because Virginia is expected to have an 8% MS job growth from 2014 to 2024 (Heinrich, 2018).

Furthermore, in Virginia, an estimated 1.5 million jobs need to be filled by 2022 (VA Executive Order 23, 2014). Of those 1.5 million jobs, as many as 50% to 65% will be at the technician and trades level, which are considered MS jobs (VA Executive Order 49, 2015).

In Virginia, there has been much policy discussion about closing the skills gap. Virginia has recently begun implementing initiatives to expand registered apprenticeships in the Commonwealth as a way to address workforce development needs such as the MS gap. On October 6, 2015, Governor McAuliffe issued VA Executive Order 49 to "dramatically" expand registered apprenticeships in Virginia (VA Executive Order 49, 2015).

Virginia Executive Order 49 directed the expansion of apprenticeships in state-level agencies and in key industry sectors that have not traditionally sponsored registered apprenticeships (such as information technology, cybersecurity, professional and business services). A total of $400,000 in state funds was made available for this initiative for FY 2016. Up to $120,000 was available to state agencies to support apprentice-related instruction and up to $280,000 was available to private sector companies to support apprentice-related instruction in targeted occupations. Virginia's Executive Order 49 (2015) also recognized registered apprenticeships as a state strategy for addressing the MS job shortage by stating that registered apprenticeships are a tried and true strategy to prepare a skilled workforce for technician and trade level MS jobs. Additionally, Virginia has received and allocated over $7.5MM in federal and state funds for apprenticeships since 2015 (VA Executive Order 49, 2015; Office of the Governor, 2015, 2016a).

Traditionally, apprenticeships have been in traditional, male dominated fields such as construction, manufacturing and the skilled trades (electrician, plumbers, carpenters, and mechanics). On a national level, the Department of Labor's Office of Apprenticeship has made a

concerted effort to attract women and register programs in new, high-growth areas, such as advanced manufacturing, health care, geospatial technology, and information technology (Office of Disability Employment Policy, 2015; Olinsky and Ayres, 2013). Similarly, Virginia has made an effort to expand apprenticeships (apprenticeable occupations) via VA Executive Order 49 (2015).

Closing the skills gap is a top priority for Virginia and expanding registered apprenticeships is a strategy Virginia is using to address the MS gap. What is unknown is whether RA programs are impacting the skills gap, specifically, MS gap occupations. More specifically, what is not known is whether Virginia has expanded and diversified its apprenticeships with high growth or in-demand MS occupations, such as information technology, cybersecurity, professional and business services, since the implementation of VA Executive Order 49 (2015).

If Virginia does not address the growing demand for workers in MS occupations, this could present a challenge for businesses, policymakers, and Virginians in the workforce system. If the future demand for MS occupations is not met, businesses will have reduced ability to serve clients, reduced productivity, and reduced innovation and creativity which will undermine the commonwealth's competitiveness both nationally and globally (Manpower Group, 2015; Virginia Chamber of Commerce, 2017). In addition, if companies do not have the appropriate skilled workers to meet their needs, companies will not be able to compete and this may cause organizations to move their operations to other states or countries. This may also impact Virginians in terms of job loss and having a tax base to provide services for the Commonwealth.

This is also an issue for the workforce system because Virginia may not have a pipeline of adequately skilled workers to meet the needs of employers or attract new employers to the

state. This is also a problem for prospective apprentices or job seekers if they are not able to develop in-demand skills to fill these MS jobs. From a policymaker perspective, it is important to understand RA programs' impact on the MS gap and the impact of VA Executive Order 49 (2015) to help plan for the future workforce development needs of the state through policy. Developing effective policy could improve registered apprenticeships as a tool for future workforce needs such as skills shortages in specific occupations.

Purpose

The purpose of this quantitative, nonexperimental study was to examine the impact of Virginia's registered apprenticeships on the MS gap in 2015 and 2018, prior to and after the implementation of VA Executive Order 49. Using a causal comparative (ex post facto) research design, this research sought to understand the likelihood of a registered apprenticeship position filling a MS gap occupation in 2018 compared to 2015. The study also analyzed factors (such as location and unemployment) that may have influenced or impacted the probability of a registered apprenticeship position filling a MS gap occupation.

Additionally, this study determined the number of registered apprenticeships in VA Executive Order 49 targeted occupations (cybersecurity and information technology) in 2018 compared to 2015. Virginia Executive Order 49 (2015) targeted three areas for registered apprenticeship expansion: information technology, cybersecurity, and professional and business services. This study examined two of the three targeted areas because professional and business services is too broad of an occupational area to analyze for the scope of this study—there are over 718 Standard Occupation Classification (SOC) codes for business services and 783 SOC codes for professional services identified on the O*NET website. Furthermore, professional and

business services is not occupational and industry specific as compared to cybersecurity and information technology.

Descriptive information was collected about Virginia's MS Gap (MS occupations with a skills gap) and Virginia's registered apprenticeships (such as program characteristics, apprentice demographics, and industry type of employers who participate). This information helped to determine if there is a MS gap or the extent of it and understand the landscape of Virginia's RA programs. Overall, this quantitative, nonexperimental study investigated the relationship and impact of Virginia's RA programs on MSGO (MS occupations with a skills gap), before and after the implementation of VA Executive Order 49 (2015).

Research Questions

Based on (a) Virginia's initiative to expand registered apprenticeships as a strategy to address the skills gap, (b) the growing employer demand for workers to fill MS jobs in Virginia due to a skills gap--almost one million MS jobs need to be filled by 2022 (VA Executive Order 49, 2015), and (c) the shortage of individuals with sufficient training or credentials to meet the demand for MS jobs, the purpose of this quantitative study was to examine the impact of registered apprenticeships on the MS gap in Virginia. The following are the research questions for this study:

1. Is there a MS gap in Virginia?
    a. Which MS occupations have a skills gap in 2015 and 2018?
    b. Which occupations (number of occupations and size of gap) are most impacted by the MS gap in 2015 and 2018?
2. How many registered apprenticeship positions are filling MS gap occupations?
    a. What are the key characteristics of registered apprenticeships in Virginia?

i. What are the apprentice characteristics and demographics?

ii. What are the key program and employer characteristics?

b. How many registered apprenticeship positions are in VA Executive Order 49 occupations (cybersecurity and information technology) in 2015 and 2018?

3. What is the impact of registered apprenticeships on the MS gap in Virginia?

a. What is the likelihood of a Virginia registered apprenticeship position in 2018 (as compared to 2015) filling a MS gap occupation?

b. How does location and unemployment impact the likelihood of a registered apprenticeship position filling a MS gap occupation?

Significance of Study

According to Olinsky and Ayres (2013), research is needed to analyze the effectiveness of apprenticeships in anticipated high-growth or in-demand occupations. This research could then inform the creation of a list of the most apprenticeable occupations for the coming decade. Accordingly, this research will add to the registered apprenticeship body of literature by analyzing whether Virginia has been effective in expanding and diversifying its RA programs (and apprenticeable occupations) since VA Executive Order 49 (2015) to meet the growing demand to fill MS occupations with a skills gap as well as in demand areas such as information technology and cybersecurity. Additionally, this study will add to the body of literature by providing descriptive data on registered apprenticeships, the MS gap, and MS occupations with a skills gap in Virginia.

The findings from this study will provide policymakers, educators, and employers' empirical evidence regarding RA programs and the MS gap in Virginia. In order for policymakers to address the skill gaps, they need information on where to make investments.

Thus, the results from this study may be useful for government officials and policymakers to identify and assess where the MS gaps are located (which occupations) and to direct resources where they are needed to meet employer demand. For example, this study identified which MS occupations have a skills gap, and this can help policymakers identify where to invest resources to scale up workers to meet employer demand.

Additionally, empirical information from this study may help government officials and policymakers to (a) explore which registered apprenticeable occupations to expand (using the MS occupations identified as having a skills gap as a guide), and (b) assess whether Virginia should continue to expand RA programs as a strategy to address the skills gap. The information from this study can help inform policy decisions to help shape workforce development strategies regarding registered apprenticeships and the skills gap, to foster more incentive programs for employers to adopt more registered apprenticeships, and to plan future research on registered apprenticeships and the MS gap in the Commonwealth of Virginia.

The findings from this study may be useful for businesses in implementing apprenticeship programs and helping them find and retain skilled workers which in turn, will help their businesses remain competitive nationally and globally. For example, understanding the effectiveness or impact of registered apprenticeships on the skills gap will provide information to help market the benefit of registered apprenticeships to businesses, especially in the information technology and cybersecurity areas. This information demonstrates the benefit of registered apprenticeships to businesses which can help with having more businesses participate and implement RA programs to meet their needs for skilled workers.

The results of this study can be beneficial to prospective apprentices, under/unemployed individuals, and the workforce system in helping individuals identify in-demand or high-growth

apprenticeable occupations as career options via marketing apprenticeships to these individuals. The results from this study may be useful for researchers in providing data to inform future studies on registered apprenticeships, MS occupations, and the MS gap.

Theoretical Framework

The primary theoretical framework associated with this study is human capital theory and the economic theory of supply and demand. The basic principle of human capital theory is that an investment in education and training yields positive returns (i.e., increases in a worker's productivity) to the individual, organization and community (Becker, 1993). Accordingly, apprenticeship training is a type of human capital investment.

Human capital theory explains the investment that employers make when they provide training, learning opportunities, and resources for apprentices to obtain the necessary technical and occupational skills needed to be successful within their organization. Likewise, the apprentices invest their time and talents into apprenticeships, with the expectation that the training, education, and skills acquired will give them a competitive advantage in the labor market with increased wages and with a nationally recognized credential that is portable.

When the education, skills, or knowledge of our human capital is not meeting employer demand in the labor market, a skills gap occurs. The quantity demanded for a particular skill is exceeding the quantity supplied. When this happens, there is a skills imbalance or disequilibrium between the demand and supply for labor which results in a shortage of people with the right human capital. Increasing the knowledge and skills of individuals through work-based learning programs such as registered apprenticeships, enables individuals to improve both their human capital and productivity as well as provide employers a tool to minimize skills gaps.

Research Methodology

This research implemented a quantitative, nonexperimental, cross-sectional research design to examine the impact of Virginia's registered apprenticeships on the MS gap. A causal comparative (ex post facto) design was used to analyze the relationship between registered apprenticeships and the MS gap in 2015 and 2018, before and after the implementation of VA Executive Order 49 (2015). This study used secondary analysis of public data collected from the Virginia Department of Labor and Industry [VDOLI], USDOL-BLS, and the Virginia Employment Commission Labor Market Information (VEC-LMI) to examine the registered apprenticeship and the MS gap data.

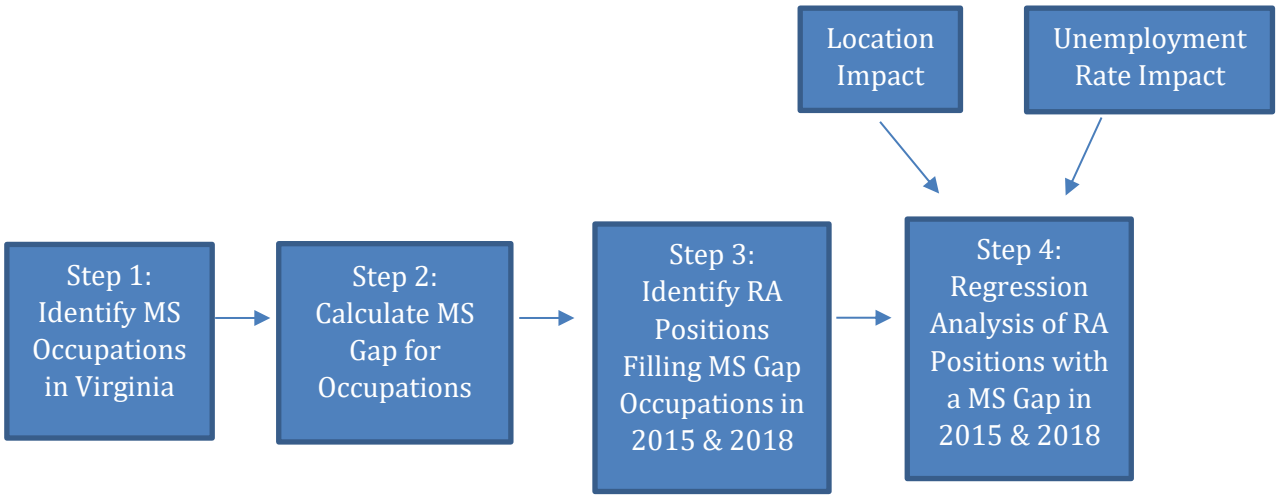
To examine the impact of registered apprenticeships on the MS gap, this study first determined if there was a MS gap by identifying MS occupations with a skills gap in Virginia (see Steps 1 and 2 in Figure 1). Next, this research determined whether registered apprenticeship positions were filling MS gap occupations (MS occupations with a gap) as shown in Figure 1, step 3. During this step, key characteristics and demographics of Virginia's RA programs were identified (e.g., registered apprenticeship position types and their occupational codes; apprentice demographics such as ethnicity, gender, and race; and employer characteristics such as industry type and number of apprentices per employer). Registered apprenticeship positions with VA Executive Order 49 (2015) targeted occupations (cybersecurity and information technology) were examined to see if there was an increase in those registered apprenticeship positions from 2015 to 2018. Descriptive statistics in SPSS® were used to help organize, describe, and summarize the characteristics of Virginia's registered apprenticeships and the MS gap data.

Using the descriptive data collected for Virginia's registered apprenticeships and MSGOs, inferential statistics were used to analyze the impact of registered apprenticeships on the middle-skills gap. Logistics regression was used to examine the likelihood of Virginia's

registered apprenticeship positions existing-in a MS gap occupation in 2018 (as compared to 2015). Additionally, logistic regression was used to analyze how location and unemployment rate might impact the likelihood of a registered apprenticeship filling a MS gap occupation (see Step 4 in Figure 1).

Figure 1

Data Analysis Implementation Steps



Definition of Key Terms

Below are key terms and definitions that will be used for this research.

Apprentice. In Virginia, a person at least 16 years of age who is covered by a written (registered apprenticeship) agreement with an employer and approved by the VDOLI. The agreement shall provide for not less than 2,000 hours of reasonably continuous employment for such person, for his participation in an approved schedule of work experience through employment, and for the amount of related instruction required in the occupation (Code of

Virginia §40.1-120). An apprentice is considered as an "active apprentice" in the VDOLI database.

Apprenticeable occupation. A list of occupations officially recognized as apprenticeable (or available for a registered apprenticeship) by the U.S. Office of Apprenticeship or State Apprenticeship Agency (such as VDOLI). An apprenticeable occupation is a skilled trade having the following characteristics:

- It is customarily learned in a practical way through a structured systematic program of on-the-job supervised work experience;
- It is clearly identifiable and recognized throughout an industry;
- It involves manual, mechanical or technical skills which require a minimum of 2000 hours of on-the-job work experience of new apprenticeable occupations not otherwise established; and
- It requires related instruction to supplement the on-the-job work experience (Code of Virginia §40.1-120).

See Appendix A for a list of Virginia's apprenticeable occupations.

Employer. An employer is any person or organization employing a registered apprentice whether or not such person or organization is a party to an apprenticeship agreement with a sponsor (Code of Virginia §40.1-120).

Internship. A form of experiential learning that integrates knowledge and theory learned in the classroom with practical application and skills development in a professional setting. Internships give students the opportunity to gain valuable applied experience and make connections in professional fields they are considering for career paths; and give employers the

opportunity to guide and evaluate talent (National Association of Colleges and Employers, 2018).

Middle-skills (MS) gap. A MS occupation or job with a skills gap. It is when the employer demand for people to fill jobs in MS occupations exceeds the labor supply of workers with middle-level skills.

Middle-skill jobs. Occupations that require education and training beyond high school but less than a bachelor's degree. This would include an occupation that requires a high school diploma and one of the following: associate's degrees, vocational certificates, apprenticeship, significant or moderate on-the-job training, previous work experience or some college without an earned degree (Holzer & Lerman 2007; Modestino, 2016; National Skills Coalition [NSC], 2017; Scaglione, 2018).

Pre-apprenticeship. A program or set of strategies designed to prepare individuals to enter and succeed in a RA program and has a documented partnership with at least one, if not more, RA program(s) (USDOL, 2012). Pre-apprenticeship programs are not tracked or approved by the USDOL Office of Apprenticeship or a state apprenticeship agency.

Registered apprenticeship: A career-training program that meets national standards for registration with the USDOL (or a federally recognized state apprenticeship agency such as VDOLI) in which an individual receives paid on-the-job training in combination with related technical instruction in a skilled occupation that leads to a nationally recognized credential (Reed et al., 2012; USDOL, 2017a). Registered apprenticeships have five defining features.

1. Business involvement—employers are considered the foundation of every RA program.

2. Program provides structured on-the-job training and is conducted in a work setting under the direction of one or more of the employer's personnel.
3. Program provides instruction on the technical and academic competencies that apply to the job.
4. Participants or apprentices are paid by their employers during training and receive pay increases as they meet benchmark for skill attainment.
5. Training results in an industry-recognized credential that certifies occupational proficiency (USDOL, 2017a).

Skills gap. The difference in the skill sets (knowledge, skills, and abilities) that an employee or job seeker possesses and the employer requirements to perform the job**;** or when there is misalignment, gap or difference between the workers skills (supply) and the employers job requirements of skills to perform the job (demand) (Hine, 2013).

- Skills gap: Skill deficiencies within an organization's existing workforce.
- Skills shortage: Difficulty in recruiting individuals from the external labor force to an organization (Schwalje, 2011). A shortage of job-related skills associated with particular occupations such as information technology (Cappelli, 2015).
- Skills mismatch: A misalignment or gap between workers skills (supply) and the skills needed to perform the job (demand) (Hine, 2013); an individual's level or type of skills does not correspond to labor market needs or the level of skills required in the job (European Quality Assurance in Vocational Education and Training [EQAVET], 2017).

Sponsor or registered apprenticeship sponsor. Either an individual employer, a group of employees, or an association or organization operating an apprenticeship program, and in whose name the program is registered (Code of Virginia §40.1-120).

Standard occupation classification (SOC) system: A federal statistical standard used by federal agencies to classify workers and jobs into occupational categories and covers all jobs in the national economy including occupations in the public, private and military sectors (U.S. Office of Management and Budget, 2018). The 2018 SOC system contains 867 detailed occupations, aggregated into 459 broad occupations which are combined into 98 minor groups and 23 major groups. See Appendix B for the 23 major groups of the SOC system.

Organization of the Study

This dissertation is organized into five chapters. This chapter provided the introduction, background or rationale for the study, statement of the problem, purpose of the study, research questions, significance of the study, an overview of the research methodology and definition of key terms. Chapter 2 will provide an overview of the relevant literature which will include an overview and history of registered apprenticeships, the skills gap and MS gap, the role of policy and legislation and the status of registered apprenticeships and the MS gap in Virginia. Chapter 3 will discuss research methodology which will include the research design, population, data collection and procedures, data analysis plan and limitations. Chapter 4 will contain the research results and findings. Chapter 5 will provide a discussion of findings, policy implications, recommendations for future research and a conclusion.

Chapter 2. Review of Literature

Registered apprenticeship is a model many lawmakers and states are using to address the MS gap. Scholarly research on registered apprenticeships and the MS gap in the United States is emerging, and limited research has been conducted on the impact of registered apprenticeships on the MS gap. More research is needed on the benefits apprenticeships provide and information that is relevant to employers to increase participation in apprenticeships (Lerman, 2014a). Accordingly, this study will investigate the impact of registered apprenticeships on Virginia's MS gap.

This chapter will provide a review of the literature regarding registered apprenticeships and the MS gap. It will begin with an examination of the skills gap, the debate of whether there is a skills gap, and defining the MS gap. Next, there will be an overview and history of registered apprenticeships; a review of RA benefits and challenges; and discuss the association between registered apprenticeships and the MS gap. This will be followed with highlights of policy and legislation pertaining to registered apprenticeships. The chapter will finish with the status of registered apprenticeships and the MS gap in Virginia.

Skills Gap

There are reports that the United States is experiencing a skills gap and predicts a shortage of MS jobs in the future (Holzer & Lerman, 2007; NSC, 2017). Specifically,

some studies have reported that many jobs are going unfilled because employers cannot find an adequate supply of workers to meet the demands of their jobs—workers do not possess the skills, experience, training, or education needed to fulfill these jobs (Carnevale et al., 2010; Hine, 2013; Levine, 2013). The skills gap is so critical it was part of the 2017 National Governors Association (NGA) summer meeting as one of the most pressing issues governors wanted to discuss (Leins, 2017). Policymakers and educators want to ensure workers obtain skills that align properly with the needs of the labor market. Per the NGA, 65% of all jobs projected within the next decade will require a postsecondary education (Carnevale et al., 2013), yet approximately 45.8% of working-age adults have obtained a postsecondary credential (Bartlett, 2018). An inability to align worker skills with the labor market could translate to unfilled jobs and lost economic opportunity for millions of workers (Bartlett, 2018). Addressing the skills gap is a critical issue for states to remain competitive in the national and global market.

Scholarly research on the skills gap is limited and primarily consists of economic analysis regarding the extent of the skills gap or whether the skills gap exists (Bivens & Shierholz, 2014; Lazear & Spletzer, 2012; Sahin, Song, Topa, & Violante, 2014; Weaver & Osterman, 2017). The term skills gap is used broadly and there is not one universal definition.

At the most basic level, the skills gap is a theory about supply and demand—there is an inadequate supply of workers with the right skills available to meet employers' demand for labor. From a worker's perspective, it is when one is unable to access available jobs due to lack of training or relevant technical experience (Path, 2016). In general, a skills gap is about skill deficiencies within an organization's workforce as defined by the American Society for Training and Development (ASTD) (2012):

> A significant gap between an organization's current capabilities and the skills it needs to achieve its goals. It is the point at which an organization can no longer grow or remain competitive because it cannot fill critical jobs with employees who have the right knowledge, skills, and abilities (p. 4).

The skills gap is often referred to as a skills shortage or skills mismatch. A skills shortage is considered a shortage of job-related skills associated with particular occupations such as information technology (Cappelli, 2015), or difficulty in recruiting individuals from the external labor force to an organization (Schwalje, 2011). A skills mismatch is when vacancies available in an industry, occupation, or location do not match the skills of the workers available (Lazear & Spletzer, 2012). A skills mismatch is also defined as a misalignment or gap between workers skills (supply) and the skills needed to perform the job (demand) (Hine, 2013); or an individual's level or type of skills does not correspond to labor market needs or the level of skills required in the jobs (EQAVET, 2017).

In general, a skills shortage relates to the external labor market while a skills gap relates internally to an organization (Schwalje, 2011). Keith Marshall, the Chief Executive of Summit Skills in the U.K. states, the difference between a skills gap and a skills shortage is that "a skills gap can be filled by further training of the existing workforce, whereas overcoming a skills shortage requires the recruitment of more people into the industry" (Marshall & Bartley, 2004). Overall, a skills gap and a skill shortage are forms of a skills mismatch (Cappelli, 2015).

A skills mismatch does not necessarily imply that workers need more education, skills, or experience but rather, that the qualifications they have simply do not match what is in demand (Hine, 2013). For example, mismatches could be vertical, horizontal, or geographical. Vertical mismatches occur when one's skill or education is more or less than what is required to perform

a job; horizontal mismatches are when the type of education or skills are not appropriate for the job (e.g., one is employed in an occupation that is unrelated to their principal field of study); and geographical mismatches are when one's types and level of skill or education are based in a country or region different from where the skills are needed (EQAVET, 2017). The term skills mismatch is very broad and can refer to a variety of concepts. See Appendix C for a summary.

For the purposes of this paper, the term skills gap refers to both a skills mismatch and a skills shortage and will be referred to as skills gap in both cases. Determining whether there is a skills gap or the extent of the skills gap depends on how the skills gap is defined and measured. This study measured the skills gap based on employer demand for skilled labor to fill an occupation minus the supply of skilled labor. Skills gap measurement will be further discussed in Chapter 3.

The Law of Supply and Demand

In terms of a theoretical framework, a skills gap or mismatch is viewed in terms of the law of supply and demand. The law of supply and demand describes the interaction between the supply of a resource, the demand for that resource, and its impact on price. In general, when there is a low supply and high demand, prices increase; and when there is a high supply and low demand, prices decrease. When supply and demand are in balance, the economy is said to be in equilibrium between price and quantity.

Likewise, the skills gap is viewed in terms of labor supply, labor demand and wage (price). Weaver and Osterman (2017) state that "a skill gap implies that the quantity demanded for a particular skill exceeds the quantity supplied" (p. 279). Thus, when the demand for skilled labor exceeds the supply (demand > supply), there is a deficit in human capital and it is considered a skills gap, skills shortage, or skills mismatch. There is an insufficient number of

workers with a specific set of skills and wages should increase. If the supply is greater than the demand, there is surplus in human capital—wages should decrease and the workers education level is more than required (over-education or underemployed) (Green, 2016).

In both cases, we have an imbalance or disequilibrium in the labor market. Zurn, Dal Poz, Stilwell, and Adams (2004) explain that "a skill imbalance [shortage or surplus] occurs when the quantity of a given skill supplied by the workforce and the quantity demanded by employers diverge at the existing market conditions" (p. 1). Labor market supply and demand for occupational skills fluctuate continuously, thus a shortage or surplus is the result of a disequilibrium between the demand and supply for labor (Zurn et al., 2004).

When an imbalance occurs, the question becomes, how long will it last? Is the imbalance temporary or permanent? Economic theory suggests that some skill imbalances (such as the skills gap) are a feature of a competitive market and most labor imbalances are temporary in nature as markets will adjust over time to alleviate the gap (Modestino, 2016; Shah & Burke, 2003). For example, when the demand for skilled labor exceeds supply, the economy will adjust—the wages of skilled workers will increase relative to those of unskilled workers. In the short run, rising wages will encourage greater labor market participation and influx inflow of skilled workers to help alleviate the shortage (Modestino, 2016). In the long run, "higher returns to skilled labor will encourage individuals to obtain more education and training and create incentives for firms to find innovative ways to increase labor productivity" (Modestino, 2016, p. 7). Imbalances tend to disappear faster the greater the reaction speed of the market and also the greater the elasticity of supply or demand (Zurn et al., 2004).

However, when an imbalance between labor supply and demand persists for long periods of time, a static imbalance occurs because supply does not increase or decrease. For instance,

wage adjustments may respond slowly to shifts in demand or supply as a result of institutional and regulatory arrangements, imperfect market competition (monopoly, monopsony), wages are constrained by wage control policies, and the lack of (or timeliness of) information to make adjustments to the increase of labor demand (Modestino, 2016; Zurn et al., 2004). Another possibility for a long imbalance is when demand continually grows more rapidly than supply (Modestino, 2016). For example, technological advancements have been shown simultaneously to increase the demand for educated workers while replacing those who are less skilled through automation (Modestino, 2016). Whereas supply side constraints such as lengthy training requirements, licensing laws, or demographic shifts (e.g., slower population growth) may restrict the supply of skilled labor for long periods of time in key occupations such as nursing and information technology (Modestino, 2016).

Factors that can shift the demand curve for labor include: a change in the quantity demanded of the product that the labor produces (demand for output); a change in the production process that uses more or less labor (i.e., technological advancements); government regulations—a change in government policy that affects the quantity of labor that firms wish to hire at a given wage (i.e., government rule may require only nurses to implement a certain medical procedure); workers' level of education and training; the number of companies in the market; and technology (OpenStax Economics, 2016).

The main factors that can shift the supply curve for labor include how desirable a job appears to workers relative to the alternatives (i.e., geographic location, wages, work environment, etc.); government policy that either restricts or encourages the quantity of workers trained for the job (i.e., executive orders for expanding apprenticeships and subsidized training); the number of workers in the economy and required education (the more education required, the

lower the supply) (OpenStax Economics, 2016). Overall, the factors that can shift the demand or supply curve for labor are factors that can contribute to a skills gap/mismatch.

The imbalance in the labor market (supply and demand) contributes to a skills gap/mismatch in our economy. Researchers have posited that structural factors, such as geographic mobility or shifting industry demands have driven a wedge between supply and demand, thus generating economic inefficiency and in some cases structural unemployment. Whether unemployment is structural (when workers do not have the skills employers are demanding or workers have some barrier to finding work that cannot be solved by boosting aggregate demand relative to potential supply (Bivens & Shierholz, 2014)) or cyclical, employers are having difficulty in finding employees (supply) with the specific skills to meet the employers demand. To help determine the extent of Virginia's MS gap, this study measure Virginia's skills gap for MS occupations in terms of supply and demand.

Skills Gap Debate

The skills gap debate is centered on the question of whether the current workforce is sufficiently skilled for current and future jobs or careers. In recent years, it has been widely publicized in the media there is a skills gap occurring in the United States primarily based on studies sponsored by trade organizations, business groups, and higher education organizations (Bridgeland, Milano, & Rosenblum, 2011; Cappelli, 2015; Dobbs et al., 2012; Giffi et al. (2015); Manpower Group, 2015; Morrison et al. 2011). However, there are many studies that say the contrary—a skills gap does not exist (Bivens & Shierholz, 2014); the skills gap is temporary (Lazear & Spletzer, 2012); and the skills gap is not significant or it is overestimated (Weaver & Osterman, 2017). Despite the debate and contradictory studies, it is still widely assumed that the

United States is suffering from a skills gap because employers are having difficulty filling positions and it is a problem in need of intervention (Eathington & Swenson, 2015).

Skills Gap Believers vs. Nonbelievers.

Currently, there are 7.1 million job openings in the United States (USDOL-BLS, 2019a). The Manpower Group (2015) reports that 32% of employers in the United States (and 38% globally) have difficulty in filling jobs. In manufacturing alone, experts estimate that 2 million jobs will go unfilled over the next decade due to the skills gap, and similar shortages are predicted in health care and information technology industries (Ladika, 2016). From a small business perspective, the National Federation of Independent Business reported that 45% of small businesses were not able to find qualified applicants to fill job openings as of the first quarter in 2017 (Kaplan, 2017). Globally, The McKinsey Global Institute predicts by 2020, there will be a shortage of 38-40 million high-skill workers (or 13% demand for such workers), a shortage of 45 million MS workers (15% of the demand for such workers), and a surplus of 90-95 million low skill workers (ASTD, 2012; Dobbs et al., 2012).

Skills Gap Believers. Research indicates the U.S. education and workforce development systems are not producing enough skilled workers to meet the future workforce demand and the traditional educational pipeline has not been adequately meeting employers' needs to produce workers with skills that are relevant in today's workplace and for jobs in high demand (Burrowes, Young, Restuccia, Fuller, & Raman, 2014; Lerman, 2012; NSC, 2017; Olinsky & Ayres, 2013). Based on research analysis (survey of employers) by Harvard Business School, Burning Glass and Accenture, employers are stating the available talent is not meeting their standards (Burrowes et al., 2014). Additionally, Carnevale, Smith, and Strohl (2013) state that by 2020, 65% of all American jobs will require some form of postsecondary education, training or

credential beyond high school and 33% of all U.S. jobs will require some college, an associate's degree, or a postsecondary vocational certificate. Their study further states at the current production rate, the United States will fall short of five million workers needed with postsecondary credentials by 2020 (Carnevale et al., 2013) due to the increasing share of jobs requiring some form of postsecondary education, such as MS jobs.

In a more recent analysis, the NGA found that approximately 45.8% of working-age adults have obtained a postsecondary credential (Bartlett, 2018) which is falling short of the 65% projected jobs requiring some form of postsecondary education. Declining rates of postsecondary credential attainment threatens both our global competitiveness and the ability to generate prosperity at home because if employers are not able to find the appropriately skilled workers, they may move their jobs overseas if they cannot find the appropriately skilled workers (U.S. Department of Labor Employment and Training Administration [USDOL-ETA], 2010). In general, academics and consulting firms argue that the inadequate or weak skills of many American workers are leading to skill shortages, limiting potential economic growth and the ability of businesses to remain competitive in the national and global market (Carnevale et al., 2010; Lerman, 2016; Morrison et al., 2011).

Skills Gap Nonbelievers. Despite the above statistics, skeptics say there is no evidence of a skills gap (such as wages would be rising and employers would be investing in more training); instead, employers are primarily experiencing hiring difficulties such as an employer having unattractive wages, work hours, or geographic location (Cappelli, 2015; Leibert, 2013; Levine, 2013). According to Levine (2013), "The consensus among top economists is the skills gap is a myth; high unemployment is mainly the result of a deficiency in aggregate demand and slow economic growth, not because workers lack the right education or skills" (p. 4).

Furthermore, many experts reject the skill-shortage or gap theory and assert that skills are not in short supply in the United States (Cappelli, 2015; Weaver & Osterman, 2017). Specifically, Cappelli (2015) argues that there is not a skills gap or shortage, but there is a skills mismatch in which the average work or job candidate has more education than the current job requires. This is primarily based on a study by Vaisey (2006) that showed the average worker in the United States is overqualified for his job. This is consistent with studies in European countries that have found that with skills mismatches, being overskilled is much more of a widespread problem than being under-skilled (Cappelli, 2015, Sutherland, 2012).

For example, Weaver and Osterman (2017) found in their study of manufacturers that less than a quarter (16% to 25%) had a skills gap and that three-quarters of U.S. manufacturing plants did not show signs of hiring difficulties. They further stated, "The majority of manufacturers do not face significant obstacles in accessing skilled production workers" (Weaver & Osterman, 2017, p. 18). Eathington and Swenson (2015) stated that Weaver and Osterman's (2014) findings found that the skills gap was not significant or was overestimated, and was impacted on how they measured the skills gap. However, Weaver and Osterman's (2017) survey is the first, to their knowledge, to directly measure concrete employer skill demands and found manufacturers tend to overestimate their worker shortages if survey questions were not crafted properly or the surveys were not administered to the right person.

While economic indicators show a historically high number of job vacancies, many experts believe that the skills gap plays a limited role, if any (Lazear & Spletzer, 2012; Sahin et al., 2014). Using job vacancy data, Sahin et al. (2014) and Lazear and Spletzer (2012) examined whether the skills mismatch contributed to the recent rise in U.S. unemployment in relation to the recession. The Sahin et al. (2014) study found that the mismatch may be responsible for up to

one-third of the recent rise in the unemployment rate across industries and occupations whereas a geographical mismatch across states or counties plays no role. The mismatch at the industry (2 digit) and occupation level (2- and 3-digit) increased markedly during the recession, but declined throughout 2010, an indication of a cyclical pattern in mismatch (Sahin et al., 2014). Thus, Sahin found only temporary mismatches during the 2007 Great Recession and those mismatches disappeared as business conditions improved (Eathington & Swenson, 2015).

Likewise, Lazear and Spletzer (2012) found no skills mismatches across industries and occupations that were lasting. Lazear and Spletzer (2012) analyzed labor market data and unemployment data relating to the 2007 recession and found that although the skills mismatch increased during the recession, it retreated after the recession across occupations and industries—the skills mismatch was temporary and cyclical, not structural. Lazear and Spletzer (2012) claim that there is no evidence that the recession resulted in a long-lasting skills gap which would require retraining experienced workers to work in different industries or reinvestment in skills or physical capital. The skills gap is not the reason for the higher unemployment rate—the unemployment rates were higher generally across all industries and occupations (Lazear & Spletzer, 2012).

Economic theory, the law of supply and demand, tells us that if the supply of qualified workers were limited, the few workers who had the desired skills would be able to command higher wages. Likewise, Cappelli (2015) states that if there was a skills gap or shortage, wages would rise; employers would raise wages to attract better applicants with the attributes to fit their job requirements, and employers would lower wages if an excess supply of such applicants exists. Overall, there is little evidence that the economy is suffering from an unusually large

skills gap because there is no evidence of rising wages in the market (Cappelli, 2015; Weaver & Osterman, 2017).

Yet, the Lazear and Spletzer (2012), Sahin et al. (2014) and Weaver and Osterman (2017) research indicates there is a skills mismatch or gap but it is considered temporary or not as significant as employers or business or trade organizations claim. In general, the research, economists, and skeptics consider the skills gap is minimal or cyclical. Similar to the "skills gap believers," this study takes the position that employers in the United States are having difficulty in filling positions (Manpower Group, 2015, 2018), the available talent is not meeting employer standards (Burrowes et al., 2014), and the United States is suffering from a skills gap (Eathington & Swenson, 2015).

Economic Impact

From an economic standpoint, the skills gap has an affect across all aspects of a businesses' operation and impacts their bottom line. According to Manpower's 2015 Talent Shortage Survey, 54% of employers say the talent shortages will impact their ability to serve client needs, and of these employers, the consequences are expected to include: reduced competitiveness and productivity (42%), a reduced ability to serve clients (42%), increase in employee turnover (32%), lower employee engagement and morale (26%), reduced innovation and creativity (25%), and higher compensation costs (25%). Employers that are unable to fill key positions are not as efficient; their output suffers and their associated industries are also impacted.

Additionally, when companies are not able to perform efficiently at their full potential, the economy suffers (locally, regionally, and nationally) due to lost sales revenues and the reduction in local supply-chain purchases (Economic Modeling Specialists International [EMSI],

2017). Furthermore, the impact of a skills shortage depends on the degree to which the gap reflects an efficiency constraint or output constraint (EMSI, 2017). For example, employers operate in a less than optimally efficient manner because they cannot find the necessary talent; or employers may have an opportunity to expand their output and market share, but they have a shortage of key workers (EMSI, 2017). As a result, this may cause an imbalance or disequilibrium in the labor market.

It is important to examine the skills gap regionally and locally because the skill and economic needs vary on a regional or local basis. For example, on a national level, it is typically stated there is a skills gap in computer technology, health care, and manufacturing. However, in Austin, TX and San Francisco, CA there is a shortage of workers with business management and leadership skills; in St. Louis, MO and Minneapolis, MN there is a shortage of workers with public policy experience (LinkedIn, 2018). Understanding and addressing the skills gap on a local and regional basis is economically crucial. That is why the USDOL is using the Workforce Innovation and Opportunity Act as a vehicle to help address the skills gap by promoting the alignment of workforce development programs with regional economic development strategies (e.g., sector partnerships) to meet the needs of local and regional employers (Maurer, 2015). Overall, the skills gap has consequences, such as economic costs, for employers, local industries, regions and the nation.

What is Causing the Skills Gap?

Overall, the skills gap is a complex issue in which there are different opinions as to the cause. According to the USDOL, some of the factors that contribute to the skills gap include not enough of the right graduates or job seekers with the appropriate skills or experience, poor yields from automated job match programs, reluctance of employers to provide training, inadequate

compensation provided by employers, and a growing need for employers with soft skills (USDOL, 2017b).

Not Enough of the Right Graduates

There are not enough people trained for the in-demand jobs and occupations such as health care, engineering, and advanced manufacturing. For example, a candidate may have the credential but not the appropriate experience. In studies by Hine (2013) and Leibert (2013), positions requiring higher levels of experience (3 or more years) were substantially harder to fill than those requiring less experience. In a survey of employers from the Liebert (2013) study, inadequate hands-on experience, inadequate applicants' experience, and overall low number of applications for openings were cited as reasons employers had difficulty hiring candidates. Furthermore, the Manpower Talent Shortage Survey (2018) states that 45% of employers cannot find candidates with the skills they need; 20% said the candidates lacked experience; and 19% said applicants lack required hard skills or technical competencies.

Poor Yields From Automated Job Match Programs

Some employers create job descriptions with a list of ideal requirements most applicants will not meet, resulting in low match rates and few potential candidates—the job description rules out more candidates. According to Burning Glass Technologies (BGT) (2014), employers are seeking candidates with bachelor's degrees for jobs that formerly required less education, even when the skills required have not changed. A recent report by BGT found that 65% of online vacancies for executive secretaries and executive assistants now call for a bachelor's degree, but only 19% of those currently employed in these roles have a B.A. (BGT, 2014; Modestino, 2016). Additionally, BGT (2014) found that entry level information technology help desk positions had little difference in the skill requirements for jobs requiring a college degree

and those that do not (also, the skill sets indicated in the job posting do not include skills typically taught at the bachelor's level). Modestino (2016) suggests that employers may be relying on a B.A. as a broad recruitment filter that may or may not correspond to specific capabilities needed to do the job.

Reluctance of Employers to Provide Training

Many employers prefer that job seekers or employees provide their own training. Studies show that employer investment in training has declined and according to an ASTD (2012) member survey, 46% of state training investments have been cut or there is a lack of leadership commitment to employee learning and development. Additionally, Capelli (2015) has stated that developing the skills employers want has been transferred from the employer to the job seekers and schools (Acemoglu & Pischke, 1999; Cappelli, 2015).

Employers Offer Inadequate Compensation

Some organizations cannot find candidates because the pay offered is not competitive with other employers for in-demand jobs in a competitive environment. For example, the Hine (2013) and Leibert (2013) survey of employers found that employer demand factors such as wages, hours, or location contributed to hiring difficulties; and according to the 2018 Manpower Talent Shortage Survey, 12% of employers said applicants expected higher pay than offered.

Growing Need for Soft Skills

Many employers seek candidates or employees with soft skills (i.e., communication, collaboration, and critical thinking) that many people do not have. According to Burrowes et al. (2014), 44% of executives indicated it was difficult to fill jobs because candidates lacked soft skills like communication and critical thinking (Adecco, 2013), and the 2018 Manpower Talent

Shortage Survey found that 8% of employers said applicants lack required soft skills (Manpower Group, 2018).

Other factors contributing to the skills gap include an insufficient pipeline of new workers with the in-demand skills, and the decline in interest in manufacturing (MS jobs) due to high school counselors emphasizing college (Ladika, 2016; Leibert, 2013). Overall, believers say the skills gap exists because there is an aging workforce of highly skilled and experienced workers (ASTD, 2012), the baby boomers are retiring and taking the knowledge with them (Dixon, 2017), there is a deficit of training programs (ASTD, 2012; Whitehouse, 2017), employers' investment in training and reskilling their employees has declined (Dixon, 2017), and technological advancements are requiring new skills (ASTD, 2012; Dixon, 2017). Today's factories employ fewer people but require employees to have greater levels of technical knowledge (ASTD, 2012; Dixon, 2017; Whitehouse, 2017). Whether one considers it a skills gap, skills mismatch, or hiring difficulty, there are employers having difficulty filling positions and it is having an economic impact.

The MS Gap and MS Occupations

Not only is there a skills gap, there is a specific gap for MS occupations, jobs that require education or training beyond a high school diploma but less than a 4-year college degree (e.g., associate degree, postsecondary certificate, apprenticeship, etc.) (Eathington & Swenson, 2015; Holzer & Lerman, 2007; Modestino, 2016; NSC, 2017; Virginia Community College System [VCCS], 2015). The MS gap refers to a situation created when significant numbers of MS jobs (identified via occupations in the Standard Occupation Classification system) remain unfilled because employers cannot find people with the appropriate skills to fill them. Historically, MS jobs were available to those with a high school diploma (or less) and served as the springboard

into the middle class (e.g., manufacturing, electrician, policeman, welders, etc.) (VCCS, 2015). However, MS jobs are in the midst of a transformation from traditional blue-collar jobs to more skilled technical jobs (e.g., nursing and teacher assistants, computer and automotive technicians, database and information clerks, etc.) (Carnevale et al., 2018). In 1979, four MS occupations (sales, office, and administrative workers, production workers, and laborers) accounted for 60% of employment in 1979; in 2007, this number was 49%; and in 2012, it was 46% (Autor, 2015).

Economic trends such as globalization, automation, and the shift from manufacturing to skilled services have contributed to the decline in traditional manufacturing blue collar jobs (Carnevale et al., 2018). Since the 1980s, employment has shifted toward professional service industries (such as information technology, finance, and health care) which have relatively higher concentrations of workers with postsecondary education and training, at the expense of traditional factory or blue-collar jobs (Carnevale et al., 2016). For example, between 1991 and 2016, more than 20 million jobs were created in the skilled services for people with a BA and 2.7 million jobs for middle-skills; whereas the number of blue collar jobs for high school level shrank slightly (-200,000) (Carnevale et al., 2018). Additionally, individuals with a high school diploma or less have faced a net loss of more than 5.5 million jobs since the 2007 recession (Carnevale et al., 2016; Bartlett, 2018). The changes in production and the introduction of new or advanced technology is requiring education and training beyond high school to fill these MS jobs.

Middle-skill jobs make up more than half of the U.S. labor market. According to the NSC (2017), 53% of all jobs in the United States were MS in 2015 and only 43% of U.S. workers were trained at the MS level. Furthermore, 48% of job openings from 2014 to 2024 are expected to be MS jobs (Kochan et al., 2012; NSC, 2017).

In terms of location, rural workers are more likely to hold MS jobs than urban workers. In 2012, 51% of workers in rural areas held MS jobs as compared to 42% of workers in urban and suburban areas (Young, 2013). According to Young's (2013) research, MS jobs in rural areas has been relatively stable from 2003 to 2012, yet in the urban areas, there has been a slow and steady decline. However, the dominance of MS jobs in rural areas could be the result of the job market or demand side factors—rural America has a greater prevalence of jobs in manufacturing and agriculture sectors, industries in which MS jobs are more common (Young, 2013).

The significance of MS jobs is highlighted in a 2018 report by the U.S. Congress Joint Economic Committee which states that "Middle-skills jobs make up one-third of all jobs in the United States, have an average annual salary of more than $45,000, are projected to remain in demand in the future" and are among the top 30 fastest growing occupations (Heinrich, 2018, p. 2). However, there are mixed reports on the growth of MS jobs in relation to low and high-skill jobs. Many economists argue that MS jobs are declining or "hollowing out" as a result of automation (digital technologies replacing routine work tasks), the recession, and globalization (Autor, 2010, 2015; Holzer, 2015; Tüzemen & Willis, 2013). The economy has increased its demand for high-skilled (high-wage) workers and low-skilled (low-wage) workers, while opportunities for MS (middle-wage) jobs have declined (Autor, 2010; Canon & Marifian, 2013). Known as job polarization, this is demonstrated by data that shows that wages and employment for mid-level jobs declined over the last 25 years, while wages for workers at the bottom and top of the wage distribution (low-skill and high-skill workers) have increased (Autor, 2010; Norris, 2015).

Although MS jobs appear to be declining, there is another set of MS jobs that are growing consistently. Research by Holzer (2015) indicates that the traditional or older middle-

jobs (i.e., construction, production, clerical) that require little education (high school diploma or less) are declining rapidly; whereas "newer" MS jobs requiring more complex technical or communication skills and postsecondary education and training (i.e., health care, mechanical maintenance, skilled trade and repair) is consistently growing. While some of the tasks in many of the current MS jobs are prone to automation, there will be a demand for MS jobs that combine routine tasks with nonroutine tasks (e.g., interpersonal interaction, flexibility, adaptability, and problem solving) (Autor, 2015; Holzer, 2015). These newer MS jobs will persist in the future (Autor, 2015).

Despite the projected decline of traditional MS jobs, there is a need for people with the appropriate skills to fill the projected MS job openings of 48% (NSC, 2017). According to the Georgetown Center on Education and Workforce, it is estimated that nearly two-thirds (65%) of American job openings in the next decade (by 2020) will require some form of postsecondary education and skills training beyond high school (Carnevale et al., 2013). Of these job openings, at least one third (30%) will require an associate's degree, technical certificate, or industry credential to fill the growing number of MS job openings in the country (Carnevale et al. 2013; Olinksy & Ayres, 2013; Steigleder & Soares, 2012). Employers are complaining that they are having difficulty in filling MS positions. This is exemplified in a 2014 Accenture and Harvard Business School survey of more than 800 human resource executives across 18 industries which found that 56% of respondents had trouble filling MS jobs, and 69% said attracting and retaining MS talent affects their company's performance (Burrowes et al., 2014; Ladika, 2016).

Overall, reports indicate there is a demand for newer MS jobs—jobs that combine routine technical tasks with nonroutine technical tasks including interpersonal interaction, flexibility, adaptability and problem solving skills (Autor, 2015) such as technical, healthcare, and skilled

services (Autor, 2015; Carnevale et al., 2018; Holzer, 2015; Modestino, 2016). It is projected that the supply of MS workers is not keeping pace with the demand. Modestino (2016) states that by 2022, the number of MS workers overall is likely to fall short of the demand by 1.3 million and the number of MS jobs overall is projected to exceed the number of MS workers by 3.4 million. Many experts believe that the shortage of skilled workers could undermine U.S. competitiveness, hamper future economic growth, and encourage firms to shift operations abroad (Kochan et al., 2012; Lumina Foundation, 2014; Modestino, 2016). Overall, "the U.S. can and must close the middle-skills gap to remain competitive, remedy wage stagnation and raise living standards" (Kochan et al., 2012, p. 90).

Defining MS Occupations and MS Workers

How do we define or classify MS jobs and MS workers? In the U.S., economists have primarily defined MS jobs by using the USDOL-BLS SOC system occupational categories using either education attainment, wages, or a combination (Rothwell, 2015; Scagolione, 2018). These approaches rank occupations by wages or educational requirements and consider MS jobs to fall within the distribution. For example, Holzer (2015) defines MS jobs as occupations with hourly wages between 75% and 150% of the median hourly wage (having earnings between 75% and 150% of the U.S. median wage). Autor (2010) also used the average wage of workers as a proxy for skill to classify occupations at the 3-digit SOC level. While, Holzer (2015) acknowledges that "middle-wage" and "middle-skill" jobs are not always identical and decisions on how to classify these occupations can affect measure outcomes, Holzer treated middle-wage jobs as a valid approximation to middle-skill jobs in his study (Scaglione, 2018).

In contrast, education requirements (plus on-the job training and work experience) of occupational categories is the most commonly cited method for defining MS jobs (Scaglione,

2018). Eathington and Swenson, (2015), Holzer and Lerman (2007), Modestino (2016), NSC (2017), and Young (2013) used the definition that MS jobs requires an education and training beyond a high school diploma but less than a bachelor's degree. This would include a high school diploma and one of the following: associate's degrees, vocational certificates, apprenticeship, significant on-the-job training, previous work experience or some college without an earned degree.

There are strengths and weaknesses in using these methods. As Holzer (2015) has noted, using wages to gauge MS jobs can be misleading because workers in the middle of the wage distribution may be relatively unskilled but compensated well because of union contracts or other characteristics of the industries in which they commonly work (Rothwell, 2015). Likewise, some low wage jobs may be relatively skilled but experiencing negative wage trends as a result of trade or technological change (Holzer, 2015). Using educational requirements can also be misleading because there is tremendous variation in the practical skills or work experience of people who drop out of college after taking remedial courses, compared to those who earn a technical degree from a strong community college program and do not have the skill or work experience.

Depending on the approach used to define or classify MS jobs, estimates of MS jobs as a proportion of U.S. jobs can vary as much as 40 percentage points (Scaglione, 2018). For example, the NSC (2017) estimates 52% of jobs in the United States are middle-skilled using educational requirements; Holzer (2015) estimates 37% of the U.S. jobs are middle-skilled based on middle-wage occupations, and Rothwell (2015) estimates 12% of the U.S. jobs are MS base on occupation specific skill demands. Thus, depending on the approach used, some jobs may fall into the category of middle-skilled and some may not. This could have implications on whether

there is a MS gap or determining the extent of the middle skills. Empirical definitions or classifications of MS jobs can also have implications on our understanding of the dynamics of the labor market, which in turn, may influence workforce development and postsecondary education policies, as well as impact critical decisions made by colleges and universities regarding which academic programs are considered high-demand and approaches to career advising that emphasize some occupations over others (Scaglione, 2018).

To identify or classify MS workers in the labor force, researchers typically use education level of the workforce as a proxy for skill primarily due to data limitations. Nationally representative demographic surveys that cover work and education experiences generally do not ask about other types of training or particular skills acquired except for high school, some college with no degree, associate's degree, bachelor's degree, graduate, or professional degree (Modestino, 2016; Rothwell, 2015). Similar to Eathington and Swenson (2015), Holzer and Lerman (2007), and Modestino (2016), this study classifies MS job occupations based on the UDOL-BLS detailed occupational categories using educational criteria (beyond high school but less than a 4-year degree). This study identifies MS workers using their education level based on educational and training requirements.

Overview and History of Registered Apprenticeships

Registered apprenticeship is a work-based learning career-training program that meets national standards for registration with the USDOL, in which an individual receives on-the-job training in combination with classroom instruction that leads to a nationally recognized credential while being paid (Reed et al., 2012; USDOL, 2017a). Apprenticeships are also known as "earn-while-you-learn" concept and consist of five components: business involvement-employers are the foundational component; structured on-the-job training—provided by an experienced mentor; job related instruction—provided by the employer or educational

institution*;* rewards for skill gain—wages increase as the apprentice gains higher level of skills; and a nationally recognized credential—apprentice receives an industry credential upon program completion (USDOL, 2017a).

The goals of the U.S. apprenticeship system are to increase the skills of American workers, to raise their productivity and earnings, and to raise the competitiveness of the United States (Lerman, 2013b, p. 140), and the purpose of a RA program is to enable employers to develop and apply industry standards to training programs that can increase productivity and improve the quality of the workforce (USDOL-ETA, 2007). The registered apprenticeship is an employer demand-driven model for competency development and skill mastery of an occupation for workers (supply). In general, registered apprenticeships create skilled or intermediate/middle-level workers for the labor market and are viewed as a pathway to developing skills above those required for competence in semiskilled jobs (low-skill) and below that required for graduate level or bachelor degree level employment (high-skill) (Fuller, 2016).

Having a skilled workforce is crucial for business' to be competitive in today's economy. Automation and globalization has led employers to demand higher-level skills of workers to remain competitive, and the need to upskill their workforce. Carnevale et al. (2018) state, "The new technology, combined with a new competitive requirements has increased both the depth and scope of competencies required on the job, accelerating the demand for an upskilled workforce" (p. 7).

Apprenticeships are a demand-driven model that helps employers address their need for skilled labor and to upskill their workforce. Per the USDOL, apprenticeships are considered good for employers because apprenticeships help recruit and develop a highly skilled workforce that helps grow a business, improve productivity, and have a positive impact on the bottom line,

provides opportunities for tax credits in some states, reduces turnover costs and increases retention, and creates industry-driven solutions to meet local and national business needs (USDOL, 2018d). This is supported by the Helper et al. (2016) study which states there is much qualitative evidence that apprenticeship is good for employers, and the need for skilled workers was the most common factor why employers use apprenticeship.

From the employee perspective, RA programs offer workers a way to start new careers with good wages and are a proven gateway to the middleclass (USDOL, 2015b). Apprenticeships give people the opportunity to earn a good living as a middle class person without going to college 4 or more years. The average annual salary for a person who completes an apprenticeship is $50,000 and over eight in10 graduates retain their employment 9 months after exiting their apprenticeship training (USDOL, 2015a, 2017a).

Registered apprenticeships are considered the "gold standard" of on-the-job training and are considered a powerful tool to close the MS gap (NSC, 2017) because they are considered a proven method of job preparation that will help people develop in-demand job skills that meet employers' needs (Helper et al., 2016; USDOL, 2017a). In the United States, there have been over 282,000 RA graduates since FY2014 and over 2MM apprentice participants since FY2015 (USDOL, 2018c). The RA system is one of the few mechanisms for improving both the supply and demand sides of the labor market (Lerman, 2018).

Human Capital, Signaling and Screening Theories

When the skills of our workforce or human capital is not meeting employer demand in the labor market, a skills gap or mismatch occurs. Human capital theory emphasizes the supply side of the labor market and suggests that investing in human capital (the education, knowledge,

and skills of individuals) will yield improved economic results for both the individual and society. Becker's (1993) human capital theory proclaims that the well-being of a society is a function not only of the traditional stocks of financial capital, labor, and natural resources, but also of human capital, the knowledge and skills of individuals (either innate or acquired) that contributes to his or her productivity.

Education and work-based learning activities (such as apprenticeships and on-the-job training) are key elements of human capital theory because it is seen as a means of developing knowledge and skills. Human capital theory explains the investment that employers make when they provide training, learning opportunities, and resources for their workers to obtain the necessary technical and occupational skills needed to be successful within their organization. Likewise, students invest their time and talents into a work-based learning program such as apprenticeships, with the expectation that the training, education, skills and nationally recognized credential acquired will give them a competitive advantage in the labor market. For example, if employees are able to improve their productivity through training, the organization can benefit by being more successful than its competitors and consequently, recovering the cost of training and the employee will be rewarded in the form of an increased salary and/or credential (Basit et al., 2015). Therefore, investment in education and training (such as registered apprenticeships) yields positive returns to the individual, organization, and community (Arthur-Mensah, 2015; Becker, 1993).

Conversely, one of the major arguments to human capital theory and a concern of RA sponsors is losing workers they train to other employers and not recouping the training costs because of "poaching" (Lerman, 2012). This concern relates to classical human capital theory which posits that employers will not pay for general-skills training; firms will only invest in

specific training valuable or relevant to that firm (Becker, 1964). Becker's human capital theory argued that general skills will be financed exclusively by workers since they can leave their employers at any time and take their investments with them, while specific skills will be partly financed by employers, since the external market for such skills is more limited (Lerman, 2014b; Muehlemann & Wolter, 2006). However, training literature indicates that firms are willing to invest for general training when there is an imbalance in the labor market, if there is a positive probability that the apprentice will remain within the firm after the training period, and the if worker will accept a wage below their productivity for a period of time (Muehlemann & Wolter, 2006, p. 4).

Firms will only offer apprenticeship positions if it is already profitable during the training period, or if they are able to recoup their investments after the training period (Muehleman & Wolter, 2006, p. 5). See Appendix D, the time paths of marginal product and wages for apprentices. In the case of registered apprenticeships, apprentices receive lower wages in the early stages to offset their lack of productivity and training costs. As the apprentices' knowledge and skills increase, they become more productive (while still receiving relative low wages) and help employers to recoup their investment before the apprentice receives the market wage rates at the end of their apprenticeship program (Fuller, 2016, p. 428). Although registered apprenticeships have been considered general training, Geel, Mure, and Backes-Gellner (2011) argued and demonstrated that apprenticeship training is not general but rather occupationally specific. Thus, registered apprenticeships appear to align with human capital theory (Fuller, 2016) in that firms are willing to pay for registered apprenticeships as long as the training is specific to and helps meets the employers' training needs, such as filling a skills gap.

Additionally, firms are willing to pay for general training because it is costly for firms to replace workers who quit. Furthermore, specific and general skills are often considered complementary. The more general skills a worker possesses (including occupational skills), the more productive that worker is likely to be after acquiring firm-specific skills (Lerman, 2014b).

Human capital theory postulates that individuals invest in education and training (including credentials) in the hope of earning a higher income and to be more competitive in the labor market. Credentials (such as educational diplomas, certificates, and degrees, RA certificates, occupational licenses, industry-recognized, or professional association certifications) hold value to employers in the market place because a credential sends a signal that the job seeker has acquired the skills, knowledge, or competencies that are relevant to the position. This is the basis of the signaling and screening theories.

For example, an apprentice receives a nationally recognized credential upon completion of the program. That nationally recognized RA credential signals to employers that a job seeker has a particular set of skills the employer is seeking to fill the job or their skills gap. Thus, the RA credential could potentially have an impact on closing the skills gap.

Signaling theory offers insights into how credentials or occupational certifications enhance marketability of the certificate holder in the labor market. Signaling theory suggests that while individuals differ in their abilities with respect to various kinds of jobs, these differences are not immediately evident to the employer at the time of hiring or soon after (Spence, 1981). Spence's (1973) signaling theory utilized the labor market to model the signaling function of education and the idea that investment in education could be undertaken as a signal to prospective employers. For example, potential employers lack information about the quality of job candidates; therefore, the job candidates obtain education to signal their quality and reduce

information asymmetries (Connelly, Certo, Ireland, & Reutzel, 2011). By choosing to invest in education and obtaining a credential, highly productive workers distinguish themselves from less productive workers; therefore, education serves as a credible signal of unobserved productivity, and it is rewarded with a higher wage (Kübler, Müller, & Normann, 2008). An implication of the model is that more educated workers receive higher pay because education provides them with a credential rather than because of acquired skill (Page, 2010). Utilizing registered apprenticeships as a vehicle to upskill or train individuals will help address employers' needs in filling the skills gap, because a RA credential signals to employers that an individual has specific competencies and skills, especially for middle-skill jobs since most RA programs are tailored to training people for middle-skill level.

Labor market signaling enables labor market screening where job seekers signal and employers screen. Employees use education to signal their productivity to employers; whereas employers screen and filter out potential employees with a minimum level of training and education credentials (Dobbs et al., 2008). Overall, signaling theory suggests that job seekers who have credentials in occupational fields that are recognized by industry (such as registered apprenticeships) have a competitive advantage over those who do not have a credential.

Overall, human capital theory and signaling theory attempt to explain the causal relationship between education and earnings. Both models imply a positive correlation between years of education and labor market earnings. Becker's (1993) human capital theory argues that investments in education increase a workers productivity, thereby enhancing human capital, and this increased productivity results in increased earnings in the labor market. Whereas, signaling theory holds that education only reflects innate human capital and that innate human capital is what increases productivity and leads to higher wages, not education itself (Kjelland, 2008; Tan,

2014). Thus, education may increase a person's wage without increasing his or her productivity. With registered apprenticeships, an apprentice receives both education (a nationally recognized credential at the end of the apprenticeship program) and productivity (the acquired skill via on-the-job training).

Registered apprenticeships are considered a tool to improve the supply of human capital as well as a tool or strategy for employers to meet their demand for labor. The apprentices are able to improve their human capital (education, skills, and productivity) because they receive structured on-the-job training provided by an experienced mentor and classroom instruction while being paid. Employers can train workers on the job for the exact skills they need, thus providing employers a tool to minimize the skills gap. Additionally, employers are able to recoup their return on investment because apprentices receive lower wages in the early stages to offset their lack of productivity and training costs. Investing in education and training with a work-based learning tool such as registered apprenticeships will help shift the labor demand and supply labor curve.

History of Apprenticeships

Apprenticeships are considered one of the oldest forms of training and the primary means by which craft and manual workers learned their trades through the exchange of labor for training (Jacoby, 2004). Since medieval times, the term apprenticeship describes the journey a person takes from novice to expert in a specific occupational field and has been used by surgeons, lawyers, engineers, carpenters, chefs, actors, and musicians (Fuller, 2016). Historically, apprenticeship was a form of education where young male apprentices were indentured to a master craftsman who provided direct instruction to the apprentice by passing on the skills and knowledge of a particular trade or occupation (Christman, 2012). It involved a

formal agreement that "bound" an apprentice to the employer who provided training, food, and shelter in exchange for work covering a specific time period (Arthur-Mensah, 2015). When an apprentice began his training, he was considered to be starting a "journey," then he moved on to become a journeyman and finally a master craftsman.

In the early years of the United States, craft workers from England and other European countries brought with them the practice of indenture and the system of master-apprentice relationships. Apprenticeships in the United States date back to the colonial period when young men and women served under a master craftsperson that groomed and mentored them to become productive members of the community—developing character traits as well as vocational skills (Christman, 2012). Traditional apprenticeships became almost extinct after the Industrial Revolution as a result of the following: (a) new technology, efficiency, and faster production; (b) trade unions opposed exploitative practices of companies employing apprentices as cheap labor and providing inadequate training; and (c) the rise of formal education which decreased interest in apprenticeship among youth, and education was sought after as the primary vehicle for upward social mobility rather than industrialization (Aivazova, 2013; Arthur-Mensah, 2015; Christman, 2012; Jacoby, 2004).

The first U.S. legislation to promote an organized system of apprenticeship was in 1911, when Wisconsin was the first state to approve a law placing authority for apprenticeships under the jurisdiction of an industrial commission (Lynn & Mack, 2008). Wisconsin also passed legislation requiring apprentices to attend classroom room instruction for 5 hours a week, which created an early model combining on-the-job learning, work experience, and classroom instruction (Lynn & Mack, 2008). This model became the basis for formal apprenticeship in the United States.

In the 1920s and 1930s, national labor and employer organizations, educators, and government officials began a concerted effort to design a national, uniform apprenticeship system to help regulate apprenticeships and on-the-job training programs in the United States because employers were abusing apprentices with low wages, insufficient training, and inadequate advancement opportunities (Jacoby, 2004; Lynn & Mack, 2008). In 1934, the federal government established the Bureau of Apprenticeship and Training which developed and monitored labor standards related to the registration, cancellation, and de-registration of apprenticeships. As a result of these efforts and a shortage of skilled workers in the late 1930's (Jacoby, 2004), the Fitzgerald Act, also known as the National Apprenticeship Act was passed in 1937. This federal law created a formal system of registered apprenticeships that is overseen by the USDOL in cooperation with state apprenticeship agencies (Lynn & Mack, 2008; USDOL, 2017a). The Fitzgerald Act also authorized the formation of an apprenticeship national advisory committee that includes representatives of employers, labor, educators, and other executive agencies.

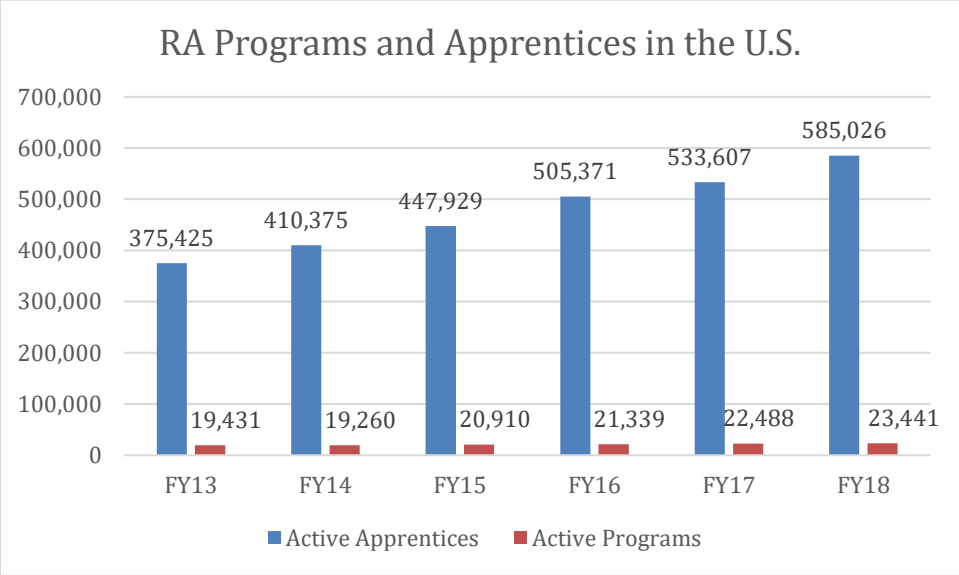
Registered Apprenticeship System in the United States

The USDOL, Employment and Training Administration (ETA), Office of Apprenticeship (OA) works in conjunction with independent state apprenticeship agencies (SAAs) to administer the RA program nationally. The USDOL-ETA administers apprenticeship programs in 25 states, Puerto Rico, and the Virgin Islands; and assists and oversees the SAA, which administers programs in 25 states (including Virginia), the District of Columbia, and Guam (Lynn & Mack, 2008; Reed et al., 2012; USDOL, 2018e). Thus, RA programs are run by the USDOL or by a state agency. See Appendix E for a map of Federal OA's and SAA's in the United States.

There are over 23,000 registered apprenticeship sponsored programs representing about 150,000 employers, 585,000 apprentices, and 1,000 occupations in the United States (USDOL, 2018c; USDOL, 2018f). See Figure 2 for number of RA apprentices and programs in the United States. In the Commonwealth, the VDOLI oversees the RA program; operates as a SAA; and has 15,429 apprentices, 1930 active programs, and 178 active apprenticeable occupations (USDOL, 2018c; VDOLI, 2018).

Figure 2

Registered Apprenticeship Programs and Apprentices in the United States



Source: U.S. Department of Labor (USDOL). (2018c). Apprenticeship data and statistics. Retrieved from https://doleta.gov/oa/data_statistics.cfm

The OA and SAA are responsible for registering apprenticeship programs that meet federal and state standards under Title 29, CFR Part 30; issuing certificates of completion to apprentices; encouraging the development of new programs via outreach and technical assistance; protecting the safety and welfare of apprentices, maintaining an apprenticeship database system; and assuring all programs provide high quality training for their apprentices

(Arthur-Mensah, 2015; Gunn & De Silva, 2008; Lerman, 2012; Lynn & Mack, 2008; USDOL-ETA, 2007).

In addition to the USDOL registered apprenticeships, there are unregistered apprenticeships, pre-apprenticeships and industry-recognized apprenticeships. An unregistered apprenticeship is a program that is not registered or tracked by the USDOL. Individuals who complete an unregistered apprenticeship do not earn a certificate from the USDOL and the legitimacy or quality of the apprenticeship cannot be verified since it is not monitored or regulated by a federal or state agency.

Pre-apprenticeship and school-to apprenticeship programs serve as pipelines or feeder programs to registered apprenticeships. The goal of these programs is to prepare individuals through instruction and/or training to increase math, literacy, and other vocational and prevocational skills needed to gain entry into a RA program. These programs also diversify the RA talent pipeline by expanding access to women, people of color, and other under-represented populations to succeed in registered apprenticeships. According to Lynn and Mack (2008), youth apprenticeships and school-to-apprenticeship programs tend to be secondary-school based and oriented to youth under the age of 21, while pre-apprenticeship programs typically operate outside the public secondary school system and may have both youth and adult participants. Like unregistered apprenticeships, pre-apprenticeships and school-to-apprenticeship programs are not officially registered with the USDOL; data is not officially tracked by the USDOL, and there are limited data on these programs.

Industry-recognized apprenticeships, recently established in 2018 by the USDOL, are similar to registered apprenticeships but use a nongovernmental entity, such as a business association or nonprofit intermediary, to certify industry-recognized apprenticeships instead of having approval from the USDOL. Industry-recognized apprenticeships were established to

make it easier for businesses to gain approval for new apprenticeship programs in new industries where apprenticeships are not well utilized. This program was recently established by the USDOL in 2018 and there are no data on these programs currently. This research focused on registered apprenticeships.

Registered Apprenticeship Program Structure

The foundation of the apprenticeship model is the RA sponsor. Registered apprenticeship programs are operated by registered apprenticeship sponsors who include employers, employer associations, and labor management organizations that range from small privately, owned businesses to national employers, and industry associations. The role of the sponsor is to register the program with the appropriate federal and state apprenticeship agencies, and to recruit, train, mentor, and pay the wages of the apprentices (Arthur-Mensah, 2015; USDOL, 2017a).

Another major principle of registered apprenticeships is that apprentices progressively increase their skills and competencies throughout the program (USDOL-ETA, 2017). Typically with an apprenticeship, an individual is employed at the start of an apprenticeship with an organization (registered sponsor), works a full 40-hour week, and receives pay and benefits while being taught by experienced workers and supervisors. Apprentices work through a series of defined curricula (academic instruction related to the apprenticeship occupation) while receiving incremental wage increases with skill attainment until the completion of their apprenticeship programs. A nationally recognized credential and certificate of completion are awarded at the end of the apprenticeship.

The duration of the registered apprenticeship training, skills, and competencies required for mastery are driven by industry (USDOL-ETA, 2007). There are three types of skill assessments or competencies an employer can use for an apprenticeship program: time-based,

competency-based or a hybrid of the two. For time-based programs, apprenticeships typically include 2,000 hours of on-the-job training and a minimum of 144 hours of classroom-based instruction each year. Apprenticeships can last between 1 and 6 years, with 4 years as the average.

Registered Apprenticeship Model

The registered apprenticeship model is a type of work-based learning. Work-based learning is defined as learning and knowledge that is acquired at the worksite and, where appropriate, in a school or training program; the worker has the opportunity to develop measurable skills through instruction; the learning may be formal, quasi-formal or informal; and may or may not culminate in qualifications such as an industry recognized credential or higher wages (Basit et al., 2015; NSC, 2017). Work-based learning programs are considered advantageous and beneficial for the development of human capital as they are likely to have a positive impact on workforce performance and productivity; they help reduce skills shortages; they allow a company to grow their own workforce; they increase employee motivation—which is likely to result in increased staff retention; and there is minimal disruption to the company as little time is taken off the job (Basit et al., 2015). In line with Becker's (1993) human capital theory, some of the main objectives of work-based learning are improved productivity and organizational benefits (Basit et al., 2015).

Studies show that the most effective learning combines theory and practice in such a way as to give purpose to the learning (Fuller & Unwin, 1998, p. 157). Through contextualized learning, apprentices are able to see a direct link between what they learn in the classroom and problems in an applied job setting. Through work-based learning, apprenticeships also help individuals integrate what they learn on the job and in the classroom. The practical training and

knowledge apprentices received through the on-the-job learning and related classroom instruction as paid employees allows them to become productive members of a team quickly. This also helps provide employers a quick return on investment with apprenticeships.

Billett (2016) contends that apprenticeships are also considered a mode of learning because apprentices are actively engaged in their work and learning (e.g., apprehending). Billett (2016) further states that apprentices also identify what needs to be learned, understand how that knowledge is acquired and actively engage to acquire it, and they monitor engagement and development interdependently rather than being taught or being dependent on others (e.g., teachers, experts, meisters, etc.). Overall, apprenticeships have become meaningful vehicles for the development and transference of occupational skills, knowledge, and understanding (Fuller & Unwin, 1998, p. 154).

Benefits and Challenges of RA Programs

Registered apprenticeships are considered beneficial and effective for both the apprentices and employers. With previous studies, research on registered apprenticeships in the United States has primarily assessed the effectiveness of RA programs by conducting cost-benefit analyses (Helper et al., 2016; Hollenbeck, 2008; Hollenbeck & Huang, 2016; Reed et al., 2012). The following is a review of some of these studies in terms of RA program benefits for apprentices and employers.

Apprentice Benefits.

Studies regarding apprentices indicate that RA programs have had a positive impact; the benefits of RA programs for apprentices have significantly exceeded the costs; and RA programs have had a strong net social benefit (Hollenbeck, 2008; Hollenbeck & Huang, 2016; Reed et al., 2012). One benefit of registered apprenticeships is that apprentices (participants) have

substantially higher earnings than nonparticipants (people who do not participate in RA programs). For example, the Reed et al. (2012) study (which assessed the effectiveness and performed a cost-benefit analysis of registered apprenticeships in 10 states) found that in the ninth year following program enrollment, RA participants earned an average of $5,839 more than similar nonparticipants, and the estimated career earnings on average for a RA participants are $240,037 more than nonparticipants. Similarly, the Hollenbeck and Huang (2016) study (which examined the net impact of registered apprenticeships among 12 workforce development programs in the state of Washington) found RA apprentices had the highest net quarterly earnings impact ($3,715) over the short term (three full quarters after exit from the programs) among the 12 workforce programs. Additionally, RA apprentices had the second highest long-term (nine to 12 full quarters after exit) net quarterly earnings impact of $3,447 (in a range from -$85 to $4,132) among Washington's workforce development programs (Hollenbeck & Huang, 2016).

Another advantage of RA programs for apprentices is a strong net social benefit. The Reed et al. (2012) study found that the social benefits of registered apprenticeships exceeded the social costs by more than $49,000 over the career of the apprentices. Furthermore, the Hollenbeck and Huang (2016) study indicated that the benefits of registered apprenticeships significantly exceeded the cost for the average participant in the short term (first 2-5 years) and over a lifetime (in the amount of $287,521). Overall, based on the Reed et al. (2012) and Hollenbeck & Huang's (2016) studies, RA participants had substantially higher earnings than nonparticipants, the social benefits appear to be substantially larger than the social costs, thus justifying the investment of resources into RA programs (Helper et al., 2016).

From an apprentice perspective, participants were overall enthusiastic about RA programs and indicated learning a skill, earning good wages, and having a future career path are benefits of the program (Gunn & DeSilva, 2008). Drawbacks from an apprentice perspective included long periods of time spent in their apprenticeship program (program length) and the relatively low levels of pay in the early stages of the program (Gunn & DeSilva, 2008). Registered apprenticeships are also beneficial to apprentices because they do not have to sacrifice earnings during their education and training (Lerman, 2014a, 2018) because "their long-term earnings benefits exceed the gains they would have accumulated after graduating from a community college" (Lerman, 2018, p. 2; Hollenbeck, 2008). In general,

> the main potential benefit of RA comes from the added productivity of workers who have become highly skilled through RA training and the value of this added productivity is accrued by employers and then paid to apprentices as additional earnings and fringe benefits (Reed et al., 2012, p. 10).

Employer Benefits.

From a U.S. employer perspective (demand side), evidence from surveys and interviews indicate that registered apprenticeships are valuable and beneficial. In a national survey of over 950 employers, 97% of employers would recommend registered apprenticeships; 80% of employers said registered apprenticeships helped meet their demand for skilled workers; and 68% of the employers cited raising productivity, strengthening worker morale and pride, and improving worker safety as beneficial (Lerman et al., 2009). Additionally, based on a qualitative study of employers in five states (37 registered apprenticeship sponsors were interviewed), most employers would strongly recommend registered apprenticeships to their peers; the most cited benefit was that registered apprenticeships produced employees who were dedicated, well-

skilled, well trained, and reliable; and 60% of the employers indicated that registered apprenticeships ensured a supply of qualified workers with documented knowledge and skills (Gunn & De Silva, 2008).

Similar to the Gunn and DeSilva (2008) and Lerman et al. (2009) studies, the U.S. Department of Commerce and Case Western University (Helper et al., 2016) recently conducted a case study of 13 businesses to understand the cost and benefits of apprenticeship from a business perspective reported that companies unanimously found value in registered apprenticeships. The Helper et al. (2016) study also found that the benefits of registered apprenticeships more than justified the costs; apprenticeships improved the employers' overall performance and provided a competitive edge over other firms; registered apprenticeships reduced production costs; companies had a better workforce through reduced turnover and improved recruitment; and registered apprenticeships led to better soft skills. This study used three types of metrics (production, workforce, and soft skills) to measure the benefits of the registered apprenticeship model from the employer perspective.

Per Helper et al. (2016), employer production costs are reduced because the apprentice labor is provided at a reduced wage, higher post apprenticeship productivity relative to tenured employees, and reduction in mistakes or errors. After apprentices graduate, many continue to have higher productivity than workers that did not receive apprenticeship training. Additionally, many firms saw a reduction in errors or mistakes and the likely driver of this improvement was considered the classroom theoretical training portion of the registered apprenticeship which explains why tasks need to be performed. Understanding the "why" gives employees the ability to diagnose potential problems before they occur or quickly troubleshoot problems after they occur, which often results in reduced errors and improved production.

Secondly, companies have a better or improved workforce because of registered apprenticeships (Helper et al., 2016). Companies in the Helper et al. (2016) study experienced (a) reduced turnover, (b) a pipeline of skilled employees, (c) better matching of employee skills and character with employer needs and firm culture, (d) lower recruiting costs, and (e) development of future managers. For example, reduced turnover was the most cited benefit among companies in the study and many of the companies say apprenticeships make employees twice as likely to stay. Third, registered apprenticeships led to better soft skills, which included improved employee engagement, greater problem-solving ability, flexibility to perform a variety of tasks, and a reduced need for supervision (Helper et al., 2016).

Drawbacks of registered apprenticeships from an employer perspective included difficulty in finding or accessing high-quality related instruction (Gunn & DeSilva, 2008); apprentices' failure to complete their program (Lerman et al., 2009; Reed et al., 2012); and poaching (competitor firms bidding away trained apprentices) (Lerman et al., 2009). Although poaching was considered a problem by 54% of the sponsors (29% as minor; 25% as major; 46% not perceived as a problem) in the Lerman et al (2009) study, 85% of employers would still strongly recommend apprenticeship to others (Lerman et al., 2009). Only a small percentage of sponsors indicated they had significant problems with administrative and operational aspects of apprenticeships, such as taking too long to produce skilled workers, too much effort to manage a program, and too much paperwork (Lerman et al., 2009).

Overall, employers reap several advantages from their apprenticeship investments—they save significant sums in recruitment and training costs, reduced errors in placing employees, avoid excessive costs when the demand for skilled workers cannot be quickly filled, and ensure an adequate supply of well-trained workers (Lerman, 2014a). Advocates of apprenticeships

believe they are a way for employers to develop a gold standard of new workers, to build a talent pipeline and replace retiring Baby Boomers, decrease recruiting costs, increase employee retention, and increase productivity (Helper et al., 2016; Ladika, 2016). Furthermore, the Urban Institute found that more than 80% of U.S. companies that sponsor apprentices say it is an effective strategy for helping them meet their demand for skilled labor (Lerman et al., 2009).

Apprenticeship Challenges.

Despite the advantages of apprenticeships, the literature has consistently identified challenges to implementing apprenticeships. In addition to the drawbacks of registered apprenticeships in the previous section, articles and reports have indicated that the reasons for the decline or slow adoption of apprenticeships in the United States include the following: limited or lack of information about apprenticeships for employers, parents, and students (Ladika, 2016; Lerman, 2014a; Olinsky & Ayres, 2013); misperceptions that apprenticeships are limited to unionized workforces (Lerman, 2014a); are primarily for the construction trades, and the jobs are considered "dark, dirty and dingy" (i.e., a blue-collar image perception) (Ladika, 2016, p. 845; Olinsky & Ayres, 2013); there is a stigma against vocational and technical education; students are encouraged to go to college and mistakenly believe that a 4-year degree is the only path to achieve economic mobility; and that apprenticeships are for the lower performing students (Cantor, 1995; Ladika 2016, p. 847; Olinsky & Ayres, 2013); lack of industry diversity, not enough industries are involved; and limited occupational and gender reach (Olinsky & Ayres, 2013); there is a lack of financial incentives for employers and minimal funding for states to develop and expand apprenticeships (Ladika, 2016; Lerman, 2014a; Olinsky & Ayres, 2013; Modestino, 2016); and inadequate infrastructure such as facilities, lack of quality instructors (Gunn & DeSilva (2008) and inconsistent certification standards and poor

coordination with educational systems (Olinksy & Ayres, 2013). In general, apprenticeships are considered to have an image problem (blue collar unionized jobs for noncollege bound students) which has impacted the adoption of apprenticeships in the United States.

Furthermore, the cost to implement an apprenticeship is expensive; employers generally fund 100% of the apprenticeship programs. Siemens (active proponent of apprenticeships) spends $160,000 to $180,000 over 4 years to train each apprentice which includes wages, benefits, tuition, and books (Ladika, 2016). In addition, the incentives for apprenticeships are considered convoluted and confusing based on how the policy or regulation is written and administered; incentives need to be simple and consistent across states (Putre, 2017). Administratively, employers state the application process is long and needs to be streamlined.

Implementing registered apprenticeships on a mass scale is a challenge to filling the skills gap because employers do not have the capacity to hire a significant number of apprentices (Bailey, 1993; Hamilton, 1993). Most apprenticeship employers are small to medium-sized firms and these organizations can only accommodate limited numbers of apprentices in a given time period (Cantor, 1995). Even if employers start apprenticeship programs, in many cases, only a few employees go through the training each year. Siemens, a sponsor of apprenticeships, only enrolls four to seven apprentices annually in its Charlotte NC facility (Ladika, 2016).

In addition to the above challenges, the United States is lagging behind other countries with implementing apprenticeships. As of 2018, there were about 585,026 registered apprentices in the U.S. civilian workforce of 162 million (USDOL 2018c; USDOL-BLS, 2018). Apprentices make up only .3% of the American workforce whereas apprentices represent 2.2% of the workforce in Canada, 2.7% of the workforce in Great Britain, and 3.7% of the workforce in Germany and Australia (Ladika, 2016; Lerman, 2014a; Lerman & Packer, 2015). Other

developed countries such as Germany and Switzerland have successfully integrated apprenticeships programs into their education and workforce systems as a mechanism to address unemployment and the skills gap or mismatch (Messing-Mathie, 2015; USDOL, 2018b).

Overall, apprenticeships have not gained momentum in the United States due to negative perceptions, the financial costs, and the administrative burden required to coordinate and implement. Implementing a registered apprenticeship model is highly dependent on substantive employer participation, and proponents of the registered apprenticeship acknowledge that it is very difficult to get employers to participate (Bailey, 1993; Hamilton, 1993; Osterman & Iannozzi, 1993). Thus, securing employer commitment is critical to the success of implementing registered apprenticeships to close the skills gap.

Registered Apprenticeships and Unemployment Rate

The scholarly consensus is that apprenticeships are strongly procyclical (Bilginsoy, 2018; Brunello, 2009; Sharpe & Gibson, 2005), expanding rapidly with economic growth and contracting during recessions. This was confirmed in a report by the Canadian Apprenticeship System trends which found that apprenticeship registration growth is highly cyclical and it is associated with the unemployment rate (Sharpe & Gibson, 2005). Specifically, the Canadian report showed that the expansions of the Canadian apprenticeship system in 1977-1981, 1985-1991, and 1997-2002 closely followed declining unemployment rates (Sharpe & Gibson, 2005). As unemployment rates decline, the availability of skilled workers is diminished because the remaining people are likely to be those with skills that do not meet current employment opportunities. During economic growth (low unemployment rates) employers tend to invest in training such as registered apprenticeships to find skilled workers.

The strong association between new apprenticeships registration and unemployment rates suggests that it is not the supply of apprentices but the employers who determine new registration (at least during economic downturns) by controlling the number of jobs available to apprentices (Sharpe & Gibson, 2005). Since apprentices must retain employment with a firm (on average) over 4 years, high unemployment rates have a strong negative impact on apprenticeship registration trends. Furthermore, in economic downturns, apprentices are vulnerable and often the first to be laid off.

In general, the unemployment rate is linked to apprenticeship registrations; however, there are mixed results with unemployment rates and apprenticeship completion rates (attrition). In Canada, the Laporte and Mueller (2013) study found there is a weak (but positive) correlation between regional unemployment rate and apprenticeship completions (the regional unemployment rate has little or no effect on whether an individual completes an apprenticeship program or not). In England, the Gambin and Hogarth (2016) study found local unemployment rates have a significant effect on the probability of completion—during economic downturns completion probabilities declined for the intermediate apprenticeships but increased for the advanced apprenticeships. In the United States, Bilginsoy (2003) found that a higher state unemployment rate reduced the hazards of both completion and cancellation; and the Bilginsoy (2007) study found that a higher state unemployment rate reduced the hazard of completion but did not affect cancellation. Individual and programmatic factors such as trade group, type of technical training, and having a journeyperson present are important correlates of program completion (Laporte & Mueller, 2013).

Registered Apprenticeships and the MS Gap

So, how does the United States address the MS gap and help prospective workers (under/unemployed) get the skills and training needed to fill MS jobs? Potential approaches identified to address the MS gap include apprenticeships and on-the-job training; employers participating in sector-based regional initiatives with other employers; and having a higher-education consortia with strong industry ties—programs that employers build with several types of postsecondary educational entities such as community colleges, internships, and cooperative education (Burrows et al., 2014; Kochan et al., 2012; Lumina Foundation, 2014). These solutions require a collaborative and coordinated effort among the following key stakeholders: employers (private sector business and industry); government and policymakers; educational and training institutions; and workforce intermediaries.

Targeted training, education, and collaborative efforts among key stakeholders are necessary for closing the nation's skills gap (ASTD, 2012; Leibert, 2013). In a survey conducted by the Minnesota Employment and Economic Development, enhancing internal training and collaborating with educational institutions were the most frequently mentioned strategies by employers to address the skills gap and hiring difficulties (Leibert, 2013). The Minnesota survey also indicated that the answer may not be more education across the board but to find ways to provide hands-on experience and work-based training (targeted training) to individuals (Hine, 2013). Despite the success in other countries, there is a lack of internships and apprenticeships for MS jobs in the United States (Modestino, 2016). Developing partnerships between education/training providers and businesses through on-the-job training and experiential learning is key to upskilling the U.S. workforce and filling the skills gap (Modestino, 2016; Whitehouse, 2017).

Apprenticeships can be a key component to the solution to the skills gap. With the combination of on-the-job training, and mentoring, the apprenticeship model is a powerful tool for addressing the skill shortages that many industries face (USDOL-ETA, 2007). Registered apprenticeships are considered a proven MS education and training model that has been shown to improve students' labor market success (Heinrich, 2018) based on the Reed et al. (2012) and Hollenbeck (2008) studies. Furthermore, apprenticeships are driven by employer demand—the employer prescribes the training, thus minimizing the skills mismatch and producing productivity in the workplace (Heinrich, 2018). By using the apprenticeship model, businesses struggling with a skills gaps for MS occupations can take steps to ensure workers are trained to employer specifications and gain the value of apprentices' work during their training (USDOL, 2018b).

There are not many studies (if any) that have examined the impact of registered apprenticeships on (a) the MS gap or (b) reducing the number of U.S. job openings (or the size of the gap). However, a recent Harvard Business School study examined the "true scope" or potential for apprenticeships in the United States if they were expanded into more occupations—especially where there is a shortage of MS talent. Fuller and Sigelman (2017) found that the 27 occupations that constitute the "core apprenticeships" (number of occupations commonly filled through apprenticeship) could be tripled to 74 occupations when they (a) examined the skills of job posting for more than 23 million job openings in 2016, (b) identified the underlying skills in apprenticeship roles, and (c) looked for similarities in other positions. According to the study, if the RA system became the standard training approach in the United States for the 27 core occupations, there could be 1.3 million jobs served or job openings filled; and if the 27 occupations were tripled to 74, there could be up to 3.2 million job openings filled by registered

apprenticeships (Fuller & Sigelman, 2017). This study indicates that by expanding apprenticeship occupations, it can have an impact on filling MS gap and MS occupations difficult to fill.

Although apprenticeships are growing due to the increased attention and funding in recent years, critics say a one-size fits all training solution to close the MS gap will not work in the United States. Employers will need solutions other than apprenticeships if they are to close a skills gap of more than five million unfilled positions (Kochan et al., 2012; Ladika, 2016; Tyszko, 2016). Other solutions are needed because apprenticeships are difficult to scale and they primarily meet the needs of particular employers in select industries, such as construction, manufacturing, skilled trades (Tyszko, 2016). Additionally, one solution is inefficient given that the labor market for MS workers is inherently local—closing the skills gap requires regional solutions. It is important to understand and address the skills gap at local and regional levels because the U.S. economy is complex and different regions face different workforce challenges (1,100 classified industries spread across 50 states, 300 metro areas). One of the most effective approaches to overcoming the skills gap is the development of regional strategies grounded in local data and local context in terms of education providers, workers, and business needs (EMSI, 2017).

Apprenticeships are considered the "most trial-tested way for firms to address their current and future skill needs" (Kochan et al., 2012, p. 5). Registered apprenticeships also provide businesses and educational institutions a proven partnership model to develop a skilled, flexible, and mobile workforce that will meet businesses' current needs as well as adapt to businesses' future needs and alleviate workforce shortages (USDOL, 2018b, p. 26.) Apprenticeships will remain a "tried and true solution," but to close a skills gap in today's

economy, employers will need to access a variety of solutions (Tyszko, 2016), one of which is apprenticeship.

Policy and Legislation

Federal and state policy play a major role in apprenticeships and how states address the MS gap. Having policies to help solve the MS gap and policies that are designed to train more individuals to meet the employer demand for labor is essential for a good economy. This section describes federal and state policies in relation to registered apprenticeships and the skills gap.

The Role of Policy and Legislation

Policymakers and employers are concerned that slower population growth combined with the retirement of the Baby Boom generation will lead to a shortage of skilled labor (Modestino, 2016). Additionally, there is a shrinking shelf-life of skills due to automation--many of the skills for the fastest growing jobs did not exist 5 years ago due to automation and a changing labor market (Craig & Bewick, 2018). Of particular concern is the lack of workers able to fill the newer MS jobs (Holzer, 2015; Kochan et al., 2012, Modestino, 2016). Policymakers and employers have a concern with not only having a sufficient number of workers but also a workforce with the right mix of skills to meet the diverse needs of the nation's economy, especially for MS occupations (Modestino, 2016).

The skill sets demanded by employers are ever changing, resulting in a dynamic labor market. From the demand side, employers struggle to identify and hire, or develop talent with the skills needed to compete (Craig & Bewick, 2018). As the labor market tightens, retention rates fall, turnover rates increase, and demand for skilled workers increases. From the supply side, workers are under pressure to embrace faster and cheaper alternatives to traditional education and training programs to remain competitive (Craig & Bewick, 2018). Thus, there is a need for

policy intervention to influence both the supply and demand side of the skilled labor market. The apprenticeship model is a solution many lawmakers are using to address the skills gap because it addresses both the demand and supply side, and it is an underutilized option to help employers to better identify, attract, and develop talent.

Federal.

Apprenticeship programs have recently garnered increasing bipartisan support as a way to bridge the skills gap between education and employment. President Trump, along with his predecessor President Obama, state governors, and elected officials on both sides of the aisle have recognized and "touted" the benefits of apprenticeship to the U.S. economy, education, and workforce development (Craig & Bewick, 2018). This support has led to recent legislative and executive actions in support of expanding apprenticeships in the United States to help fill the skills gap.

In President Obama's 2014 State of the Union address, he made a call to action to "double and diversify" apprenticeships to 750,000 by 2019 (USDOL, 2015a) and made apprenticeships a priority by investing $265 million for an expansion of registered apprenticeships (White House Office of Press Secretary, 2016). Of the $265 million, USDOL awarded $175 million in apprenticeship grants to 46 public-private partnerships in 2015, and Congress made a bipartisan decision to appropriate $90 million toward apprenticeships via the Consolidated Appropriations Act of 2016 (Collins, 2016; Field, 2016; White House, 2016).

President Trump continued this investment and registered apprenticeship expansion by issuing an Executive Order 13801, Expanding Apprenticeships in America in 2017 (White House Office of Press Secretary, 2017). Executive Order 13801 states that America's education and workforce development programs are in need of reform to meet the challenges of today's

rapidly changing economy, namely the skills gaps that result from a workforce that is insufficiently trained to fill existing and newly created jobs (USDOL, 2018b, p. 12).

The U.S. Department of Labor has announced over 245 million in grants funds toward Executive Order 13801 (USDOL, 2018a). The $245 million in funding includes $150 million in H-1B funds to support sector-based approaches to expand and strengthen apprenticeship programs targeting new industries, veterans and their spouses, women, people of color, and ex-offenders; $994,000 to help recruit, train, and retain more women in "quality pre-apprenticeship and apprenticeship programs in specific industries and $95 million to support states, industry and equity partnerships, outreach and technology modernization to scale apprenticeships and pre-apprenticeship opportunities" (USDOL, 2018a, p. 4).

President Trump's 2017 Executive Order, Expanding Apprenticeships in America, also required the establishment of a Taskforce on Apprenticeship Expansion. The taskforce was challenged to identify strategies and recommendations to promote apprenticeships and create new apprenticeship opportunities to serve a more diverse group of learners and a more expansive set of occupations in well paying, high-demand fields (USDOL, 2018b). Based on Executive Order 13801, this taskforce was called to establish an alternative system apprenticeship called "industry-recognized apprenticeships" that would not require direct approval by a government entity versus the current RA program that requires USDOL government approval under 29 Code of Federal Regulations (CFR) 30. The alternative system is intended to make the administrative process easier for businesses to gain approval for new apprenticeship programs in industries where apprenticeships are not well utilized while also supporting the development of quality standards in these industries (NSC, 2018; USDOL, 2018b).

The taskforce submitted their final report to the president on May 10, 2018, and included a proposal that would expand apprenticeships through the development of a new and more flexible apprenticeship model called industry-recognized apprenticeship. In July 2018, the USDOL moved forward with the taskforce proposal and published a Training and Employment Notice 03-18, which provides the framework for creating the new model, industry-recognized apprenticeships. As of date, there are two apprenticeship models recognized by the USDOL, registered apprenticeships, and industry-recognized apprenticeships. This dissertation focuses on registered apprenticeships.

Additionally, President Trump issued an Executive Order in July 2018 to establish the President's National Council for the American Worker. The purpose of the council is to develop a national strategy to meet the skills gap that is brought on by an economy that is changing at a rapid pace because of technology, automation, and artificial intelligence (White House, 2018). This federal interagency body will focus on increasing job training opportunities for students and workers through education, skills-based training, and a demand-driven approach to workforce development; consolidating existing federal programs and funding new job training initiatives; and concentrate on expanding apprenticeship programs (Thrush, 2018; White House, 2018).

In addition to the executive orders on apprenticeship, the Workforce Innovation and Opportunity Act provides funding for workforce development programs to help address the skills gap and utilizes registered apprenticeships as a workforce training strategy (USDOL-ETA, 2007, 2017). The Workforce Innovation and Opportunity Act is an integrated, job-driven system that links diverse talent (supply side) to U.S. businesses (demand side) through the public workforce system (USDOL-ETA, 2017). The act is designed to help job seekers access employment, education, training, and support services to succeed in the labor market and to match employers

with the skilled workers they need to compete in the global economy. Additionally, the Workforce Innovation and Opportunity Act promotes the alignment of workforce development programs with regional economic development strategies such as sector partnerships to address the skills gap. The act supports registered apprenticeships as a workforce training strategy for workers and as a partner in the workforce system.

School-to-work initiatives and youth apprenticeships became one of the hottest trends in educational reform in the 1980s and early 1990s. One of the most prominent legislative actions related to skills development was the School to Work Movement which emphasized that the way to improve student skills and to increase employability was to bring schools and employers closer together in an effort to smooth the transition from school to work (Cappelli, 2015). Researchers, advocates, and the U.S. General Accounting Office began an effort to inform and influence policymakers about the advantages of incorporating formal apprenticeships into the vocational education system and to promote the transition from school-to-work (Bailey, 1993; Lerman, 2012).

As part of the School-to-Work Movement, Congress passed the National Youth Apprenticeship Act of 1992, The School-to-Work-Opportunities Act of 1994, and the National Skills Standards Act of 1994. Legislators hoped that integrating work-based learning with traditional classroom instruction would make education more relevant to all students. This meant utilizing work-based learning activities such as apprenticeships, internships, and co-op programs as methods to help students understand the value of classroom lessons, apply theoretical concepts in a workplace setting, and utilize more workplace examples in the classroom (Cappelli, 2015).

The School-to-Work Opportunities Act provided administrative and financial support to help build work-based learning programs, the school-to-work transition for students, and the

connections between schools and employers (Cappelli, 2015). The standards created through the National Skills Standards Act gave the school-to-work programs attainable goals and helped determine which skills to teach. In spite of bipartisan support, youth apprenticeship and school-to-work initiatives lost momentum and support; and the School-to-Work Opportunities Act was not extended beyond its 2001 expiration date (Lerman, 2012). The Act did encourage local school systems to increase their collaborations with employers but with low intensity work-based learning activities, such as job shadowing and mentoring.

States.

The NGA and states are encouraging legislation to expand apprenticeship and/or to address the skills gap through their higher education and workforce policies. According to the NGA (2018a), workforce development and filling the skills gap is critical to the "well-being" of state economies and is a high priority. To help governors address their workforce challenges, some key areas the NGA are focusing on is supporting state acceleration of work-based learning strategies including apprenticeship, accelerating the adoption of sector strategies, and adopting innovative approaches to increase postsecondary credential attainment (NGA, 2018b).

Many states are adopting sector strategies as an approach to address the skills gap and often utilize the RA model as a solution. There are an estimated 1,000 sector partnerships operating across the United States (NGA, 2013), and 32 states (including Virginia) have policies in place to support sector partnerships (Wilson, 2017). The NGA is providing comprehensive support and assistance to 46 grant recipients of the DOL's American Apprenticeship Initiative to expand apprenticeships and have written policy documents such as "State Sector Strategies Come of Age: Implications for State Workforce Policymakers" (NGA, 2013).

Sector strategies are "partnerships of employers within one industry that bring government, education, training, economic development, labor, and community organizations together to focus on the workforce needs of an industry within a regional labor market" (NGA, 2013, p. 2). When these sector partnerships meet, it is an opportunity for businesses to voice or share their recruitment needs and regional partners collaborate to develop customized solutions (e.g., registered apprenticeships) to meet those business needs.

These industry partnerships typically meet regularly and use labor market information to analyze and stay informed of shifting demands in the labor market. For example, sector partnerships typically analyze the current and future skill needs in the local area and identify occupations with skills gaps, develop a plan to close the skills gaps in the industry, and assist in the implementation of the plan by carrying out activities such as identifying common skill standards, promoting industry recognized credentials, and building career pathways to skilled jobs in the industry (Wilson, 2017). Using this labor market information, the sector partners align the skill needs of their industries with the education and training programs in the area or region. For example, the industry sector partners assist educational partners with creating (or advising) training programs and curricula, advise education partners how to best structure their curriculum offerings to meet the demands of their industry, inform the education partners of employment opportunities, and how to navigate the employment process for their students or participants.

This collaborative approach among industry and workforce partners is a proven strategy for helping workers prepare for MS jobs and helping employers find skilled workers (Wilson, 2017). Sector strategies are one of the few workforce interventions with empirical evidence showing improved employment opportunities and wages for workers and increased productivity, declines in staff turnover, and reductions in customer complaints for employers (Lea, 2004;

Maguire, Freely, Clymer, Conway, & Schwartz, 2010; NGA, 2013). For example, 84% of surveyed employers participating in industry partnerships in Pennsylvania reported significant increases in productivity (Commonwealth of Pennsylvania, 2009; NGA, 2013); and in Massachusetts, 41% of surveyed employers reported reduced turnover, 19% reported less rework on the job, 23% reported fewer customer complaints, and 100% of the companies said participating in sector partnerships was valuable (Lea, 2004; NGA, 2013). Additionally, the Aspen Institute found that 48% of participants in sector-based programs exited poverty (NGA, 2013), and findings from a sectoral employment impact study found that program participants are significantly more likely to work in jobs with higher wages and jobs that offered benefits (Maguire et al., 2010). This empirical evidence demonstrates why so many states are adopting sector strategies as an approach to address the skill gap.

States such as Kentucky and Colorado are focused on skill development and apprenticeships as the way to increase labor participation, to attract mid- and high-wage jobs, and to address the skills gap (Leins, 2017; Whitehouse, 2017). Kentucky has a program, Justice to Journeyman that prepares inmates for MS jobs through apprenticeship by having inmates accrue about 2,000 apprenticeship hours while in prison (Leins, 2017). Colorado is addressing the gap by connecting workers with MS jobs through its pioneering partnership with the Markle Foundation, a nonprofit that aims to advance technology to broaden employment opportunities (Leins, 2017). Colorado is also addressing the skills gap by developing talent pipelines through their innovative youth-apprenticeship model known as CareerWise Colorado, a public-private partnership that has the first modern youth apprenticeship system in the United States.

South Carolina's Apprenticeship Carolina™ is considered one of the fastest growing programs in the country. It has had an 846% increase in registered apprenticeship programs

(from 90 in 2007 to 990 in 2018) and a total of 29,800 apprentices have participated in Apprenticeship Carolina™—a 36x growth since 2007 (South Carolina Technical College System, 2018). Other states are working to bridge the MS gap by connecting leaders in high school systems, community college systems and the workforce through the Pathways to Prosperity Network, a collaboration among regions; states; the nonprofit, Jobs for the Future, and the Harvard Graduate School of Education.

Summary

Many employers and policymakers look to our institutions of higher education and our public workforce system to help address the issues of how to fill the "newer" MS jobs (Holzer, 2015). Policymakers can help bridge education and workforce development by aligning the resources of the educational and training systems with the needs of local employers (including curricula with job requirements), removing regulatory and legal impediments to collaboration among stakeholders, and providing funding for experimentation and for the scaling of successful models (Burrowes et al., 2014; Carnevale et al., 2018) such as Careerwise Colorado and Apprenticeship Carolina™.

Additional recommendations for policymakers to address the skills gaps in terms of both supply and demand include the following: government to help foster relationships or linkages between employers and supply-side institutions (education) to expand work-based learning, on-the-job training, and experiential learning (Holzer, 2015; Modestino, 2016); provide resources to help promote or market apprenticeships and other work-based learning opportunities as a pathway to in-demand or new MS careers to stakeholders such as schools, parents, educators, employers, and students (Craig & Bewick, 2018; Holzer & Lerman, 2009; Modestino, 2016); provide more funding and incentives (i.e., public tax credits, grants, or technical assistance) for

employers to help create more MS jobs (Holzer, 2015); and help build public private partnerships that can support robust apprenticeship programs such as Colorado CareerWise (Craig & Bewick, 2018).

Virginia: Apprenticeships and the MS Gap

Current Status: What is Known?

Virginia estimates it needs to fill approximately1.5 million jobs by 2022, of which 50-65% are technician, trade-level MS jobs, due to new job creation and retiring workers (VA Executive Order 23, 2014; VA Executive Order 49, 2015). Additionally, the demand for MS jobs is expected to increase by 8% from 2014 to 2024 (Heinrich, 2018). There is a concern (by key stakeholders such as businesses, legislators, and educators) of having people with sufficient training to meet the demand for these MS jobs in Virginia (Commonwealth of VA, 2017; Center for Urban and Regional Analysis [CURA], 2016; VA Board of Workforce Development [VBWD], 2018).

According to Virginia Performs, Virginia has a low number of individuals with credentials that are suitable for MS positions and the state is lagging behind in providing workers for MS employment (Commonwealth of VA, 2017). For example, in 2015, Virginia ranked 40th among states for adults ages 25-64 with some college experience (Commonwealth of VA, 2017). In 2015, 8.1% of VA's workforce had an associate's degree, ranking the state below the national average of 9.0% and 39th among other states (Commonwealth of VA, 2017). Virginia's rankings were considerably lower than other states for sub-baccalaureate degrees that prepare workers for MS jobs.

According to the NSC (2017), 45% of job openings from 2014 to 2024 will be for MS occupations in Virginia. While MS jobs currently account for 49% of Virginia’s labor market,

only 39% of the state's workers are trained at the MS level (NSC, 2017). Furthermore, Virginia businesses cannot find enough qualified in-state candidates to fill the vacant MS jobs and the impact is significant (VCCS, 2015). For example, in 2014, there were more than 175,000 MS job openings in Virginia with an average hourly wage of $28.17 or $58,594 per year (VCCS, 2015). On average, each of those open jobs took 26 days to fill; this equates to 36.4 million hours of lost productivity for business, more than $1 billion in potential wages for Virginians, and $54.3 million in tax revenue (Office of the Governor, 2016b; VCCS, 2015).

In 2015, The VEC in collaboration with the Virginia Commonwealth University's (VCU) Center for Urban and Regional Analysis (CURA) conducted a job vacancy survey using a sample of 30,000 business establishments in the Commonwealth of VA from the VEC quarterly census of employment and wages. In terms of MS jobs, some of the key findings of this report were that jobs requiring middle skills are growing throughout the state and employers perceive they will have difficulty in filling these jobs.

The report also stated that extensive formal education does not appear to be required for a majority of the job vacancies (only 12% require an associate's degree or some college with no degree); however, one-third of the projected vacancies require licensing or industry recognized credential (CURA, 2016). Thus, about 45% of the projected vacancies require a credential or education beyond a high school degree but less than a college degree (middle skills).

Out of a projected 15,110 Virginia MS job vacancies for 2016, 85% require a credential and 15% do not require credential (CURA, 2016, pp. 127 & 137). See Table 1 for the top 10 projected MS job vacancies by detail occupation for the Commonwealth of Virginia in 2016. For all projected vacancies in Virginia for 2016 (high, middle, and low skills), 80% were in 12 occupations (see Table 2). For vacancies (high, middle, and low skills) that employers expected

Table 1

Top 11 Projected MS Job Vacancies in 2016 by Detail SOC Code*

	SOC code detailed occupation	Estimated no. MS vacancies	%	Credential requirement Yes (%)	No (%)	Total (%)
1.	31-1014-Nursing Assistants	1,217	8	85	15	100
2.	25-3099-Teachers and Instructors, All Other	834	6	92	8	100
3.	43-6014-Secretaries and Administrative Assistants, except Legal, Medical, and Executive	750	5	89	11	100
4.	25-9041-Teacher Assistants	750	5	93	7	100
5.	41-3099-Sales Representatives, Services, All Other	667	4	85	15	100
6.	33-2011-Firefighters	600	4	94	6	100
7.	42-4171-Receptionists and Information Clerks	450	3	89	11	100
8.	39-9011 Childcare Workers	450	3	96	4	100
9.	43-4051 Customer Service Representatives	384	3	100	0	100
10.	29-1141-Registered Nurses	384	3	87	13	100
11.	11-9199-Managers, All Other	334	2	85	15	100

*SOC-Standard Occupational Classification. Source: Center for Urban and Regional Analysis at VA Commonwealth University (2016). 2015 VA Job Vacancy Survey prepared for the VA Employment Commission, pp. 128-129.

Table 2

Top Projected Job Vacancies (Low, Middle, and High Skills) in 2016 by Major SOC Code*

SOC code	Occupational group	No. of vacancies	% of total vacancies
41-0000	Sales and related occupations	11,788	9
43-0000	Office and administrative support occupations	11,671	9
35-0000	Food preparation and serving related occupations	11,235	9
31-0000	Healthcare support occupations	10,296	8
25-0000	Education, training, and library occupations	9,893	8
47-0000	Construction and extraction occupations	9,122	7
37-0000	Building and grounds cleaning and maintenance occupations	8,904	7
33-0000	Protective service occupations	8,535	7
53-0000	Transportation and material moving occupations	7,194	5
49-0000	Installation, maintenance and repair occupations	5,617	4
39-0000	Personal care and service occupations	5,433	4
29-0000	Healthcare practitioners and technical occupations	4,880	4
51-0000	Product occupations	4,846	4

*SOC = Standard Occupational Classification. Source: CURA at Virginia Commonwealth University (2016). 2015 Virginia Job Vacancy Survey prepared for the Virginia Employment Commission, p. xiii.

to be the hardest to fill and appeared the most often on the 2016 Job Vacancy Report, these occupations comprised 47% of total projected vacancies. See Table 3 for the top five vacancies that appeared the most often.

Based on the data shown in Tables 1, 2, and 3, there is a demand for workers with middle skills in the Commonwealth. If Virginia does not address this demand to fill middle-skill occupations, the impact could be substantial for Virginians, businesses, and the Commonwealth economically in terms of lost wages, production, taxes and sales revenue (VCCS, 2015). If Virginia is unable to fill the workforce pipeline for the in-demand or high-growth middle-skill occupations, companies may go to other states to meet their workforce

needs. Thus, addressing the MS gap is critical to developing a skilled and knowledgeable workforce for Virginia to be competitive in a global economy.

Table 3

Top Five SOC Codes That Appeared the Most Often in the 2015 Virginia Job Vacancy Survey Report*

SOC code	Occupational groups that appeared the most often in the 2015 Virginia Job Vacancy Survey	No. of vacancies	No. of times occupation appeared
29-0000	Healthcare practitioners and technical occupations	4,880	5
15-0000	Computer and mathematical occupations	2,817	4
25-0000	Education, training, and library occupations	9,893	4
49-0000	Installation, maintenance, and repair occupations	5,617	4
17-0000	Architecture and engineering occupations	1,811	4
23-0000	Legal occupations	771	4

*SOC = Standard Occupational Classification. Source: CURA at Virginia Commonwealth University (2016). 2015 Virginia Job Vacancy Survey prepared for the Virginia Employment Commission, p. xiv.

What Has Virginia Done to Address the MS Gap?

The overarching goal of Virginia's workforce system is to close the skills gap by preparing and placing individuals in high-demand jobs in industries of priority for Virginia's economic success (Commonwealth of Virginia, 2018). Thus, filling the skills gap is a top priority for the governor and the VBWD. The VBWD is a business-led board appointed by the governor to help Virginia's public workforce development system build a strong workforce with skills aligned with employer needs by recommending policies and strategies to the governor. The

VBWD endorses a dual-customer model that recognizes and meets the needs of both businesses (demand) and job seekers (supply) (VBWD, 2018a).

The VBWD (2018a) Strategic Plan states that one of the factors impacting Virginia's future workforce development needs is the shortage of individuals with sufficient training to meet the demand for MS jobs. A primary objective of the VBWD is to recommend and support strategies to better prepare and match trained workers and close the skill gap. To meet this objective, one of the VBWD goals is to improve the quality of the labor force (supply) by investing in credential attainment, work-based learning, on-the-job training and apprenticeships (VBWD, 2018a). This will help improve career opportunities for Virginians and support employer demands. Another VBWD goal to help close the skills gap is to collaborate with businesses to address skill shortages in priority industries and in-demand occupations (VBWD, 2018a).

Key policies or regulations Virginia has implemented to address the MS gap include two executive orders by the governor. In a call to action to strengthen Virginia's workforce and fill those approximately 1.5 million job openings by 2022, Governor Terry R. McAuliffe issued Executive Order 23, The New Virginia Economy in 2014, and VA Executive Order 49, Expanding Registered Apprenticeships in Virginia in 2015. One of the goals in VA Executive Order 23 was to increase postsecondary education and workforce credentials. The governor outlined an initiative, Pathway to 50K, as a goal of attaining 50,000 STEM H credentials, licensures, apprenticeships, and associate degrees to meet Virginia's workforce needs (VA Executive Order 23, 2014). In VA Executive Order 49, the goal was to expand registered apprenticeships in Virginia's state agencies and key industry sectors that have not traditionally

sponsored registered apprenticeships (such as information technology, cybersecurity, professional and business services).

In 2016, the Virginia General Assembly passed HB 66 establishing the New Economy Workforce Grant Program. The primary purpose of this grant program is to increase the interest of Virginia workers in technician, technologist, and trade level positions to the fill the (available and emerging) MS jobs in Virginia; create a supply of credentialed workers for high-demand occupations by addressing and closing the skills gaps of workers in the Commonwealth; and make workforce training and credentialing more affordable to Virginians (Code of Virginia § 23.1-627.2.; State Council of Higher Education for Virginia [SCHEV], 2018). Overall, this innovative grant program is the first of its kind in the United States and it provides a pay-for-performance model for funding noncredit workforce training that leads to a credential in a high demand field (SCHEV, 2018).

The VBWD is required to identify high-demand occupational fields in accordance with the New Economy Workforce Credential Grant Program. In 2016, the VBWD created the Demand Occupation Task Force to identify the fields and occupations for the Virginia Demand Occupations list. The taskforce identified three primary criteria for inclusion on the Virginia Demand Occupations list. They include: (a) the occupational groups' relevance to the state's economic development strategy; (b) the degree to which advanced skills are required for entry into an occupation—this was limited to greater than high school diploma and less than a master's degree; and (c) the projected statewide demand for an occupation based on VEC-USDOL-BLS 10-year employment projections (SCHEV, 2018). Based on a review of the occupations meeting the criteria above, the VBWD identified high-demand occupations in 11 fields. See Table 4 and Appendix F for more detailed information.

Table 4

VBWD Total Annual Openings for High-Demand Occupations by Occupational Field

Occupational field	Total annual openings for high-demand occupations (includes openings from growth and replacement)
17-0000 Architecture and engineering	2,268
15-0000 Computer and mathematical	8,525
47-0000 Construction and extraction	4,020
25-0000 Education, training, and library	6,881
29-0000 Healthcare practitioners and technical	5,379
31-0000 Healthcare support	3,930
49-0000 Installation, maintenance, and repair	4,782
19-0000 Life, physical, and social science	372
43-0000 Office and administrative support	15,704
51-0000 Production	2,600
53-0000 Transportation and material moving	3,207
Total	57,668

Source: Virginia Board for Workforce Development selection of high-demand occupations based on Virginia Employment Commission/Bureau of Labor Statistics 10-year employment projections for 2016 and SCHEV, 2018.

These high-demand occupations overlap with the projected vacancies in 2016 based on the SOC codes that appeared the most often in Table 3 and in the MS job vacancies by detail occupations in Table 1. Many of the high-demand occupations are MS jobs that may be unfilled due to the MS gap.

Summary—What is Not Known?

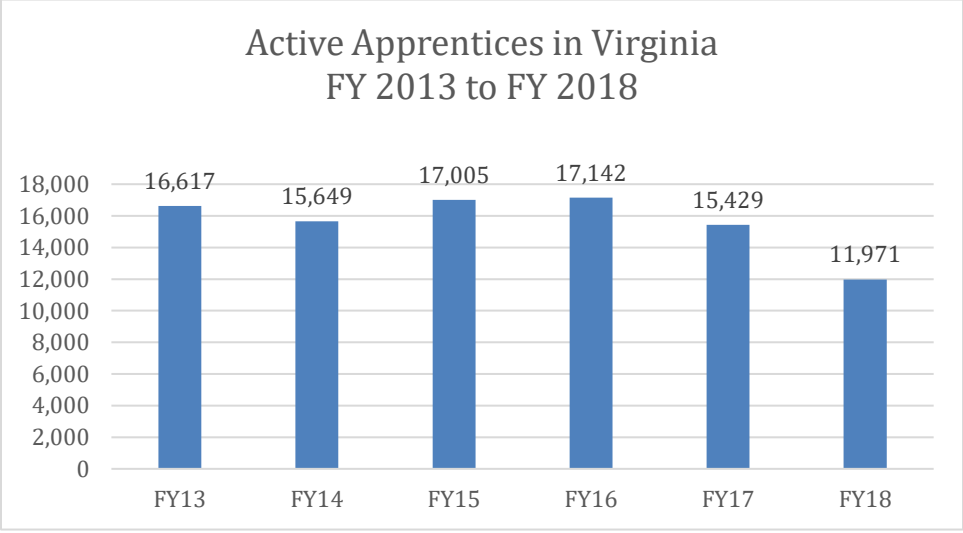
The overarching goal of the workforce system in Virginia is to close the skills gap (Commonwealth of VA, 2018), and registered apprenticeship is one of the work-based learning and on-the-job training tools Virginia is investing in to close the MS gap. Specifically, Virginia's Executive Order 49 recognizes registered apprenticeships as a state strategy for addressing the MS shortage by stating that registered apprenticeships are a "tried and true strategy to prepare a

skilled workforce for these technician level" middle-skill jobs (VA Executive Order 49, 2015, p.1). As a result, Virginia has begun implementing initiatives to expand registered apprenticeships via VA Executive Order 49, VA Executive Order 23 and allocating over $7.5MM in federal and state funds for apprenticeships since 2015 (VA Executive Order 49, 2015; Office of the Governor, 2015, 2016a).

Since the implementation of these initiatives, what is not known is the impact of registered apprenticeships in filling MS gap occupations and whether registered apprenticeships are making an impact in closing the MS job gap in Virginia. Additionally, the VDOLI has minimal reporting regarding Virginia's registered apprenticeship programs. We know Virginia's registered apprenticeship programs have 11,971 active apprentices, 2,000 active programs, 1,943 completers, and 178 apprenticeable occupations in FY2018 (USDOL, 2018c; VDOLI 2018). See Figure 3 for the number of apprentices in Virginia's RA program from FY13 to FY18.

Figure 3

Active Apprentices in Virginia FY2013 to FY2018



Source: USDOL, 2018c. Apprenticeship data and statistics. Retrieved from https://doleta.gov/oa/data_statistics.cfm

Yet, there is not much known in regards to the characteristics of Virginia's RA programs. Specifically, what are the demographics of the apprentice population (gender, ethnicity, and age); who is benefitting from (participating in) the RA programs; and who are the primary participants? This information will help identify who are filling the MS positions in the Commonwealth of Virginia.

Chapter Summary

The MS gap is when significant numbers of MS occupations (requiring skills less than a bachelor's degree but more than a high school degree) remain unfilled because employers cannot find people with the appropriate skills to fill them. Likewise, the MS gap is about the economic theory of supply and demand—there is an inadequate supply of workers with the right skills available to meet employers' demand for labor. The RA model is a solution many lawmakers and states are using to address the MS gap because the RA model is structured for developing middle-level skills employees for the labor market (Fuller, 2016), and registered apprenticeships address both the demand and supply side. The RA system is one of the few mechanisms for improving both the supply and demand sides of the labor market (Lerman, 2018).

Many economists view the skills of the labor force (human capital) as the engine of growth, or at the very least, a major contributor to economic performance. The human capital theory suggests that investment in education and training increases human capital, this investment leads to higher productivity rate (which benefits the employer), and in turn brings a higher wage for the individual (Tan, 2014). Thus, investing in human capital (education, knowledge, and skills) of individuals will yield improved economic results for the individual, business, and society. Investing in education and training with a work-based learning tool such as the registered apprenticeship is considered to increase the knowledge and skills of individuals as

well as help employers meet their demand for labor. Individuals are able to improve both their education (receiving a nationally recognized portable credential) and productivity (participating in on-the-job training) and employers can train workers on the job for the exact skills they need—minimizing the skills gap.

There is a growing demand for workers in the newer MS occupations such as skilled and technical services (Autor, 2015; Carnevale et al., 2018; Heinrich, 2018; Holzer, 2015; Modestino, 2016) and the demand for middle-level skills is expected to grow faster than the supply of these services (Holzer & Lerman, 2007, 2009; Modestino, 2016). In Virginia, jobs requiring middle skills is growing (CURA at VCU, 2016) and there is a concern of having people with sufficient training to meet the demand for MS jobs (Commonwealth of Virginia, 2017; CURA at VCU, 2016; VBWD, 2018).

Closing the skills gap is a top priority for Virginia and expanding registered apprenticeships is a strategy Virginia is using to address the MS gap via policy and regulations such as VA Executive Order 49 (2015). Is the RA strategy having an impact on filling Virginia's projected MS job openings and closing the MS gap? If so, to what extent? This research examined the impact of registered apprenticeships on Virginia's MS gap occupations. This study identified MS occupations with a skills gap in Virginia and examined these occupations in relationship to RA positions. This will determine the likelihood of a RA position filling a MS gap occupation.

Chapter 3. Methodology

The purpose of this quantitative study was to examine the impact of Virginia's registered apprenticeships on the MS gap. This research is significant because Virginia has a growing demand for MS jobs and employers perceive they will have difficulty filling these jobs (CURA at VCU, 2016) which could have a major economic impact on businesses as well as the Commonwealth. Additionally, Virginia has invested over $7.5M in federal and state funds and has implemented policies and regulations (e.g., VA Executive Order 49, 2015) to expand registered apprenticeships as a workforce strategy to help address the skills gap. Examining the impact of registered apprenticeships on the MS gap will help inform future policy decisions to assist in shaping workforce development strategies that will address the skills gap, such as whether to invest additional resources in registered apprenticeships, and develop incentives for employers to adopt more registered apprenticeships.

To examine the impact, this study first identified MS occupations with a skills gap in Virginia and examined those occupations in relation to Virginia's RA positions. Descriptive statistics were used to describe the landscape of Virginia's registered apprenticeships and MS gap. Inferential statistics were used to analyze the impact (of registered apprenticeships on the MS gap) by examining the likelihood of a RA position filling a MS gap occupation in 2018 as compared to 2015. This study used secondary analysis of public data collected from the

VDOLI registered apprenticeship database and the VEC-LMI database which is based on the USDOL-BLS information.

This chapter begins with reviewing the research questions and identifying the hypotheses. Next, a description of the research design and the methodology is provided, including the population, data collection procedures, operational definitions of the variables, and data analysis plan. This is followed by with the threats to validity, limitations, and a chapter summary.

Summary of Key Issues

The following are seven key issues regarding registered apprenticeships and the MS gap:

1. Federal and state funding has increased to expand RA programs and apprenticeable occupations as a strategy to address the skills gap.
2. The registered apprenticeship model is a solution many lawmakers and states are using to address the MS gap because of its proven model of on-the-job training.
3. The RA model is structured for developing middle-level skills employees (Fuller, 2016) and registered apprenticeships address both the demand and supply side of the labor market (Lerman, 2018).
4. There is a strong and growing demand for MS jobs in Virginia (Heinrich, 2018; NSC, 2017), and there is a concern of having people with sufficient training to meet the demand for these MS jobs (Commonwealth of Virginia, 2017; CURA at VCU, 2016; VBWD, 2018). Rural workers are more likely to hold MS jobs than urban workers (Young, 2013).
5. There is limited data about Virginia's RA programs and the MS gap.
6. Apprenticeships are strongly procyclical (Bilginsoy, 2018; Brunello, 2009; Sharpe & Gibson, 2005), expanding rapidly with economic growth and contracting during

recessions. New apprenticeship registration is associated with the unemployment rate (Sharpe & Gibson, 2005)

7. Virginia implemented initiatives such as VA Executive Order 49 (2015) to expand registered apprenticeships in the areas of information technology, cybersecurity, professional and business services as a way to address the skills gap and its workforce development needs; and the impact of registered apprenticeships on the MS gap is unknown.

Research Questions and Hypotheses

Based on the summary of key issues and that limited studies, if any, have explored the relationship between registered apprenticeships and the MS gap, the overarching research question for this study is: What is the impact of registered apprenticeships on the MS gap in Virginia? The following are the research questions and hypotheses that were examined for this research:

Research Questions

1. Is there a MS gap in Virginia?
    a. Which MS occupations have a skills gap in 2015 and 2018?
    b. Which occupations (number of occupations and size of gap) are most impacted by the MS gap in 2015 and 2018?
2. How many registered apprenticeship positions are filling MS gap occupations?
    a. What are the key characteristics of registered apprenticeships in Virginia?
        i. What are the apprentice characteristics and demographics?
        ii. What are the key program and employer characteristics?
    b. How many registered apprenticeship positions are in VA Executive Order 49

occupations (cybersecurity or information technology) in 2015 and 2018?

3. What is the impact of registered apprenticeships on the MS gap in Virginia?

a. What is the likelihood of a Virginia registered apprenticeship position in 2018 (as compared to 2015) filling a MS gap occupation?

b. How does location and unemployment impact the likelihood of a registered apprenticeship position filling a MS gap occupation?

Research Hypotheses

H_1: Virginia's 2018 RA positions have a higher likelihood of filling a MS gap occupation than Virginia's 2015 RA positions.

H_2: Registered apprenticeship positions located in an urban area decreases the likelihood of a RA position filling a MS gap occupation.

H_3: Higher levels of unemployment in the location of a RA position decreases the likelihood of a registered apprenticeship filling a MS gap occupation.

Primary Variables Under Investigation

The primary variables under investigation included the dependent variable, *registered apprenticeship position filling a middle-skills gap occupation* (RAPMSGO) and the independent covariates *2018 RA positions, urban location, and unemployment rate*. The unit of analysis was the RA position.

Research Design

Utilizing a quantitative, nonexperimental, cross-sectional research design, this study examined the impact of Virginia's RA positions on MS gap occupations. A causal comparative (ex post facto) design was used to analyze the relationship between registered apprenticeships

and the MS gap in 2015 and 2018, before and after the implementation of VA Executive Order 49 (2015), the expansion of registered apprenticeships.

A causal comparative (ex post facto) design examines the impact or effect of variable X on variable Y in a nonexperimental setting. This design seeks to identify causal relationships and suggests causal conclusions by comparing two or more groups of individuals after an action or event has occurred (Brewer & Kuhn, 2012; McMillan, 2016). There is no direct control or manipulation of the variable, the groups are formed prior to the study, and the data has already been collected (post facto) because the event has already occurred.

Accordingly, a causal comparative (ex post facto) design was appropriate for this study because this research investigated the impact of registered apprenticeships on the MS gap using analyses of secondary of RA data collected in 2015 (Group 1) and 2018 (Group 2). Additionally, this research examined factors such as unemployment rate and location (urban versus rural) that may influence the likelihood of RA positions filling a MS gap occupation. Using this research design was similar to the Hollenbeck and Huang (2016) net impact study of workforce development (RA) programs and the design is an appropriate choice to advance knowledge in registered apprenticeships.

The advantage of using a causal comparative design (ex-post facto) is that it is similar to experimental research because it investigates cause-effect relationships and compares groups (Brewer & Kuhn, 2012), but it is not as time-consuming and costly. This research design also helps identify explanations for an existing condition or event such as the MS gap occurring in Virginia. Furthermore, most of the data for the causal comparative design use existing groups and is collected from existing sources, thus simplifying steps of the research process (e.g.,

reducing data collection procedures) and minimizing institutional review board or ethical concerns.

Research Data and Methodology

This study used secondary analysis of public data collected from the VDOLI, USDOL-BLS, and the VEC-LMI to examine the registered apprenticeship and the MS gap data. This methodology was selected because it was fast (data were readily available from a public source), low cost, and provided a quantitative and numeric analysis of the MS gap and registered apprenticeship in Virginia. This section outlines the population and sample, data collection procedures, operational definition of variables, and data analysis process.

Population and Sample

The target population consisted of RA apprentices in Virginia's RA programs. The sample frame was derived from the VDOLI which oversees Virginia's RA program. The RA population consisted of apprentices who participated in Virginia's RA program during fiscal year (FY) 2015 (Oct. 1, 2014 to Sept. 30, 2015) and FY2018 (Oct. 1, 2017 to Sept. 30, 2018). These data included active carryovers (apprentices) from the prior year and apprentices who started, finished, cancelled, or completed during FY2015 and FY2018. This selection criteria resulted in approximately 31,158 RA positions (by apprentice) that were examined for this study (15,229 RA positions in 2015 and 15,929 RA positions in 2018)[1].

FY2015 data were used to examine patterns prior to the effective date of VA Executive Order 49 on October 6, 2015. FY2018 data were used to examine patterns and relationships after

[1] The total number of positions examined in FY15 and FY18 does not match what is reported by the U.S. Department of Labor or VDOLI. The U.S. Department of Labor (USDOL) RA positions include apprenticeships that are managed nationally and are not in Virginia's database. Additionally, the USDOL does not include completed/cancellations whereas this study does. This study included any apprentice or position that had activity during the year.

the implementation of VA Executive Order 49 (2015). Similar to the Bruno and Manzo (2016), this study did not take a representative sample and used a census of the entire population of apprentices for FY15 and FY18 due to the nature of this study and size of the sample frame.

Additionally, this study reviewed registered apprentice program and apprenticeable occupation data for Research Question 2 (RQ2). Each apprentice is a part of or associated with a RA program. A registered apprenticeship program consists of a written plan to move an apprentice from a low or no skill entry-level position to full occupational proficiency (USDOL, 2018d) that has been validated by the USDOL or a state apprenticeship agency (e.g., VDOLI) and is sponsored by an individual business, an employer association, or a labor organization through a collective bargaining agreement (USDOL, 2018d). In Virginia, there were 2,000 RA programs in FY18, 2,168 RA programs in FY15, and 178 active apprenticeable occupations (see Appendix A). These data were used to help describe the RA characteristics prior to and after the implementation of VA Executive Order 49 (2015).

Data Collection Procedures

A Freedom of Information Act (FOIA) request was submitted to the VDOLI to collect the RA data including program characteristics and demographic data. A specific variable request was developed based on prior studies from the literature review and in collaboration with the RA staff at VDOLI. See Appendix G for the sample forms. The data were received via an Excel® spreadsheet from VDOLI. The information was cleaned up (e.g., format RA positions and SOC codes, convert birth date to age) and then exported to Statistical Product and Service Solutions® (SPSS) for analysis.

Operational Definitions

This section contains the operational definitions of variables for this research. Table 5 provides the primary variables, scales of measurement, variable type, and operationalization. For additional variables (control and descriptive variables for RQ 1 and 2), see Appendix H for definitions.

Table 5

Primary Variables, Scales of Measurement, Variable Type, and Operationalization

Variable name	Scales of measurement	Variable type	Coding	Source
RA position	Nominal	Unit of Analysis	N/A	VDOLI-apprentice SOC code
RAPMSGO	Dichotomous	Dependent	0 = No 1 = Yes	Based on VEC-BLS data
2018 RA positions	Dichotomous	Independent	0 = No 1 = Yes	Based on the RA data year. Obtained from VDOLI
Urban location	Nominal	Independent	0 = No 1 = Yes	VDOLI-RA position FIPS code.
Unemployment Rate	Ratio	Independent	N/A	VEC/BLS local area unemployment statistics
Number of businesses	Interval	Independent (Control)	N/A	U.S. Census Bureau, county business patterns

Note. VDOLI = Virginia Department of Labor and Industry; SOC code = Standard Occupation Classification code; VEC = Virginia Employment Commission;

RAPMSGO = Registered apprenticeship position filling a middle- skills gap occupation;

RA = Registered apprenticeship; FIPS code = Federal Information Processing Standard code.

Registered apprenticeship position (RAP). It is a position or occupation filled by an apprentice in a RA program. The position is reported in the VDOLI Registered Apprenticeship (VDOLI RA) database as a Standard Occupation Classification (SOC) code. RA position (RAP) is the unit of analysis for this study.

Middle-skills gap occupation (MSGO). A dichotomous variable indicating a middle-skills occupation (jobs that require education or training beyond a high school diploma but less than a 4-year degree) with a skills gap. The MSGO was calculated based on Employer Demand *minus* Labor Supply. MSGO will be coded as 1 = yes or 0 = no.

RAPMSGO. A dichotomous variable indicating whether a RA position is filling a middle-skills occupation with a skills gap. RAPMSGO was coded as 1 = yes or 0 = no.

2018 RA positions. A dichotomous variable representing RA positions in the year 2018. This variable was coded as 1 = yes or 0 = no. This research only had 2018 and 2015 RA data--1 signified yes, it is 2018 RA position and 0 signified no, it is not a 2018 RA position but a 2015 RA position.

Urban location. Represents the location of a RA position which is reported in the VDOLI RA database as a county FIPS code (Federal Information Processing Standards code is a geographic code which uniquely identified counties and county equivalents in the United States). Urban location was based on the CDC 2013 NHCS Urban-Rural Classification Scheme for Counties (U.S. Dept. of Health, 2014) and the Virginia Department of Health Rural (non-metropolitan areas) as defined by the Office of Management and Budget (VDH, 2019). Urban areas were coded as a 1 = yes or 0 = no.

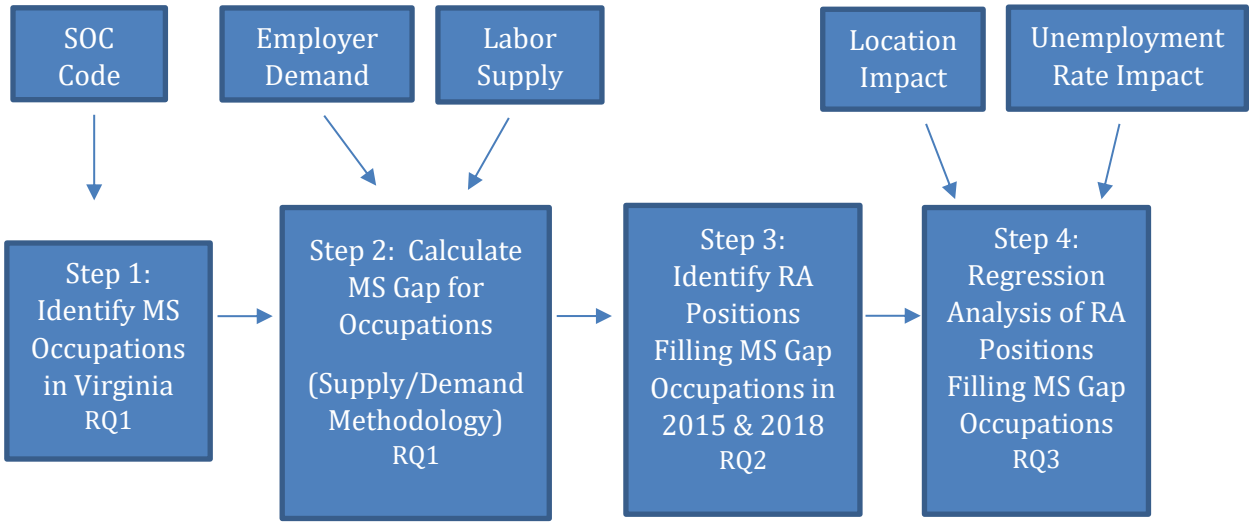
Unemployment rate. Represents the unemployment rate for each Virginia county, which is reported by the USDOL-BLS Local Area Unemployment Statistics. The 2015 and 2018 county unemployment rate was matched to the FIPS code for each RA position in SPSS®.

Data Analysis Process

This section provides the data analysis process for each research question. Figure 4 provides a diagram of the steps (data analysis process) used for this study.

Figure 4

Data Analysis Implementation Steps



Research Question (RQ) 1: Is There a MS Gap in Virginia?

a. Which middle-skills occupations have a skills gap in 2015 and 2018?

i. How many of Virginia's occupations are MS occupations, and MS occupations with a gap in 2018.

b. Which occupations (number of occupations and size of gap) are most impacted by the MS gap in 2015 and 2018?

To determine if there is a MS gap, this study first identified MS occupations in Virginia. Secondly, the employer demand and labor supply for each MS occupation was identified to calculate Virginia's MS gap. Third, the MS gap was calculated using the formula (employer demand minus labor supply). Following the methodology of previous studies (Pennsylvania State System of Higher Education, 2016; State of Washington Workforce Training and Education Coordinating Board [WTECB], 2019; Wilson, 2014), the supply and demand formula was used to determine if there was a gap for each Virginia MS occupation in 2015 and 2018 (before and after the implementation of VA Executive Order 49 [2015]). Descriptive analyses in Microsoft Excel® and SPSS® were conducted for each step to answer RQ1 and the subquestions.

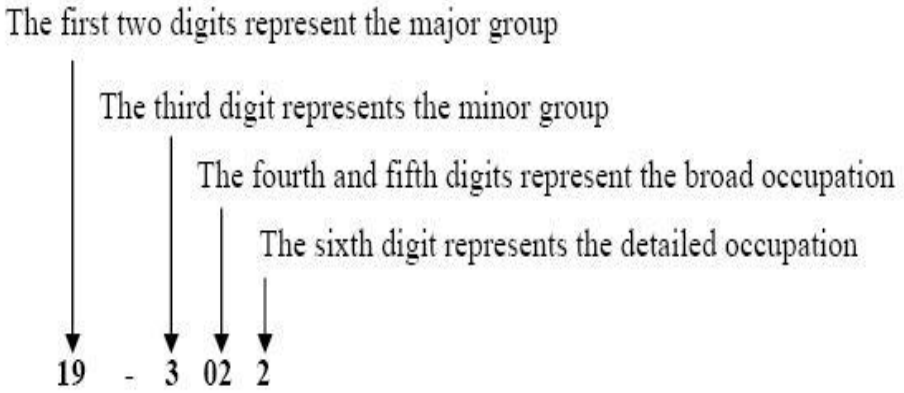
Identifying MS Occupations in Virginia.

Virginia's occupational data are derived from the USDOL-BLS SOC system, which is a federal statistical standard used by federal agencies to classify workers and jobs into occupational categories (U.S. Office of Management and Budget, 2018). The USDOL-BLS SOC system covers all jobs in the national economy including occupations in the public, private, and military sectors and provides a common language for categorizing and analyzing occupations for the purpose of collecting, calculating, or disseminating data (U.S. Office of Management and Budget, 2018). The 2018 SOC system contains 867 detailed occupations, aggregated into 459 broad occupations, which are combined into 98 minor groups and 23 major groups as shown in Figure 5. Each detailed occupation has a 6-digit SOC code which was used for identifying MS occupations for this research. Figure 5 provides an example of the SOC system structure and the 6-digit SOC code.

Figure 5

Example of the U.S. Standard Occupational Classification (SOC) System Structure and SOC Code

SOC System	Example
23 Major Groups	**29-0000** Healthcare Practitioners and Technical Occupations
98 Minor Groups	**29-1000** Health Diagnosing or Treating Practitioners
459 Broad Occupations	**29-1020** Dentists
867 Detailed Occupations	**29-1022** Oral and Maxillofacial Surgeons



Source: U.S. Department of Labor Bureau of Labor Statistics (2018). Standard Occupational Classification Manual.

Publicly available information from the VEC LMI website (Occupational Details Dashboard data page) and the 2016-2026 Long-Term Occupational Virginia Projections report (which are based on the U.S. SOC system) were used as the basis for identifying Virginia's MS occupations. Both reports were used as the basis for identifying MS occupations because they provided the detailed data (by 6 digit SOC code) to identify MS occupations in Virginia. Also,

the VEC-LMI Dashboard provides the supply and demand data needed to calculate the 2018 MS gap where other sources did not.

An occupations-based definition of middle skills (education and training beyond high school but less than a bachelor's degree) similar to Eathington and Swenson (2015), Heinrich (2018), Holzer & Lerman (2007), Modestino, (2016), and NSC (2017) was used to identify MS occupations in Virginia. Using the data from the VEC-LMI website, this study identified MS occupations using the following four criteria derived from the occupation-based MS definition above: Occupations that require an (a) associate's degree; (b) postsecondary nondegree award; (c) some college, no degree; or (d) a high school degree and one of the following: apprenticeship, long-term on-the-job training, moderate-term on-the-job training, or work experience (Holzer & Lerman 2007; NSC 2017; Scaglione, 2018). Thus, if an occupation had one of the four education and training criteria, it was considered a MS occupation.

Based on the four criteria above, 229 occupations were initially identified as MS occupations in Virginia using the VEC Occupational Details Dashboard data (referred to as Dashboard henceforth). To ensure the MS occupation list was complete, this study compared the Dashboard to the VEC 2016-2026 Long-term Occupational Virginia Projections report because the Dashboard is based on this report. Out of 765 occupations from the 2016-2026 long-term occupations report, there were 443 MS occupations initially identified based on the four criteria established[2]. The 443 occupations were reconciled to the 229 MS occupations from the VEC Dashboard resulting into 286 MS occupations identified for this study.

[2] Virginia's 2016-2026 Occupations report had 765 occupations compared to the U.S. SOC Code System 867 Detailed Occupations. The Virginia report includes occupations only represented in Virginia and did not include occupations from the U.S. Military – SOC Code Major Group 55-0000.

The primary difference between the two reports was the 2016-2026 report had many occupations with SOC code groups that used the 2- and 3-digit SOC codes (e.g., 49-0000 and 45-2000) with summary information, whereas this study is using the 6-digit detailed SOC code (e.g., 47-2031). See Figure 5 and Appendix B for the structure of the SOC codes. The 2- and 3-digit SOC codes were removed from the middle-skill occupations identified for the study.

Additionally, there were some discrepancies between the two reports regarding the education criteria used to identify a MS occupations. For example, an occupation would be considered a MS occupation on one report and not the other report because the education and training criteria listed for that occupation was different for the two reports. For example, Occupation "A" would have a high school diploma and short-term on-the-job training on one report (this would not be considered a MS occupation according to the criteria) and the same occupation would have a high school diploma and long-term on-the-job training (which is considered a MS occupation) on the other report. To resolve the discrepancy, this study looked at occupational information from the O*NET to see if the occupation was classified as a Job Zone 3 and reviewed the education and training criteria in more detail to determine if it was a MS occupation[3]. Once the reconciliation was completed, 286 MS occupations (out of 765 occupations) were identified for this study. See Appendix I listing the 286 MS occupations for this study.

[3] O*NET (Occupational Information Network) is based on the U.S. Bureau of Labor Statistics Standard Occupational Classification (SOC) System. The O*NET uses job zones (one to five) to group occupations that are similar in education, work experience, and on-the job training necessary to perform the job. O*NET Job Zone 3 (occupations that need medium preparation and requires education that includes a high school diploma and training in vocational schools, related on-the job experience or an associate's degree) was used because it had the most "comparable" definition to middle-skill occupations based on the four criteria used for this study.

Calculating the MS Gap Methodology.

Once the 286 MS occupations were identified, the researcher determined whether each Virginia MS occupation had a skills gap. There are three primary ways to determine a skills gap:

1. Job vacancy (Kimmell & Martin, 2015; Modestino, 2010; Weaver & Osterman, 2017) examines job vacancy rates (calculated as a share of the total unemployment) by detailed occupation. The duration of the vacancy for an occupation (e.g., 3 months or more) is often used as a measure of labor shortage or a tight labor market—the longer a job takes the fill, the more likely a shortage exists for that occupation;

2. Supply and demand (Eathington & Swenson, 2015; State of Washington WTECB, 2019) compares the supply and demand of an occupation; and

3. Employer surveys (Hine, 2013; Leibert, 2013; Morrison, et al.) is one of the most common and well publicized methods of the skills gap (Kimmell & Martin, 2015) and typically asks employers if they believe if they have a skills gap, shortage of workers, or difficulty in filling positions or job vacancies.

The supply and demand methodology was used because it is what many states use (e.g., Washington and Virginia) and the data is readily available (State of Washington WTECB, 2019; VEC-LMI, 2019a). Additionally, employer surveys tend to have subjectivity (Kimmel & Martin, 2015) and there is a lack of reliable job vacancy data in Virginia. For example, a 3-month job vacancy could result from a company being mandated to keep the job open for a certain period (the position may be filled but the company will not close the job until a certain time period elapses) and a 3-month vacancy could be a hiring difficulty instead of a skills gap as mentioned in the literature review in Chapter 2. Furthermore, in Virginia, employers must repost their

positions every 3 months because the postings expire after 3 months at the VEC. Thus, there is no reliable data source to capture job vacancies over 3 months in the Commonwealth.

Calculating the MS Gap for 2015 and 2018.

The 2015 and 2018 MS gap was calculated for each MS occupation using the supply and demand methodology—employer demand (projected employment for people needed to fill jobs in MS occupations) minus labor supply (current supply of workers with middle-level skills). This measures whether the current labor supply meets the projected demand (future employment) for each MS occupation. The employer demand and labor supply information was obtained from the VEC-LMI website at www.virginiaworks.com. The VEC in cooperation with the USDOL-BLS uses the Occupational Employment Statistics (OES) report to gather occupational employment data. The OES data are the basis for the staffing patterns used in the occupational projections or projected employer demand (VEC-LMI, 2019b). Using the data from the VEC website, the labor supply and employer demand amount for each Virginia MS occupation in 2015 and 2018 was identified to calculate the MS gap. Table 6 provides a summary of how the 2018 and 2015 middle-skills gap was calculated and the data sources.

2018 MS Gap. As shown in Table 6, the 2018 MS gap was calculated using the projected or future employer demand (2026 occupational demand data) minus the current labor supply (2019 labor supply). The employer demand and labor supply information was obtained directly from the VEC-LMI website, Occupational Details Dashboard page. This was the most current information available to calculate the 2018 MS gap in Virginia after the implementation of VA Executive Order 49 (2015).

Table 6

Data Sources for the 2018 and 2015 MS Gap Calculation

MS gap (demand minus supply)	2018 MS gap calculation	2015 MS gap calculation
Employer demand	2026 projected employment by MS occupation	2023 projected employment by MS occupation-calculated
Source	2016-2026 VEC long-term occupational projections, VEC-LMI Occupational Details Dashboard	2018-2020 VEC short-term Occupational Projections Report
Calculation	N/A	2018 base year employment + (annual change * 5)
Labor supply	2019 estimated labor supply of MS workers	2016 labor supply of MS workers-calculated
Source	2016-2026 VEC long-term occupational projections, VEC-LMI Occupational Details Dashboard	2016-2026 VEC long-term Occupational Projections Report, 2016 base year employment
Calculation	N/A	N/A

Note. VEC-LMI = Virginia Employment Commission Labor Market Information.

Once the employer demand and supply was identified, the MS gap was calculated for the 286 MS occupations identified for Virginia. If the demand exceeded the supply, it was considered a MS gap for the occupation. As shown in Table 7, there is a MS gap if there is a negative number for that occupation.

2015 MS Gap. As shown in Table 6, the 2015 MS gap was calculated using the projected employer demand (2023 occupational demand data) minus the current labor supply (2016 labor supply).The 2016 labor supply was used instead of the 2015 labor supply because the 2014-2024 Long-Term Occupational Virginia Projections report data were not available from the VEC to

calculate the 2015 supply. It was recommended by the VEC economists to use the "2016 base year employment data" from the 2016-2026 Long-Term Occupational Virginia Projections report for the 2015 labor supply[4]. Furthermore, the 2016 base year employment was used for the 2015 MS gap calculation because it provides labor supply data on a 6-digit SOC code level and it is consistent with how the VEC calculated the data for the 2019 labor supply.

Table 7

MS Gap Calculation Example

SOC code	MS occupation	2019 Labor supply	2026 employer demand	Estimated MS gap (demand minus supply)	Ratio of supply to demand
53-2021	Air traffic controller	1,182	1,266	(84)*	.93
49-3011	Aircraft mechanics and service technicians	2,281	2,419	(138)*	.94
27-4012	Broadcast technicians	694	688	6	1.00
49-9021	Heating, air conditioning, and refrigeration mechanics and installers	12,268	13,245	(977)*	.93
43-6013	Medical secretaries	5,620	6,604	(984)*	.85
29-2052	Pharmacy technicians	9,421	10,320	(899)*	.91

*Indicates a MS gap. Source: Virginia Employment Commission (2019a). Virginia's Career and Workforce Labor Market Information, Occupational Details. Retrieved from https://virginiaworks.com/occupational-detail.

[4] The base year employment is derived from occupational employment projections. Per the USDOL-BLS (2019b) and the VEC, occupational employment projections are created based on an Industry Occupation Matrix that uses data from the Occupational Employment Statistics program (OES), the Current Employment Statistics program (CES), the Quarterly Census of Employment and Wages (QCEW) and the Current Population Survey (CPS). The long-term or short term industry employment projections, along with the staffing patterns from the OES, national data from the BLS and state data are combined in the matrix to develop the base-year employment.

The 2023 employer demand was calculated using the 2018 estimated base year employment from the VEC 2018-2020 Short-Term Occupational Virginia Projections Report (the 2023 data were not available from the VEC, thus it had to be calculated). The calculation formula (2018 base year employment + (annual change * 5) is consistent with how the VEC calculated the 2020 and 2026 projected employer demand for employment in their reports. The projected year (2023) for the employer demand was used because it was the same length of time used for the 2018 MS gap calculation (7 years is same length of time between the current supply and future demand for both years—2016-2023 and 2019-2026).

The 2018-2020 Short-Term Virginia Occupational Report was used to calculate the 2023 employer demand (instead of the 2016-2026 report) because it was recommended by the VEC for the reason that the estimates are more up-to-date (the 2018 base period uses first Quarter 2018 Quarterly Census of Employment and Wages and May 2017 OES data whereas the 2016 base period uses 2016 Quarterly Census of Employment and Wages data. Additionally, the risk appears to be less because the study only has to calculate out for 5 years to 2023 (using the 2018 data) instead of 7 years if the 2016 base employment was used. See Table 7 for an example of how the MS gap was calculated.

Ratio of Supply to Demand.

Similar to Indiana University's supply and demand gap analysis for Pennsylvania (Pennsylvania State System of Higher Education, 2016), a relative demand gap was calculated, which is the ratio of supply to demand. A ratio below 1 (or 100%) indicated the demand exceeds supply, whereas a ratio over 1 (or 100%) indicated the supply exceeds the demand. This analysis factored in both the absolute measure (nominal comparison—the number of labor supply that needs to meet the employer demand) and the relative measure (ratio) to provide a more

comprehensive perspective for interpreting the skills gap (Pennsylvania State System of Higher Education, 2016). For example, an occupation that may indicate an employer demand for 40 jobs with a labor supply of 30 would require 25% more labor supply to bridge the gap (30/40 = 0.75). Yet, the absolute gap of 10 (40 minus 30) would suggest the gap is relatively small. Therefore, examining both the ratio and absolute (nominal) size of the gap provided a more in-depth interpretation of the MS gap. As shown in Table 7, the ratio of supply to demand was computed for the MS occupations.

Once the MS gap occupations were identified, each RA position was coded (yes/no) as to whether it was filling a MS gap occupation based on the nominal amount (see RQ 2).

Research Question (RQ) 2: How many Registered Apprenticeships are Filling MS Gap Occupations?

Subquestions:

a. What are the key characteristics of registered apprenticeships in Virginia?

i. What are the apprentice characteristics and demographics?

ii. What are the key RA program and employer characteristics?

How many RA position are in VA Executive Order 49 occupations (cybersecurity or information technology) in 2018 and 2015?

Prior to determining how many registered apprenticeships are filling MS gap occupations, the RA characteristics were analyzed first. The primary apprentice demographics examined were gender, ethnicity, veteran status, and age. In preparation to analyze the RA characteristics, this study converted the birthdate to age and grouped them into age categories for analysis. Additionally, information regarding the apprentice gender, ethnicity, and veteran status were coded into categories (based on the data received from VDOLI) for analysis in SPSS®

(e.g., male and female; White, Black, Hispanic, Asian, Native American, Other; Veteran and Non-Veteran).[5]

Additional RA characteristics examined in the descriptive analysis included: (a) employer characteristics such as number of RA positions per employer and number of RA positions by employer industry[6]*;* and (b) program characteristics such as number of RA positions: by urban location; by SOC Code Major Groups; by specific occupations on the Virginia Demand Occupations List; and by VA Executive Order 49 (2015) occupations (cybersecurity and information technology).

In determining whether a RA position filled a MS gap occupation, RA positions in 2015 and 2018 were compared to the MS occupations identified with a skills gap from RQ1 (see Appendixes K1 and K2). If a RA position in 2015 or 2018 was determined to match a MS occupation with a skills gap, it was considered a RA position filling a MS occupation with a gap (RAPMSGO = yes). If the RA position did not match a MS occupation with a skills gap, then RAPMSGO = no.

The 6-digit detailed SOC code was used as the common identifier to determine if the RA position filled a MS occupation with a skills gap in 2015 and 2018. There were a small amount of RA positions that had an incorrect SOC code. In those instances, the most appropriate SOC

[5] Based on the data obtained from VDOLI, a small number of apprentices had two RA positions in PY2018 (286, 1.8%) and in 2015 (345, 2.3%). The demographic characteristics reflect these apprentices twice because each apprentice had two positions and the unit of analysis for this study is a registered apprenticeship position.

[6] To determine the number apprenticeships by industry, the study used the SIC Code (Standard Industrial Classification) from the data received from VDOLI and converted it to a NAICS (Northern American Industry Classification System) 2-digit Industry Sector Code using the SIC to NAICS crosswalk from the NAICS website (NAICS, 2018). NAICS was established in 1997 to replace the SIC system, it is the standard for classifying business establishments and is used by the US. Bureau of Labor Statistics (BLS, 2019c; NAICS, 2017). See Appendix J for the NAICS Codes.

code was determined based on the position description (e.g., 842.361-030 was converted to 47-2081).

There were some RA positions in which the SOC code was not on the MS occupations list or the VEC 2016-2026 Long-term Occupations Detail Report from RQ1[7]. In those situations, if the SOC code was found on O*NET and was considered a Job Zone 2, it was coded as a "0" or "no" because it did not meet the criteria of a MS occupation. However, if that SOC code was considered a Job Zone 3 on O*NET (which meets the criteria of a MS occupation), it was coded to a SOC code with a similar description or to the SOC Code Detailed Group "Other" ending in 099 (e.g. 27-4099 and 51-7099). Once the RA position had the appropriate SOC code, it was then compared to the list of MS occupations with a skills gap (from RQ1) to determine if the RA position was filling a MS gap occupation (RAPMSGO).

Research Question (RQ) 3: What is the Impact of RA on the MS Gap in Virginia?

Subquestions:

a. What is the likelihood of a 2018 Virginia RA position (as compared to 2015 Virginia RA position) filling a MS gap occupation?

b. How does location and unemployment impact the likelihood of a Virginia RA position filling a MS gap occupation?

Inferential statistics in SPSS® were used to analyze RQ 3 and its subquestions. Based on the data collected in RQ 1 and 2, logistic regression analysis was used for all hypotheses (H_1, H_2, and H_3). Binary logistic regression analysis was used because the dependent variable (RA

[7] There were some RA positions that had SOC Codes or occupations pertaining to the Military (SOC Code Major Group 55-0000). These RA positions were excluded from the study because those occupations (SOC Codes) were not included in the VEC data reports to determine if Virginia's occupation were middle-skilled or had a middle-skill gap. The impact was minimal. The military occupations accounted for 618 positions (3.9%) of the RA population in 2015 and 477 positions (2.9%) of the RA population in 2018.

positions filling a MS gap occupation-RAPMSGO) was defined as a binary (yes or no) variable and this research sought to estimate the likelihood of a RA position filling a MS gap occupation. The logistic regression assumptions were tested prior to conducting the analyses and the outcomes are presented in Chapter 4.

A binary logistic regression analysis was conducted for the dependent variable (RA position filling a MS gap occupation-RAPMSGO) using a binary regression model that included both the 2015 and 2018 RA data. See Figure 6 and Table 8 for the regression equation. The regression model results compared the 2018 RA data to the 2015 RA data using the categorical variable, *2018 RA position*, to answer H_1: Virginia's 2018 RA positions have a higher likelihood of filling a MS gap occupation than Virginia's 2015 RA positions.

Logistic regression was also used to analyze (a) the influence of location on a RA position filling a MS gap occupation, and (b) the influence of unemployment rate on a RA position filling a MS gap occupation to answer Hypothesis 2 and 3, respectively. This research initially included two control variables (*number of businesses* and *number of jobs*). However, there was a high level of correlation between the variables and number of jobs was removed to eliminate any multicollinearity concerns for this analysis. An analysis was also conducted for 2018 RA data and 2015 RA data in two separate logistic regression models (see Appendix L for the Regression Equations). This provided a more in-depth analysis of whether the variables had a different effect on RA positions filling MS gap occupations (RAPMSGO) in 2015 versus 2018. The following are the hypotheses and statistical tests for RQ3 (see Figure 6 and Table 8).

Figure 6

Logistic Regression Equation

$$Z_i = ln\left(\frac{P_i}{1-P_i}\right) = \alpha + \beta_1 x_1 + .. + \beta_n x_n$$

Table 8

Hypotheses and Statistical Tests for Research Question 3

Hypothesis:

- Hypothesis 1. Virginia's 2018 RA positions have a higher likelihood of filling a MS gap occupation than Virginia's 2015 RA positions.
- Hypothesis 2. RA positions located in an urban area decreases the likelihood of a RA position filling a MS gap occupation.
- Hypothesis 3. Higher levels of unemployment in the location of a RA position decreases the likelihood of a RA filling a MS skills gap occupation.

Binary logistic regression equation:

$Z_i = ln\ (P(\text{RAPMSGO}) / 1 - P(\text{RAPMSGO})) = b_0 + b_1 2018RAPosition + b_2 UrbanLocation + b_3 UnemploymentRate + b_4 Businesses$

Variables:

RAPMSGO = RA position filling a middle-skills gap occupation

- Y = RAPMSGO (1 = yes, 0 = No)
- X_1 = 2018 RA positions (categorical variable, 1 = Yes, 0 = No)
- X_2 = Urban location (categorical variable, 1 = Yes, 0 = No)
- X_3 = Unemployment rate (ratio)
- X_4 = Number of businesses (control and interval variable)

Threats to Validity

The primary threat to internal validity in this research was history and quality of the data. This research was examined and compared data from 2015 and 2018. During that time,

uncontrolled events could have occurred that might have affected the middle-gap occupation data or RA data. Additionally, this study utilized secondary data collected by government organizations (e.g., RA data from the VDOLI and MS occupation data from the VEC-LMI). Although using secondary data was efficient and not as costly, the researcher had no control over the data collection methods and quality of data for the two different time periods. The researcher controlled for these threats via reviewing data for consistency between the 2 years and determining whether VDOLI had made any changes to the methodology in collecting data between 2015 and 2018. The external validity for this study is strong because a census of the entire RA population will be used instead of a sample. Therefore findings of this study can be generalized to other registered apprenticeships.

Limitations

There were some limitations for this study. First, calculating or identifying the supply data for the MS gap was a potential limitation because the supply side data did not include migrations of students and workers in and out of the state. Many states adjust the supply calculation to include unemployed and net migrants (net-in/net out-migration of workers with postsecondary education and training). However, similar to Colorado and Washington (Wilson, 2014; State of Washington WTECB, 2019), this study did not include interstate migration of students and workers because of the lack of available data by 6-digit SOC-codes and it keeps the analysis more manageable—the analysis shows the gap between supply and demand if one assumes no net interstate migration (Wilson, 2014). The supply and demand analysis was simplified by comparing the current labor supply by occupation with projected occupational demand. This study identified the labor supply data directly from the VEC website (Occupational Details Dashboard Labor Market Information data page) or calculated the labor supply data for

each occupation using the same methodology as the VEC (which did not include labor supply migrations).

Second, limiting the population to only registered apprenticeships from the VDOLI database could be considered a limitation of this study. There are many employers across the Commonwealth that have positions, jobs, or occupations they call apprenticeships. However, these are considered unregistered apprenticeships and are not officially registered with the state or national registered apprenticeship system. Individuals who participate in an unregistered apprenticeship do not earn a certificate from the Department of Labor and the legitimacy or quality of the apprenticeship cannot be verified since it is not monitored or regulated by a federal or state agency. Individuals participating in unregistered apprenticeships could also be filling MS gap occupations. The number of unregistered apprenticeships is unknown and is hard to capture and quantify. This study focused on registered apprenticeships because there is quality data captured on registered programs via VDOLI registered apprenticeship database. Additionally, Industry Recognized Apprenticeships programs were not used in this study because the USDOL just introduced them in 2018, they are still in the formative stage, and there is no formal program or data captured on Industry Recognized Apprenticeships as of date.

Chapter Summary

The goal of this research was to investigate whether registered apprenticeships had an impact on Virginia's MS gap. A comparative (ex post facto) research design was used to examine the impact of registered apprenticeships on MS gap occupations in 2015 and 2018. This study implemented a quantitative, nonexperimental, cross-sectional research design using public secondary data collected from the VDOLI, USDOL-BLS, and the VEC-LMI.

To examine the impact, this study first determined if there is a MS gap and identified the key characteristics and demographics of registered apprenticeships in Virginia. Registered apprenticeship positions were examined in relation to MS gap occupations and occupations from VA Executive Order 49 (2015) (information technology and cybersecurity). Descriptive statistics were used to help organize, describe, and summarize the characteristics of Virginia's registered apprenticeships and the MS gap data.

Using the MS gap and RA position descriptive data collected for RQ 1 and 2, inferential statistics, such as logistic regression, was used to analyze the impact of RA positions on MS gap occupations by examining whether Virginia's 2018 RA positions (as compared to Virginia's 2015 RA positions) were likely to fill a MS gap occupation. Study limitations included the labor supply data for the MS gap calculation did not include net migrations of students and limiting the scope to only registered apprenticeships as a factor impacting the MS gap. Overall, the methodology for this study was appropriate and met the research goal of examining the impact of registered apprenticeships on Virginia's MS gap.

Chapter 4: Results

The purpose of this quantitative study was to examine the impact of Virginia's registered apprenticeships on the MS gap (MS occupations with a skills gap), prior to and after the implementation of VA Executive Order 49. Using descriptive and inferential statistics, this chapter reports the results of the quantitative analysis of secondary data. The results are presented in accordance to the research questions that guided this study.

RQ1: Is There a MS Gap in Virginia?

Virginia has a growing demand for jobs requiring middle skills (CURA at VCU, 2016) and there is a shortage of individuals with sufficient training and credentials to meet that demand (Commonwealth of Virginia, 2017; VBWD, 2018). Referred to as a MS gap, this occurs when significant numbers of MS jobs remain unfilled because employers cannot find people with the appropriate skills to fill them. This section addresses the question of whether there is a MS gap in Virginia and if so, which MS occupations are most impacted.

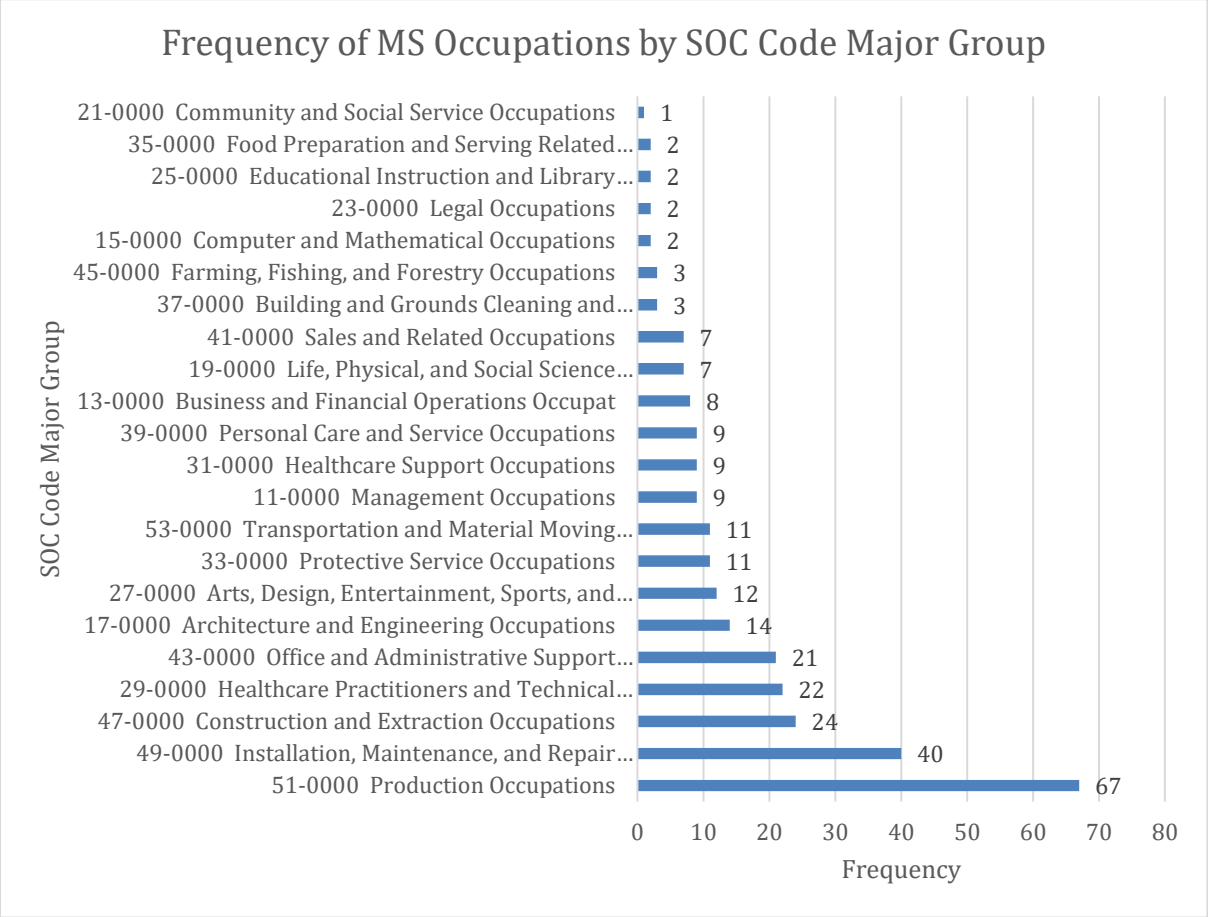
MS Occupations in Virginia

To determine if there is a MS gap, this study first identified MS occupations in Virginia based on the MS definition "education and training beyond high school but less than a bachelor's degree." Thus, if an occupation required one of the following four education and/or training criteria from the VEC-LMI website data, it was considered a MS occupation: (a) associate's degree; (b) postsecondary nondegree award; (c) some college, no degree; or (d) a high school degree and one of the following: apprenticeship, long-term on-the-job training,

moderate-term on-the-job training, and work experience (Holzer & Lerman 2007; NSC 2017; Scaglione, 2018). Out of the 765 occupations identified from the VEC 2016-2026 Long Term Occupational Virginia Projections report, 286 occupations qualified as MS occupations. For a list of the 286 MS occupations, see Appendix I.

Figure 7

Frequency of MS Occupations by SOC Code Major Group



The MS occupations were diverse and spread across the 23 Standard Occupational Classification (SOC) Code Major Groups as shown in Figure 7. There was a MS occupation represented in every SOC Code Major Group except for military (55-0000 Military Specific Occupation) because military information was not included in the VEC-LMI data used for this research. The SOC Code Major Group, 51-0000 Production Occupations (67, 23.4%) had the highest frequency of MS occupations. This was followed by 49-0000 Installation, Maintenance and Repair Occupations (40, 14%) and 47-0000 Construction and Extraction Occupations (24, 8.4%).

The type of education or training requirement associated with a MS occupation defines whether an occupation is middle skilled and is an indicator for the level of skill requirements needed by the employee (labor supply) for that occupation. As shown in Table 9, a majority (68.5%, 196) of the MS occupations required a high school diploma or equivalent (and one of the following: apprenticeship, long-term on-the-job training, moderate-term on-the-job training, or work experience) followed by occupations with an associate's degree. Outside of the educational requirements, a MS occupation may require some training. For those MS occupations, a majority (52%, 148) required moderate-term on-the-job training (as compared to apprenticeship, short-term on-the-job training, long-term on-the-job training, and none).

Is There a MS Gap in Virginia?

Once the MS occupations were identified, the MS gap was calculated for each MS occupation (at the 6-digit level) in Virginia using the supply and demand method. The MS gap calculation provided the data to answer RQ1 and its subquestions: (a) which MS occupations have a skills gap in 2015 and 2018, and (b) which occupations (number of occupations and size of gap) are most impacted by the MS gap in 2015 and 2018?

Table 9

Number of MS Occupations by Education and Training

	Education				
Training	High school diploma or equivalent	Postsecondary nondegree award	Associate's degree	Some college, no degree	Total
Short-term on-the-job training	0	3	2	2	7
Moderate-term on-the-job training	136	5	7	0	148
Long-term on-the-job training	32	7	4	1	44
Apprenticeship	11	0	0	0	11
None	17	27	32	0	76
Total	196	42	45	3	286

Of the 286 (6-digit) MS occupations identified in Virginia, 238 occupations had a MS gap in 2015 and 216 occupations had a MS gap in 2018. For both 2015 and 2018, a majority of the MS occupations had a skills gap (83.2% and 75.5%, respectively). Therefore, the current supply of workers in 2015 and 2018 are not projected to meet the future workforce needs of businesses for a majority of the MS occupations in Virginia. For a complete list of Virginia's MS occupations with a gap in 2015 and 2018, see Appendixes K1 and K2.

However, on a positive note, the total number of MS occupations with a gap declined from 2015 to 2018 by 9% (from 238 to 216) as shown in Table 10. Furthermore, 75% (178) of the 2015 MS gap occupations had a MS gap decline (between 2015 and 2018), while only 25% (60) had an increase or no change.

Table 10

Number of MS Gap Occupations by the Size of the Gap

MS occupations gap size	2015*	%	2018*	%
(1) to (99)	99	41.6	98	45.4
(100) to (499)	82	34.5	68	31.5
(500) to (999)	27	11.3	30	13.9
> (1,000)	30	12.6	20	9.3
Total MS occupation with a skills gap	238	100	216	100
Total MS occupations without a gap > = 0	48		70	
Total MS occupations	286		286	

*Number of MS gap occupations.

Gap Size-Absolute Demand Gap.

Although Virginia had a MS gap, the size of the gap was not substantial. In 2015, the size of the gap ranged from -1 to -9375 and the average size of the gap was -492. Similarly, in 2018, the size of the gap ranged from -1 to -7720 and the average MS gap size was -393. As shown in Table 10, most of the MS gap occupations had a gap size[8] less than -100 (between -1 and -99) in both 2015 and 2018 which indicates there is a MS gap in Virginia but not of significant size (see Table 10).

There were only 30 (12.6%) occupations in 2015 and 20 (9.3%) occupations in 2018 that had a MS gap size greater than -1000. MS occupations with a gap size between (100) and (499) had the largest change among the category sizes—the number of MS gap occupations in that category decreased by 17% from 2015 to 2018. The MS gap occupations with the largest

[8] The size of the gap is based on the difference between the employer demand for an occupation and the supply of labor for that occupation.

decrease from 2015 to 2018 were carpenters (47-2031), first-line supervisors of construction trades and extractions (47-1011) and real-estate agents (41-9022). Overall, the number of MS gap occupations and the average size of the MS gap in Virginia decreased from 2015 and 2018.

Gap Ratio-Relative Demand Gap.

Another way of analyzing the MS gap is calculating the relative demand gap which is the ratio of supply to demand (Pennsylvania State System of Higher Education, 2016). The ratio of supply to demand for the MS gap occupations was relatively high in both 2015 and 2018. The average supply to demand ratio was .92 and .94, respectively. See Table 11, which indicates the labor supply is close to meeting employer demand of 1.0.

Table 11

MS Gap Occupations Supply to Demand Ratio (Relative Demand Gap)

MS gap year	No. of MS gap occupations	Min	Max	*M*	*SD*
2015	238	0.71	1.00	0.9175	0.04723
2018	216	0.81	1.00	0.9374	0.03962

The supply to demand ratio in 2015 ranged from .71 to .99 for all MS gap occupations which indicates that the labor supply shortage for MS gap occupations ranged between 1% and 29%. In 2018, the supply to demand ratio ranged from .81 to 1 for all MS gap occupations which is an indication that the shortage of labor for MS gap occupations is 19% and below (does not exceed 19%). Similar to the Absolute Demand Gap (gap size), the MS Gap Ratio (relative demand gap) indicates Virginia has a MS gap but it is not substantial—the MS gap labor supply shortage is less than 29% in 2015 and 19% in 2018.

SOC Code Major Groups Most Impacted by the MS Gap.

The SOC Code Major Groups (aggregate occupational groupings of the 6-digit SOC codes) most impacted by the MS gap were examined in two ways: (a) by gap size—MS occupations with the largest gap size (between employer demand and labor supply), and (b) by frequency—the highest number of MS occupations with a gap (SOC code groups with the most MS-gap occupations).

In terms of frequency (see Figure 8), the SOC Code Major Group most impacted by the MS gap in 2015 was 51-000 production, which had the highest number (20%, 47) of MS occupations with a gap followed by 49-0000 Installation and Repair, and 47-0000 Construction and Extraction occupations; whereas the SOC Code Major Group 49-0000 Installation, Maintenance and Repair (16%, 35) was most impacted by the MS gap in 2018 which was followed by 51-0000 Production, and 29-0000 Healthcare Practitioners and Technical Occupations. For a detailed list and graph of MS gap occupations by SOC Code Major Group, see Appendix M, Table M1.

As shown in Figure 9, the SOC Code Major Group that had occupations with the largest MS gap size (between employer demand and labor supply) in 2015 was 47-000 Construction and Extraction occupations with a total gap size of -17,038, and this was followed by 13-0000 Business and Financial Operations and 47-0000 Installation Maintenance and Repair occupational groups. In 2018, Construction was not one of the top three occupational groups with the largest MS gap. Instead, the Business and Financial Operations Occupations SOC Code Major Group had the largest total gap size (-11,833) followed by the 29-0000 Healthcare Practitioners and Technical Occupations in 2018.

Figure 8

SOC Code Major Groups Most Impacted by the MS Gap by Frequency

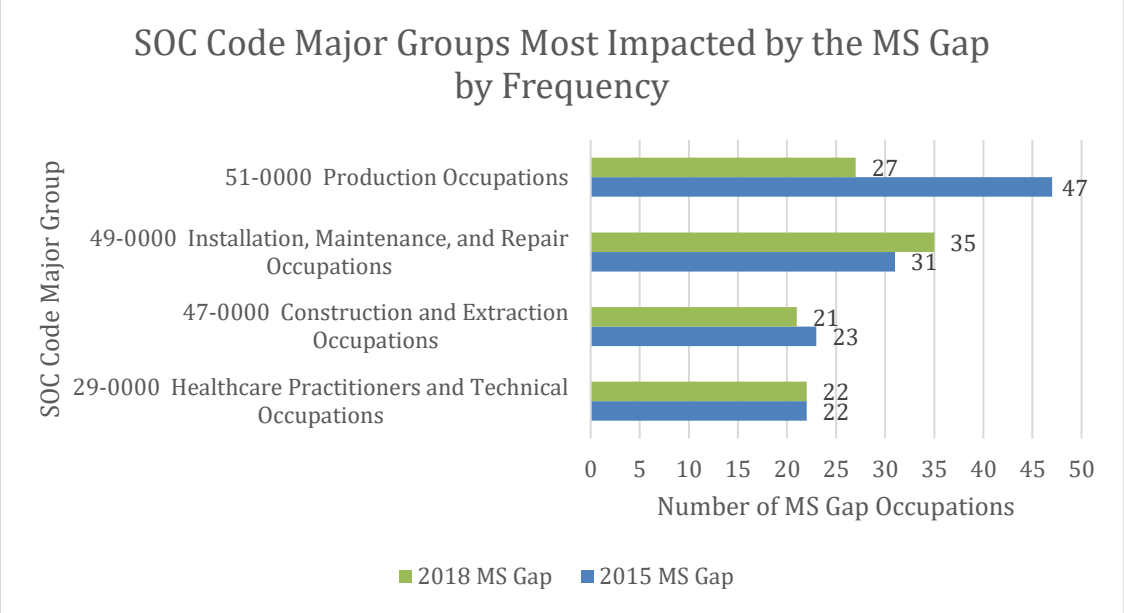
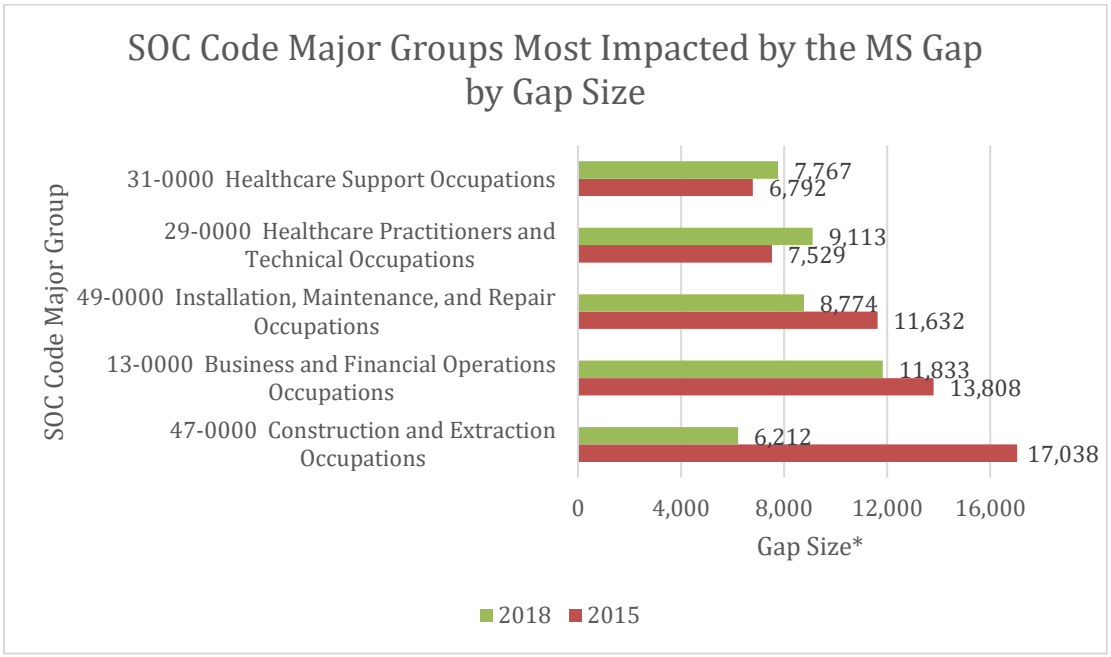


Figure 9

SOC Code Major Groups Most Impacted by the MS Gap Based on Gap Size



*Gap size is the difference between employer demand for labor and the supply of labor available.

If the two SOC Code Major Groups related to Healthcare were combined (29-0000 and 31-0000), Healthcare would have had the largest total MS gap size (-16,880) in 2018.

Overall, the SOC Code Major Groups most impacted by MS gap were different based on the frequency and gap size. The primary difference was the SOC Code Major Group 51-0000 Production had a high frequency of MS occupations with a gap in both 2015 and 2018, but the gap size for these occupation was not large (in comparison to the other SOC Code Major Groups) in 2015 or 2018. Although there was a high frequency of occupations in the Production SOC Code group that had a MS gap, the extent of the gap was relatively small. Whereas, the Healthcare and the Business/Financial SOC Code Major Groups had the occupations with the largest gap size, which indicates that the labor supply shortage or the extent of the gap is more significant in those occupational groups.

Specific Occupations (6-Digit Detailed) Most Impacted by the MS Gap.

MS gap occupations were also examined at the 6-digit detailed occupational level (which falls under the individual SOC Code Major Group) to get a more detailed view of specific occupations most impacted by the MS gap. Out of the top three detailed occupations most impacted by the gap in 2015 and 2018, none were in the four SOC Code Major Groups most impacted by the MS gap based on frequency (see Figure 8) except for Carpenters, which is in the 47-0000 Construction and Extraction group. The Management Analyst occupation (SOC Code 13-1111) by far had the largest MS gap size among all the MS occupations in both 2015 (-9,375) and 2018 (-7,720) and therefore most impacted by the MS gap[9] as shown in Table 12. On a positive note, this MS gap decreased by 18% from 2015 to 2018 for this occupation.

[9] The size of the gap is based on the difference between the employer demand (projected employment for people needed to fill jobs in middle-skill occupations) and the labor supply (current supply of workers with middle-level skills).

Table 12

Virginia's 20 Occupations (6-Digit Detail) Most Impacted by the MS Gap in 2015 and 2018

	2015 MS Gap				2018 MS Gap			
Rank	SOC Code	SOC Code Description	2015 MS Gap Size	2015 MS Gap S/D* Ratio	SOC Code	SOC Code Description	2018 MS Gap Size	2018 MS Gap S/D* Ratio
1.	131111	Management Analysts	-9,375	0.86	131111	Management Analysts	-7,720	0.89
2.	111021	General and Operations Managers	-5,000	0.91	111021	General and Operations Managers	-4,359	0.93
3.	472031	Carpenters	-4,405	0.85	319092	Medical Assistants	-3,214	0.81
4.	351012	First-Line Supervisors of Food Preparation and Serving Workers	-3,379	0.89	292061	Licensed Practical and Vocational Nurses	-2,734	0.89
5.	499071	Maintenance and Repair Workers, General	-3,337	0.91	131199	Business Operations Specialists, All Other	-2,535	0.93
6.	533032	Heavy and Tractor-Trailer Truck Drivers	-3,180	0.93	533032	Heavy and Tractor-Trailer Truck Drivers	-2,488	0.95
7.	471011	First-Line Supervisors of Construction Trades and Extraction	-3,175	0.87	351012	First-Line Supervisors of Food Preparation and Serving Workers	-2,346	0.92
8.	431011	First-Line Supervisors of Office/Admin. Support	-3,100	0.93	499071	Maintenance and Repair Workers, General	-2,292	0.94
9.	319092	Medical Assistants	-2,733	0.82	151151	Computer User Support Specialists	-1,871	0.92
10.	292061	Licensed Practical and Vocational Nurses	-2,601	0.89	431011	First-Line Supervisors of Office/ Admin. Support	-1,810	0.96

	2015 MS Gap				2018 MS Gap			
Rank	SOC Code	SOC Code Description	2015 MS Gap Size	2015 MS Gap S/D* Ratio	SOC Code	SOC Code Description	2018 MS Gap Size	2018 MS Gap S/D* Ratio
11.	151151	Computer User Support Specialists	-2,484	0.89	411011	First-Line Supervisors of Retail Sales Workers	-1,615	0.96
12.	472111	Electricians	-2,430	0.88	319091	Dental Assistants	-1,487	0.86
13.	472152	Plumbers, Pipefitters, and Steamfitters	-2,327	0.86	433021	Billing and Posting Clerks	-1,416	0.89
14.	419022	Real Estate Sales Agents	-2,296	0.87	395012	Hairdressers, Hairstylists, and Cosmetologists	-1,373	0.93
15.	131199	Business Operations Specialists, All Other	-1,837	0.95	333051	Police and Sheriff's Patrol Officers	-1,259	0.94
16.	413021	Insurance Sales Agents	-1,765	0.88	471011	First-Line Supervisors of Construction Trades and Extraction Workers	-1,231	0.95
17.	333051	Police and Sheriff's Patrol Officers	-1,714	0.92	272022	Coaches and Scouts	-1,138	0.89
18.	499021	Heating, Air Conditioning, and Refrigeration Mechanics	-1,705	0.87	472152	Plumbers, Pipefitters, and Steamfitters	-1,044	0.93
19.	395012	Hairdressers, Hairstylists, and Cosmetologists	-1,581	0.92	414012	Sales Representatives, Wholesale, Mfg., Except Technical and Scientific	-1,026	0.97
20.	433021	Billing and Posting Clerks	-1,564	0.88	472031	Carpenters	-1,007	0.96

*S/D = Supply to Demand Ratio

The supply to demand ratio for the Management Analyst position was .86 (2015) and .89 (2018) which indicates there is a labor supply shortage of 14% and 11%, respectively for this occupation.

The Management Analyst occupation gap size was almost twice the size of General and Operations Managers (SOC Code 11-1021), which was the second occupation most impacted by the gap. The General and Operation Managers occupation had a gap size of -5000 in 2015 and -4359 in 2018 with a supply to demand ratio of .91 and .93, respectively (see Table 12). Although the MS gap size was large, the ratio shows there is a labor supply to employer demand shortage of 9% in 2015 and 7% in 2018.

The third occupation most impacted by the MS gap was Carpenters in 2015 and Medical Assistants in 2018. Carpenters (SOC Code 47-2031) had a MS gap size of -4405 and relative demand ratio of .85 (15% supply shortage); whereas Medical Assistants (SOC Code 31-9092) had a MS gap size of -3214 and supply to demand ratio of .81 (19% labor shortage). Although Carpenters and Medical Assistants had the third largest gap size, they had the higher percentage of labor supply shortage. There were 16 (out of the top 20) MS gap occupations that overlapped in both years. For the top 20 occupations most impacted by the MS gap in 2015 and 2018, see Table 12.

RQ1 Summary

Yes, there is a MS gap in Virginia. Out of 765 occupations examined, 286 were identified as MS occupations and a majority of the MS occupations had a gap in 2015 (83.2%, 238) and in 2018 (75.5%, 216). The SOC Code Major Group most impacted by the MS gap based on frequency, was Production (51-0000) in 2015 and Installation, Maintenance, and Repair (49-0000) in 2018—those occupational groups had the highest number of MS occupations with a

gap. Whereas the Construction (2015) and the Business and Financial Operations (2018) SOC Code Major Groups were most impacted by the MS gap because they had the occupations with the largest gap size (difference between employer demand and labor supply)—signifying the labor supply shortage or the extent of the gap was more significant in these occupational groups.

Specific occupations (6-digit detailed SOC codes) most impacted by the MS gap (largest gap size) in both 2015 and 2018 were (a) Management Analysts (SOC Code-13-1111) and (b) General and Operations Managers (SOC-Code 11-1021). The third occupation most impacted by the MS gap was Carpenters (SOC-Code 47-2031) in 2015 and Medical Assistants (SOC-Code 31-9092) in 2018. Although a majority of Virginia's MS occupations had a gap in both 2015 and 2018, the total number of MS gap occupations decreased from 2015 to 2018 by 9%. Furthermore, Virginia's MS gap does not appear to be extensive—the MS gap size is less than 100 for a majority of the MS gap occupations and the MS gap ratio or labor supply shortage is less than 29% in 2015 and 19% in 2018.

RQ2: How Many RA Positions Are Filling MS Gap Occupations?

Registered apprenticeship is a strategy the Commonwealth of Virginia is using to address the MS gap via policy and regulations such as Virginia Executive Order 49—Expanding Registered Apprenticeships in Virginia. However, there is limited data on Virginia's RA programs and the impact of RA programs on the MS gap is unknown. This section outlines the key characteristics of Virginia's RA program and examines whether Virginia's registered apprenticeships are filling MS gap occupations.

Apprentice Characteristics

To acquire a better understanding of Virginia's RA program characteristics and apprentice demographics, this study obtained data from the VDOLI. A total of 31,158 RA

positions were analyzed for this research (15,229 RA positions in 2015 and 15,929 RA positions in 2018). The RA data consisted of apprentices (RA positions) that were active during FY2015 and FY2018[10], prior to and after the implementation of Virginia Executive Order 49. A summary of the apprentice characteristics and demographics are presented in Table 13.

The apprentice demographics remained similar between 2015 and 2018. For both years, a majority of the RA positions were held by White males (50.29%, 53.76%), between the ages of 22 and 29. See Appendix M, Table M2. Black males (16.92%, 15.26%) were the second largest group to hold the most RA positions in 2015 and 2018 followed by White females (9.24 %, 9.28%). Overall, White males held three times the number of RA positions as Black males and five times the number of RA positions as White females in both 2015 and 2018.

Traditionally, registered apprenticeships have been a male-dominated field and one of the goals of the USDOL RA program is to increase the number of women and minorities in apprenticeship (USDOL-ETA, 2017) via grants, pre-apprenticeship programs and the Women Apprenticeships and Nontraditional Occupations Act of 1992. The results from this study show that the number of females holding RA positions in Virginia decreased (-3%) and increased for males (7%) from 2015 to 2018 as shown in Table 13. There was also a decrease in the number of RA positions held by Native Americans (-48%), Blacks (-8%) and Hispanics (-1%) from 2015 to 2018, while there was an increase for Whites (11%) and Asians (2%). Most RA positions were held by nonveterans (92.2% in 2018 and 73.6% in 2015).

[10] There were a small number of apprentices that had two RA positions in 2018 (286, 1.8%) and in 2015 (345, 2.3%). The unit of analysis for this study is the RA position, therefore demographic characteristics in Table 13 reflect these apprentice demographics twice because they are represented in two RA positions.

Table 13

RA Positions: Apprentice Characteristics and Demographics

Demographic characteristics	2015 RA positions	% of 2015 RA positions	2018 RA positions	% of 2018 RA positions	Change from 2015 to 2018	% change from 2015 to 2018
Gender						
Male	12,172	79.9	12,972	81.4	800	7
Female	3,057	20.1	2,957	18.6	-100	-3
Race/Ethnicity						
White	9,065	59.5	10,042	63.0	977	11
Black	3,492	22.9	3.215	20.2	-277	-8
Hispanic	1,337	8.8	1,330	8.3	-7	-1
Asian	411	2.7	418	2.6	7	2
Native American	147	1.0	76	0.5	-71	-48
Other[a]	777	5.1	848	5.3	71	9
Veteran Status						
Veteran	3,796	24.9	1,073	6.7	-2,723	.72
Non-Veteran	11,215	73.6	14,684	92.2	3,469	31
Unknown[b]	218	1.4	172	1.0	-46	-21
Age Group (Yrs)						
16-21	1,919	12.6	1,852	11.6	-67	-3
22-29	7,044	46.3	7,376	46.3	332	5
30-39	4,200	27.6	4,410	27.7	210	5
40-49	1,435	9.4	1,556	9.8	121	8
50-59	493	3.2	566	3.6	73	15
60-69	118	0.8	116	0.7	-2	-2
70-79	15	0.1	8	0.1	-7	-47
Other[c]	5	0.0	45	0.3	40	800
Number of RA Positions	15,229	100	15,929	100	700	5

[a] "Other" includes Indian or the race is unknown. [b] "Unknown" represents an unknown or undisclosed veteran status. [c] "Other" represents ages that were missing or not within the range of age groups.

The apprentices who held RA positions in Virginia ranged in age from 16 to 76. Consistent with other studies, the average age of an apprentice (excluding the "Other" category) was 29.9 in 2015 and 30.1 in 2018 (Council of State Governments, 2017; Olinsky & Ayres, 2013). Apprentices in the 22-29 age group held most of the RA positions, followed by the 30-39 year old age group in both 2015 and 2018. Likewise, when analyzing age group by gender and by ethnicity, the 22-29 age category had the most apprentices for all ethnicities and for both genders followed by the 30-39 age category.

Key RA Employer and Program Characteristics

RA Sponsor (Employer) Characteristics.

Examining RA sponsors (also referred to as employers) provides insights as to what type of RA sponsors (industry type) are participating in RA programs and whether these industries are aligned with the occupations most impacted by the MS gap. Additionally, the number of RA sponsors and the number RA positions per sponsor provides the extent of Virginia's RA program regarding employer participation and an indication of whether the RA strategy is scalable to address the MS gap. The key RA sponsor characteristics examined were the number of RA positions by industry and the number of RA positions per RA sponsor.

There were a total of 1,605 RA sponsors that represented the 15,229 RA positions in 2015 and 1908 RA sponsors that represented 15,929 RA positions in 2018 (see Table 14). Over 50% of the RA sponsors sponsored one RA position and there were very few (less than 2%), that sponsored 50 or more RA positions. Overall there was a 19% increase in RA sponsors in Virginia from 2015 to 2018.

Table 14

Number of Registered Apprenticeships Per RA Sponsor

	2015		2018	
No. of RA sponsors with:	No. of RA sponsors	%	No. of RA sponsors	%
< 5 RA positions	1,351	84.2	1,565	82.0
5 to 19 RA positions	198	12.3	251	13.2
20 to 49 RA positions	32	2.0	57	3.0
50 to 100 RA positions	14	0.9	21	1.1
> 100 RA positions	10	0.6	14	0.7
Total number RA sponsors	1,605	100	1,908	100
Number of sponsors with one RA position	886	55.2	978	51.3

Understanding which sponsors have the most RA positions gives an indication of what type of sponsors are participating in RA on a large scale, the level of employer engagement and what type of employers are able to expand registered apprenticeships—make RAs scalable. The RA sponsor with the most positions in both 2015 and 2018 was the U.S. Military. The U.S. Military Apprenticeship program sponsored 6,481 (43%) RA positions in 2015 and 3,707 (23%) RA positions in 2018 as shown in Appendix M, Table M3. After the Military Apprenticeship Program, the Norfolk Naval Shipyard (5.6%, 6.3%) and Newport News Shipbuilding (4%, 6.2%) RA sponsors had the most RA positions in both 2015 and 2018.

The three industry sectors[11] with the majority of registered apprenticeships in Virginia were Public Administration (49.7%), Construction (24.7%), and Manufacturing (14.1%) in 2015 as compared to Construction (34.5%), Public Administration (29.7%), and Manufacturing (20.7%) in 2018. The U.S. Military is classified under the Public Administration industry. With the U.S. Military having the most RA positions in both 2015 and 2018, this is consistent with the Public Administration industry being the top industry sector in 2015 and the second industry sector in 2018 with the most RA positions. For a detailed list of RA Positions by Industry, see Appendix M, Table M4.

Key RA Program Characteristics.

Some of the key program characteristics examined included: where are the majority of the RA positions located (urban or nonurban areas), which SOC Code groups and specific occupations had the most RA positions, and what percentage of the RA positions are on the Virginia In-Demand Occupations List. A majority (95%) of Virginia's RA positions were located in urban areas. The top three SOC Code Major Groups for Virginia's RA positions were the same in 2015 and 2018—(a) 47-0000 Construction and Extraction (31.7%, 41.7%), (b) 49-0000 Installation Maintenance and Repair (23.4%, 22.6%), and (c) 51-0000 Production (9%, 11.3%) as shown in Appendix M, Table M5. In comparison to the top three MS occupations and MS occupations with a gap in RQ1, Virginia's RA positions had the same top three SOC Code Major Groups but with different rankings.

[11] There is a difference between Industry Sectors and SOC Code Major Groups. The 23 SOC Code Major Groups (See Appendix B) are comprised of specific or 6-digit detailed occupations or jobs based on occupational skills. An industry sector is a group of companies that are related based on their primary business activities. The RA Sponsor/Employer Industry Sectors are classified based on the NAICS (Northern American Industry Classification System) 2-digit industry sector code. See the 20 NAICS codes in Appendix J.

There were a total of 152 occupations (6-digit detailed) that represented Virginia's 15,229 RA positions in 2015 and a total of 159 occupations that represented 15,929 RA positions in 2018. For the 10 occupations with the most RA positions in 2015 and 2018, see Appendix M, Table M6. The two occupations with the most RA positions in Virginia were the same in 2015 and 2018—Electricians (18% and 22%, respectively) and Plumbers, Pipefitters, and Steamfitters (9% and 13%, respectively) which are both in the SOC Code Major Group 47-0000 Construction and Extraction. These two occupations accounted for 27% and 36% of Virginia's RA positions. Additionally, the 10 occupations with the most RA positions represented 60% and 66% of Virginia's RA positions in 2015 and 2018, respectively, and eight of the 10 occupations were the same in both years.

However, the occupations with the most RAs did not overlap with the occupations most impacted by the MS gap in 2015 or 2018, signifying that the occupations with the most RAs in Virginia are not consistent with the MS occupations with the largest gap. See Table 15 for a comparison of the top10 RA positions in 2018 with the top MS gap occupations in 2018.

The VBWD developed a list of occupations that were considered in-demand (high-growth or high-demand occupations) for Virginia's workforce system (see Appendix F). Per review of the VBWD 2018-2019 In-Demand Occupation List and Virginia's RA positions in 2018, 68.8% (10,960) of Virginia's RA positions were an occupation on the VBWD In-Demand Occupations List, and 94% (10, 354) of those positions were MS gap occupations. Thus, a majority of Virginia's RA positions in 2018 are on the Virginia In-Demand Occupations List of high-growth or high-demand occupations for the Commonwealth of Virginia.

Table 15

RA Positions Compared to 2018 MS Gap Occupations (Top 10 RA Occupations Compared to the Largest MS Gap Occupations in 2018

	Top 10 RA Positions in 2018			**Top 10 MS Gap Occupations in 2018**		
Rank	SOC code	SOC code description	Frequency of RA positions	SOC code	SOC code description	2018 MS gap size
1.	472111	Electrician	3,564	131111	Management Analysts	-7,720
2.	472152	Plumbers, Pipefitters, and Steamfitters	2,119	111021	General and Operations Managers	-4,359
3.	395012	Hairdressers, Hairstylists, and Cosmetologists	1,037	319092	Medical Assistants	-3,214
4.	499041	Industrial Machinery Mechanics	894	292061	Licensed Practical and Vocational Nurse	-2,734
5.	499021	Heating, Air Conditioning, and Refrigeration Mechanics	762	131199	Business Operations Specialists, All Other	-2,535
6.	514041	Machinists	615	533032	Heavy and Tractor Trailer Truck Drivers	+2,488
7.	173023	Electrical and Electronics Engineering Technicians	509	351012	First-line Supervisors of Food Preparation and Serving Workers	-2,346
8.	492011	Computer, Automated Teller, and Office Machine Repairers	365	499071	Maintenance and Repair Workers, General	-2,292
9.	292081	Opticians, Dispensing	315	151151	Computer User Support Specialists	-1,871
10.	514121	Welders, Cutters, Solderers and Brazers	284	431011	First-line Supervisors of Office and Administrative Support Workers	-1,810

Are RA Positions Filling MS Gap Occupations?

To examine whether RA positions are having an impact on the MS gap, this study analyzed whether RA positions were filling MS gap occupations (are RA positions in occupations with a MS gap?). Using the 6-digit detailed SOC Code occupation as the common identifier, a RA position is considered filling a MS gap occupation if the RA position matched a MS gap occupation (as identified in RQ1 and shown in Appendixes K1 and K2).

In both 2015 and 2018, a majority of Virginia's RA positions were filling MS gap occupations (see Table 16). In 2015, 81.4% (12,390) of Virginia's RA positions filled a MS gap occupation and that number increased to 88.8% (14,139) in 2018—a 14% increase. This is an indication that Virginia's registered apprenticeships may be having an impact on filling MS gap occupations.

Table 16

Number of RA Positions Filling MS Gap Occupations

	2015		**2018**	
RA position filling a MS gap occupation	No. of RA positions	%	No. of RA positions	%
Yes	12,390	81.4	14,139	88.8
No	2,839	18.6	1,790	11.2
Total	15,229	100.0	15,929	100.0

Characteristics of RA Positions Filling MS Gap Occupations.

The distribution of RA positions filling MS gap occupations are primarily the same as RA positions more generally (as cited in the prior section, RA employer and program characteristics). For example, a majority of the RA positions filling MS gap occupations are located in urban areas (96%), and are more likely to be held by men (over 80%) as shown in

Appendix M, Tables M7 and M8. A large proportion of White apprentices (62.8%) are filling MS gap occupations — therefore, more than any other race or ethnicity. Additionally, RA positions filling MS gap occupations were primarily in the Public Administration Industry in 2015 and the Construction Industry in 2018 (see Appendix M, Table M9); and a majority of the RA positions filling MS gap occupations were in the 47-0000 Construction and Extraction SOC Code Major Group (38% in 2015 and 46% in 2018) followed by the 49-0000 Installation, Maintenance and Repair occupational group (27.2% in 2015 and 24%% in 2018), see Appendix M, Table M10.

Table 17

Occupations With the Most RA Positions Filling MS Gap Occupations in 2015 and 2018

2015 rank	SOC code	SOC code description	No. of RA positions filling MS gap occupations in 2015	%*	No. of RA positions filling MS gap occupations in 2018	%*
1.	472111	Electricians	2,682	21.6	3,564	25.2
2.	472152	Plumbers, Pipefitters, and Steamfitters	1,440	11.6	2,119	15
3.	499041	Industrial Machinery Mechanics	957	7.7	894	6.3
4.	395012	Hairdressers, Hairstylists, and Cosmetologists	737	5.9	1,037	7.3
5.	499021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	627	5.1	762	5.3

*Percentage of total RA positions filling MS gap occupations.

As shown in Table 17, the specific occupations with the highest number of RA positions filling MS gap occupation for both years were the same but with different rankings. The top two occupations were (a) Electricians and (b) Plumbers, Pipefitters, and Steamfitters which are in the SOC Code Major Group 47-0000 Construction and Extraction. These two positions accounted for at least one-third of the RA positions filling MS gap occupations in 2015 (33%) and 2018 (40%).

Newer versus Traditional MS Gap Occupations.

There is a growing demand for workers in the "newer" MS occupations such as skilled and technical services (Autor, 2015; Carnevale et al., 2018; Heinrich, 2018; Holzer, 2015; Modestino, 2016). Based on this premise, MS occupations were classified as newer versus traditional using Holzer's (2015) definition[12]. Of the 286 Virginia MS occupations, 57% (164) were classified as traditional occupations and 43% (122) as newer MS occupations. In 2015, 33% (5032) of Virginia's RA positions were the newer MS occupations and 99% (4966) of those positions were filling MS gap occupations. Similarly, in 2018, 31% (4926) of Virginia's RA positions were the newer MS occupations and 99% (4883) of those positions were filling MS gap occupations. The number of RA positions categorized as the newer MS occupations decreased by 2% from, 2015 to 2018.

[12] Per Holzer (2015), the newer middle-skilled jobs fall into the "broader categories" of healthcare and health technicians; other technicians; installation, maintenance and repair of mechanical systems; management (low-end in terms of pay and education); and services (high end); whereas traditional or older MS jobs included construction, production, and clerical. Holzer (2015) also identified some specific occupational groups (e.g. paralegals, protective service, chefs and eating/drinking managers, sales reps, and retail managers) as newer MS occupations.

How many RA Positions are in VA Executive Order 49 Occupations (Cybersecurity and Information Technology) in 2015 and 2018?

The underlying premise of VA Executive Order 49 was to expand RA in state agencies and key industry sectors (e.g., information technology, cybersecurity, professional and business services) to help fill projected MS job openings by 2022. This research focused on two of the sectors identified in VA Executive Order 49 that the Commonwealth wanted to expand registered apprenticeships—cybersecurity and information technology. If a RA position had a SOC Code of 15-1122 or 15-1212 (Information Security Analyst) or 15-1199 (Information Technology Project Manager), it was considered a cybersecurity position. In 2015, there were no RA positions identified as a cybersecurity occupation, but in 2018 there were three positions (< 1%) out of 15,929 RA positions as shown in Table 18.

In terms of information technology positions, any RA position that had a SOC Code in the minor groups of 15-1200 or 15-1100 was considered an information technology position. Virginia had 245 (1.6%) information technology RA positions in 2015 and 185 (1.2%) in 2018, a 24.5% decrease (see Table 18).

Table 18

RA Positions in Virginia's Executive Order 49 Occupations

	2015		**2018**	
Virginia EO 49 occupations	No. of RA positions	% of Total RA positions	No. of RA positions	% of total RA positions
Cybersecurity	0	0.0	3	0.0
Information Technology	245	1.6	185	1.1
Total RA Positions	15,229	N/A	15,929	N/A

Out of the 245 RA information technology positions in 2015, two positions (.8%) were filling MS gap occupations. Similarly, in 2018 eight (4%) of the 185 information technology RA positions were filling MS gap occupations and zero out of the three cybersecurity positions were filling MS gap occupations. Virginia Executive Order 49 directive by the Governor in 2015 appears to have little or no impact on expanding RA positions in cybersecurity and Information Technology occupations between 2015 and 2018.

RQ2 Summary

A majority of Virginia's RA positions are held by White males between the ages 22 and 29 followed by Black males and White females. The two occupations with the most RA positions in Virginia are (a) Electricians and (b) Plumbers, Pipefitters and Steamfitters; and the majority of Virginia's RA positions are in the Public Administration, Construction and Manufacturing industry sectors. Over 95% of the Commonwealth's RA positions are located in urban areas and a majority of the RA employers sponsor one RA position.

As shown in Table 19, a majority of Virginia's RA positions were filling MS gap occupations in 2015 (81.4%) and 2018 (88.8%). With a 14.1% increase in the actual number of RA positions filling MS gap occupations from 2015 to 2018, this is an indication RAs are having an impact on filling MS gap occupations. Despite the VA Executive Order 49 policy focus to expand registered apprenticeships in cybersecurity and information technology occupations, there was little or no impact on expanding RA positions in those areas between 2015 and 2018; in fact, there was a decrease in information technology occupations.

Table 19

Summary of Virginia's RA Characteristics in 2015 and 2018

RA characteristics summary	2015	% of RA positions	2018	% of RA positions	Change from 2015 to 2018	% change
No. of RA positions	15,229	100.0	15,929	100.0	700	4.6
No. of RA sponsors	1,605	10.5	1,908	12.0	303	18.9
No. of RA occupations (6-digit (detailed)	152	N/A	159	N/A	7	4.6
No. of RA positions filling MS gap occupations	12,390	81.4	14,139	88.8	1,749	14.1
No. of RA positions in EO49 occupations - cybersecurity	0	0.0	3	0.0	3	100.0
No. of RA positions in EO49 occupations - information technology	245	1.6	185	1.2	(60)	-24.5
No. of RA positions on the VBWD Virginia Demand Occupations List	N/A	N/A	10,960*	68.8	N/A	N/A

*Ninety-four percent of RA positions on the VBWD Demand Occupations List were filling MS gap occupations.

RQ3: What is the Impact of Registered Apprenticeships on the MS Gap in Virginia?

To analyze the impact of RA on the MS gap, binary logistic regression analyses were used to examine (a) the likelihood of Virginia's RA positions filling a MS gap occupation in 2018 as compared to 2015, and (b) how location and unemployment impact the likelihood of a Virginia RA position filling a MS gap occupation. This section provides the results of the binary logistic regression analysis.

Logistic Regression Assumptions Testing

The key assumptions for logistic regression analysis were assessed. The dependent variable (RA position filling a MS gap occupation) was categorical and binary. Each observation in the dataset was independently recorded and there was no possibility of overlap between data points and, therefore, the assumption of independence of observation was satisfied. For the most part, the tests of correlation between independent variables yielded no multicollinearity issues with the exception of *number of businesses* and *number of jobs* which had a high correlation of -0.987, a tolerance value less than .1 and a variance inflation factor (VIF) above 10. Upon removing the variable *number of jobs*, there were no multicollinearity concerns for this analysis.

There was a relative high correlation (.809) between the independent variables *unemployment rate* and *2018*; however, the VIFs were well below the suggested maximum of 10 (3.553 and 3.053, respectively) and the tolerance value was above .1 (0.281 and 0.328) as shown in Appendixes M11 and M12. Since the collinearity statistics yielded no multicollinearity issues, both variables remained in the model. Lastly, the binary logistic regression model consisted of a large sample size of (N = 31,258; n = 15,229 in 2015 and n = 15,929 in 2018), therefore the large sample size assumption was satisfied.

Hypotheses

H_1: Virginia's 2018 RA positions have a higher likelihood of filling a MS gap occupation than Virginia's 2015 RA positions.

With the implementation of Virginia Executive Order 49 to expand registered apprenticeships starting in 2016, this study hypothesized that Virginia's RA positions have a higher likelihood of filling MS gap occupations in 2018 than in 2015. The researcher combined the 2015 and 2018 data sets into one regression model and an independent

variable for the year 2018 was created (1 = yes, it is a 2018 RA position; 0 = no, it is not a 2018 RA position but a 2015 RA position). To test the hypothesis, a binary logistic regression model was used to ascertain the effects of the independent variables (a) *2018* RA positions (compared to 2015), (b) urban (*RA positions in an urban location*), (c) *unemployment rate*, and (d) *number of businesses* on the likelihood of a RA position filling a MS gap occupation.

The binary logistic regression model was statistically significant, χ^2 (4, N = 31,158) = 1419.283, $p < .001$, indicating that the model itself in totality explained a portion of the variability in the dependent variable, *RA position filling a MS gap occupation*. The model as a whole explained between 4.5% (Cox and Snell R square) and 7.8% (Nagelkerke R square) of the variance and correctly classified 85.5% of the cases. Even though the level of variance explained was low, the statistically significant *p*-values indicated a relationship between the independent variables and the dependent variable.

As shown in Table 20, all independent variables were statistically significant. Although *number of businesses* had a statistically significant contribution to the model, the odds ratio was 1, which means this independent variable essentially has no impact on the likelihood of an RA position filling a MS gap occupation.

Holding all other factors equal, a RA position in 2018 is less likely to fill a MS gap occupation than a 2015 RA position. The negative relationship between the independent variable *2018* and the dependent variable *RA position filling a MS gap occupation* suggests that a position occurring in 2018 as opposed to 2015 decreased the odds of that RA position filling a MS gap occupation. The independent variable *2018* odds ratio (.860) was less than 1, indicating that the

odds of a 2018 RA position filling a MS gap occupation are .860 that of 2015 RA position holding all other factors constant.

Table 20

Binary Logistic Regression Model (2015 and 2018 Datasets) Predicting the Likelihood of a RA Position Filling a MS Gap Occupation

Independent variables*	B log-odds	*SE*	Wald	*df*	*p*-value**	Odds ratio	95% C.I. for odds ratio Lower	Upper
2018	-0.150	0.057	7.069	1	0.008	0.860	0.770	0.961
Urban location	0.850	0.060	200.523	1	0.000	2.341	2.081	2.633
Unemployment rate	-0.368	0.023	258.547	1	0.000	0.692	0.662	0.724
No. of businesses	0.000	0.000	61.657	1	0.000	1.000	1.000	1.000
Constant	2.495	0.153	266.576	1	0.000	12.117		

* Variable(s) entered on Step 1: 2018 RA position, urban location, unemployment rate, no. of businesses.
**Indicates significance at the 95% level ($p < 0.05$).

Therefore, those who held a Virginia RA position in 2018 have a lower likelihood of filling a MS gap occupation than those who held a RA position in 2015, which does not support H_1. The results of the regression analysis testing did not provide sufficient statistical evidence to support this hypothesis. The null hypothesis failed to be rejected.

H_2: RA positions located in an urban area decreases the likelihood of a RA position filling a MS gap occupation.

Based on Young's (2013) research[13], this study hypothesized that RA positions in urban areas decrease the likelihood of a RA position filling a MS gap occupation. The results show that an urban location had a strong correlation to the dependent variable (*RA position filling a MS gap occupation*) and the *p*-value (0.000) was statistically significant.

Urban location was the strongest influencer of a RA position filling a MS gap occupation with the highest odds ratio (see Table 20). Hence, there was a positive relationship between urban location and RA positions filling MS gap occupations, suggesting that a position in an urban location (as opposed to a rural position) increases the odds of a RA position filling a MS gap occupation in Virginia. Therefore, a RA position in an urban location was 2.3 times more likely to fill a MS gap occupation than a RA position in a nonurban location

Based on the regression analysis, Virginia RA positions located in an urban area increase the likelihood of a RA position filling a MS gap occupation. Therefore, H_2 was not supported. The results of the regression analysis testing did not provide sufficient statistical evidence to support this hypothesis—the null hypothesis failed to be rejected.

H_3: Higher levels of unemployment in the location of a RA position decreases the likelihood of a RA filling a MS gap occupation.

There is a strong association between new apprenticeship registration and unemployment rates (Sharpe & Gibson, 2005)—high unemployment rates have a negative impact on apprenticeship registration trends. Likewise, during economic growth (low unemployment rates)

[13] In 2012, 51% of workers in rural areas held middle-skill jobs as compared to 42% of workers in urban and suburban areas (Young, 2013). There has been a decline of middle-skill jobs in urban areas, whereas in rural areas, middle-skill work has remained relative stable over the last decade (2003-2012) (Young, 2013).

employers tend to invest in training such as registered apprenticeship to find skilled workers. Thus, the higher the unemployment, the fewer number of apprenticeships. Based on that premise, this study hypothesized that RA positions located in areas with higher levels of unemployment decrease the likelihood of a RA position filling a MS gap occupation.

As shown in Table 20, the unemployment rate made a statistically significant contribution to the model. There was a negative relationship between the unemployment rate and RA positions filling MS gap occupations, suggests that an increase in the unemployment rate decreases the likelihood of a RA position filling a MS gap occupation. The unemployment rate odds ratio (.692) was less than one indicating that the likelihood of RA position filling a MS gap occupation was lower based on the change in the unemployment rate. Hence, an increase in the unemployment rate was associated with a reduction in the likelihood of a RA position filling a MS gap occupation.

Based on the regression analysis, those who held RA positions located in areas with higher levels of unemployment decreases the likelihood of a RA position filling a MS gap occupation. Therefore, H_3 was supported. The results of the regression analysis testing H_3 provided sufficient statistical evidence to support this hypothesis—the null hypothesis is rejected.

Independent Regression Analysis for 2015 and 2018

In addition to running a combined regression model, two separate regression models were implemented, one for 2015 and one for 2018. The purpose of running the models separately was to determine if each variable had a different impact on 2015 cases than it had on 2018 cases. Both models were statistically significant ($p < .001$), see Tables 21 and 22. The 2015 model explained between 5.1% (Cox and Snell R square) and 8.2% (Nagelkerke R square) of the

variance in RA positions filling MS gap occupations; the 2018 between 2.4% (Cox and Snell R square) and 4.7% (Nagelkerke R square). The two models generally followed similar patterns of influence with a few notable differences. The influence of urban location was stronger on likelihood among 2018 cases than it was on likelihood among 2015 cases (3.4 odds ratio and 1.7 respectively). The influence of unemployment was higher but not significant in 2018 (odds of .99 vs. .61). Lastly, the number of businesses was significant with negligible influence in both years.

Table 21

Binary Logistic Regression Predicting the Likelihood of a RA Position Filling a MS Gap Occupation in 2015

Independent variables*	B log-odds	*SE*	Wald	*df*	*p*-value**	Odds ratio	95% C.I. for Odds ratio Lower	Upper
2015 urban location	0.521	0.084	38.104	1	0.000	1.683	1.427	1.986
2015 unemployment rate	-0.488	0.027	317.661	1	0.000	0.614	0.582	0.648
2015 No. of businesses	0.000	0.000	16.639	1	0.000	1.000	1.000	1.000
Constant	3.479	0.195	318.646	1	0.000	32.419		

*Variables entered on Step 1: 2015 urban, 2015 unemployment rate, 2015 no. of businesses.

**Indicates significance at the 95% level ($p < 0.05$).

Table 22

Binary Logistic Regression Predicting the Likelihood of a RA Position Filling a MS Gap Occupation in 2018

Independent variables*	B log-odds	*SE*	Wald	*df*	*p*-value**	Odds ratio	95% C.I. for Odds ratio Lower	Upper
2018 urban location	1.228	0.085	206.244	1	0.000	3.413	2.887	4.036
2018 unemployment rate	-0.007	0.049	0.023	1	0.881	0.993	0.901	1.094
2018 No. of businesses	0.000	0.000	66.175	1	0.000	1.000	1.000	1.000
Constant	0.721	0.203	12.561	1	0.000	2.057		

*Variables entered on Step 1: 2018 urban, 2018 unemployment rate, 2010 no. of businesses.
**Indicates significance at the 95% level ($p < 0.05$).

RQ3 Summary

The regression analysis results show that an urban location had the strongest influence on the likelihood of a RA position filling a MS gap occupation in both 2015 and 2018 (1.7 and 3.4 odds ratio, respectively). Furthermore, RA positions located in an urban area increase the likelihood of a Virginia RA position filling a MS gap occupation. Therefore H_2 (RA positions located in an urban area decreases the likelihood of a Virginia RA position filling a MS gap occupation) was not supported.

Regarding the unemployment rate, Virginia had an odds ratio less than one in all models signifying that those who held RA positions located in areas with higher levels of unemployment decreases the likelihood of a RA position filling a MS gap occupation—therefore H_3 was supported and the null hypothesis was rejected. Thus, when the

unemployment rate is low, registered apprentices are more likely to fill MS gap occupations. In terms of H_1 (Virginia's 2018 RA positions have a higher likelihood of filling a MS gap occupation than Virginia's 2015 RA positions), the combined regression model did not support this hypothesis. Instead, the 2018 combined model odds ratio (.860) was less than one signifying that Virginia's 2018 RA positions have a lower likelihood of filling a MS gap occupation than a 2015 RA position.

What is the impact of registered apprenticeships on the MS gap in Virginia? The regression analysis results show RA positions in urban locations are more likely to fill a MS gap occupation, and when the unemployment rate is low, registered apprentices are more likely to fill MS gap occupations. Therefore, location and the unemployment rate influence the impact of registered apprentices on the MS gap in Virginia, whereas number of businesses had no significant impact. However, it does not appear registered apprenticeships are having as much of an impact on the MS gap in 2018 as compared to 2015 based on the regression results for H_1 which show that Virginia's 2018 RA positions (as compared to 2015 RA positions) have a lower likelihood of filling a MS gap occupation.

Chapter 5: Discussion and Implications

The purpose of this study was to examine the impact of registered apprenticeships on the MS gap in Virginia. Registered apprenticeships are a solution many policymakers and states are using to address the skills gap, as it is a model that addresses both the supply and demand side of the labor market. Registered apprenticeships enhance our labor supply by providing in-demand job skills (Helper et al., 2016; USDOL, 2017a) and help employers meet their demand for skilled labor by upskilling their workforce**.** Major investments have been made in registered apprenticeships on a federal and state level, yet there has been minimal research on the effectiveness of RA programs in the United States, particularly as they pertain to the skills gap.

Likewise, Virginia made an investment in expanding RA programs as a strategy to close the skills gap, including implementing VA Executive Order 49 (2015). This research examined the likelihood of a RA position filling a MS gap occupation after the implementation of VA Executive Order 49. Investigating the impact of registered apprenticeships on the MS gap is important because Virginia has a growing demand for workers to fill MS jobs—almost 1 million MS jobs need to be filled by 2022 (VA Executive Order 49, 2015); and there is a shortage of individuals with sufficient training and credentials to meet the demand for MS jobs (Commonwealth of Virginia, 2017; VBWD, 2018). Furthermore, this research is relevant because there is limited data on

Virginia's RA programs and the impact of registered apprenticeships on the MS gap in Virginia is unknown.

Using descriptive statistics and binary logistic regression analysis, the following research questions guided this study: *Is there a MS gap in* Virginia—which MS occupations have a skills gap in 2015 and 2018, and which occupations (number of occupations and size of gap) are most impacted by the MS gap in 2015 and 2018; *How many RA positions are filling MS gap occupations*—what are the key characteristics of registered apprenticeships in Virginia, and how many RA positions are in VA Executive Order 49 occupations (cybersecurity and information technology) in 2018 and 2015; and *What is the impact of registered apprenticeships on the MS gap in Virginia*—what is the likelihood of a Virginia RA position in 2018 (as compared to 2015) filling a MS gap occupation, and how does location and unemployment impact the likelihood of a registered apprenticeship filling a MS gap occupation?

Following is a discussion of the key findings, and their implications for existing literature and policy. This will be followed with recommendations for future research and the conclusion.

Discussion of Findings and Implications

The results of this study indicate there is a MS gap in Virginia and registered apprenticeships are having an impact. There was an increase in the number of RA positions in MS gap occupations from 2015 to 2018, and the number of occupations with a gap decreased. However, the regression analysis revealed that after the implementation of Virginia Executive Order 49, Virginia's 2018 RA positions (in comparison to 2015) have a lower likelihood of filling a MS gap occupation. Study results also established that the location of RA positions in an urban area increases the likelihood that it would be filling a MS Gap occupation and unemployment decreases the likelihood. Examining the extent of the MS Gap, the factors

influencing RA positions filling MS gap occupations, and the hypotheses results informs the question—what is the impact of registered apprenticeships on the MS gap. A discussion of the findings follows.

A MS Gap Exists in Virginia

There is a debate among scholars as to whether a MS gap exists in the U.S. (Cappelli, 2015: Levine, 2013). Therefore, the first research question guiding this study asked if there is a MS gap in Virginia. The findings signify there is, in fact, a MS gap in Virginia. A majority of Virginia's MS occupations had a gap in both 2015 (83.2%) and 2018 (75.5%). However, Virginia's MS gap does not appear to be substantial or extensive because the MS gap size is less than 100 for a majority of the MS gap occupations. These findings are also consistent with data from the VCU Workforce Development 2015 survey of employers which used job vacancy as a measurement of the MS gap and showed that for the majority of Virginia's MS occupations with a gap (71.3%), the gap was less than 100 (CURA at VCU, 2016). Additionally, the MS gap supply to demand ratio (or labor supply shortage) was less than 29% in 2015 and 19% in 2018, indicating that the gap was not as extensive in 2018 as it was in 2015.

The alignment of these findings with previous studies is mixed. The findings for the first research question are consistent with studies that argue that the skills gap is overestimated. Specifically, the MS gap supply to demand ratio (labor supply shortage) findings are consistent with the Weaver and Osterman (2017) study of manufacturers which estimated the skills gap to be less than a quarter (16 to 25%). The research findings are less in agreement with Bivens and Shierholz (2014) who concluded that a skills gap does not exist. It is too early to assess, as Lazear and Spletzer (2012) contend, whether the skills gap is temporary.

The SOC Code Major Groups most impacted in Virginia by the skills gap — both in terms of size and number of six-digit occupations per group with a gap— are consistent with previous studies. Findings in this study show that Business and Financial Operations; Healthcare; Installation, Maintenance, and Repair; and Office and Administrative Support occupations had the largest skills gap based on size in 2018. Except for the Installation, Maintenance and Repair group, these findings are well aligned with the findings of Restuccia et al. (2018) with a few minor differences.

Further, the SOC Code Major Groups with the highest number of 6-digit detailed occupations with a MS gap in Virginia were Production (Manufacturing); Installation, Maintenance and Repair; Construction; and Healthcare occupations. Except for Installation, Maintenance and Repair—these results are similar to those identified by previous studies as having the most difficulty in filling MS jobs or having MS shortages (see Christo-Baker et al., 2017; Kochan et al., 2012; Ladika, 2016; Modestino, 2016). These findings suggest that what is happening in Virginia is consistent with national trends.

Although the SOC Code Major Groups (a) Production; and (b) Installation, Maintenance, and Repair had the highest number of occupations with a skills gap, the Business and Financial Operations and the Healthcare groups had the occupations with largest gap size. This means skill gaps are occurring more frequently in Production and Installation, Maintenance, and Repair, but the extent (or the largest degree) of the MS gap is in the Healthcare and the Business and Financial Operations occupational groups because they have the largest skills gaps. These occupational results imply there should be a policy focus on the occupational groups with the largest skills gap and/or the ratio of supply to demand because these occupation show the extent of the MS gap and gives a better indication of the labor supply shortage.

Findings from this study showed that a majority (69%) of Virginia' MS occupations had the minimal requirements (high school diploma or equivalent and some type of training (moderate-term on-the-job training, long-term on-the-job training, or apprenticeship) or work experience, and only 31% of Virginia's MS occupations required a postsecondary education (e.g. associate's degree, some college, or postsecondary non-degree award). The study results are consistent with data from Commonwealth of Virginia (2017) report that shows Virginia has a low number of individuals with credentials that are suitable for MS positions—Virginia is ranked 40th among states for adults with some college experience and ranked below the national average for adults with an associate's degree in 2015 (Commonwealth of Virginia, 2017).

While on the surface, there appears to be a match between labor supply and labor demand occupational requirements, according to Carnevale et al. (2013), most jobs within the next decade will require workers to have postsecondary education and training beyond high school—40% of jobs will require a postsecondary certificate, some college or associates degree, whereas 24% require a high school diploma. These projections suggest that Virginia needs to increase the number of people with postsecondary qualifications to meet the future requirements for MS jobs.

This is an opportunity for policymakers to implement more policies (like the 2016 New Economy Workforce Grant whose purpose is to create a supply of credentialed workers for high-demand occupations) to help educators and training providers to increase their capacity to provide programs and postsecondary education and credentials that will help skill up more individuals to meet the demands for MS occupations. For example, the policy should include using registered apprenticeships as a tool to help increase the number of people with postsecondary qualifications because it is a work-based learning training program that provides

training for employer driven in-demand occupations and results in a postsecondary certification (e.g., nationally recognized credential) upon completion.

The research revealed that Virginia's current labor supply (human capital) is not meeting the employer demand for MS jobs—Virginia has a MS gap. The human capital theory provides a framework that Virginia's needs to build our workforce capacity by investing in our human capital (the education, knowledge, and skills) to meet the employer demand for MS jobs. Human capital theory suggests that investments into education increases a workers productivity (Becker, 1993), thereby enhancing human capital, and increased earnings for the individual and for the business. Increasing the knowledge and skills of individuals through work-based learning programs that provide postsecondary credentials such as registered apprenticeships, enables the individual to improve both their productivity as well as provide employers a tool to minimize skills gaps. Helping Virginia's labor supply attain the education, training credentials, and certifications will "signal" (signaling theory) to employers that Virginia's workforce has the skills and qualifications for MS jobs.

A MS gap in Virginia signifies the employer demand to fill for MS jobs openings is not being met. If businesses are not able to find the skilled workers, there could be an economic impact. Businesses would have reduced ability to serve clients, reduced production, reduced innovation and creativity that could undermine Virginia's competitiveness globally and nationally. To reduce the economic impact, Virginia should use public policy to help address its MS gap as discussed in the next section—MS gap implications.

MS Gap Implications.

Although Virginia's MS gap is not extensive and Virginia has made progress with the MS gap decreasing from 2015 to 2018[14], a MS gap exists in Virginia and it needs to be addressed. The study results provide policymakers a roadmap of where to direct their resources and investment to address Virginia's MS gap. Accordingly, the findings imply there should be a policy focus on (a) the occupational groups and occupations most impacted by the MS gap, and (b) increasing the certifications and credentials of Virginia's workforce to meet employers demand for MS labor.

Having targeted policy toward particular occupational groups identified in this study can yield significantly more effective results than policies that are generic to all occupational groups. The primary occupational groups where policymakers should consider investing or focusing their resources to address Virginia's MS gap and scale up workers to help meet employer demand are Healthcare; Business and Financial Operations; and Installation, Maintenance, and Repair; and the detailed occupations include Management Analysts (13-1111), General and Operations Managers (11-1021), Medical Assistants (31-9092) and Licensed Practical and Vocational Nurses (29-2061). There should be an investment in resources and a policy focus on these occupations and occupational groups because they have the largest skills gap (or occupations that have a small ratio of supply to demand) in Virginia. Creating policy targeted to those occupational groups and occupations will help Virginia to build a pipeline of skilled workers to meet the needs of employers.

[14] The number of MS gap occupations decreased by 9% from 2015 to 2018 and the labor supply shortage went from less than 29% in 2015 to less than 19% in 2018.

Virginia should have a policy focus on increasing the certifications and credentials of Virginia's workforce to meet employer demands for MS labor because policies that aim to deregulate or incentivize employers may be particularly effective in closing MS gaps. Specifically, policymakers and government agencies can issue (or remove) policy and regulation to help provide training and credentialing in the primary occupational areas with a skills gap to meet employer demand. They can also provide incentives to employers and workers to participate in training and credentialing programs (such as registered apprenticeships) that target occupations with a MS gap and funding for scaling successful models that address MS gap occupations. Overall, public policy can bridge and foster relationships among stakeholders to further decrease Virginia's MS gap for employers while providing credentialing and training opportunities for Virginia's workers that are unemployed or underemployed.

Virginia's RA Program Characteristics Are Consistent With National RA Data

Overall, the landscape of Virginia' RA program is similar to the national data in terms of ethnicity and age (see Gunn & DeSilva, 2008; ODEP, 2015; Reed et al., 2012). The majority of Virginia's RA positions are held by White males between the ages 22 and 39. Registered apprenticeships in the Commonwealth are however, more diverse than the nation from a gender perspective with an average of 19% participation from women in 2015 and 2018 compared to an average of 7% participation from women nationally from 2008 to 2017 (Hanks et al., 2018; ODEP, 2015; Olinksy & Ayres, 2013).

Regarding employer and program characteristics, the findings from this study are consistent with national RA data statistics and in alignment with previous literature. A majority (83% on average) of Virginia's RA sponsors or employers had a small RA program with 1 to 4

RA positions or apprentices, which is typical of registered apprenticeship programs based on previous studies (Lerman et al., 2009). The study also revealed employers are investing in registered apprenticeships— there was an increase in the number RA sponsors and the number of RA positions filling MS gap occupations from 2015 to 2018. According to human capital theory, employers are willing to invest in a training as long as the investment is meeting their needs. If Virginia employers are seeing a return on their RA investment, Virginia policy makers should capitalize on this momentum by further incentivizing employers to participate in RA programs through tax incentives and additional funds. This is an area of opportunity to build upon the success of Virginia's RA program to further reduce the middle skills gap.

A majority of Virginia's RA positions are in the traditional RA industry sectors and occupations. For example, Virginia's RA positions are primarily in the public administration, construction and manufacturing industry sectors, which is consistent with the USDOL (2018c) national RA data which has construction, military, public administration and manufacturing industries with the most RA apprentices. Additionally, the occupation with the most RA positions in Virginia was electricians (SOC Code 47-2111), which is also the occupation with the most RA nationally per the USDOL (2018c). Virginia's occupation with the second most RA positions was plumbers, pipefitters, and steamfitters (SOC Code 47-2152) was fourth (occupation with the most positions) on a national level (USDOL, 2018c).

Scholars and policymakers have called for expanding the occupational base of local and national RA programs from the traditional sectors to high-growth occupations and industries such as healthcare, information technology, and skilled services in order to meet business needs (Fuller & Sigelman, 2017; Olinsky & Ayres, 2013; ODEP, 2015; USDOL-ETA, 2017). Information technology and cybersecurity sectors and related occupations have a need for

middle-level skills and are targeted for high growth in Virginia (Virginia Chamber of Commerce, 2017; VA Executive Order 49, 2015). Specifically, Virginia is one of the top five states for cybersecurity job opportunities with one of the highest number of job openings in the country (over 4,500) which are expected grow by 37% over the next 5 years (Bischoff, 2019). Despite Virginia's Executive Order 49 (2015), which aimed to expand positions in cybersecurity and information technology, findings from this research show minimal progress. More specifically, from 2015 to 2018 cybersecurity RA positions went from zero to three, and information technology RA positions experienced a reduction of 65%. Furthermore, the ratio of cybersecurity positions to total RA positions was less than one percent.

Yet, a January 27, 2017, press release from the Virginia Governor's office stated that VA Executive Order 49 "has spurred an increase of 1,100 new registered apprentices in the past year including development of apprenticeship programs in occupations new to apprenticeship" (p.1). There were new registered apprentices or RA positions, but not many in the cybersecurity or information technology occupations according to the findings from this study. Considering Virginia's invested up to $280,000 in 2016 to expand registered apprenticeships in targeted occupations via VA Executive Order 49, the return on investment was nominal in expanding cybersecurity and information technology occupations. This is an area of opportunity for Virginia's RA program to develop strategies to specifically target expansion in information technology and cybersecurity apprenticeships to help meet the employer demand for middle-skill labor in those occupational areas.

Conversely, there is one positive indication that Virginia's RA program is moving in the right direction (or on the right path) in filling positions that are considered in-demand or high-growth occupations in the Commonwealth. The research findings show that over 68.8% of

Virginia's RA positions represented an occupation from the Virginia In-Demand Occupations List and 94% of those positions were RA positions filling MS gap occupations. There is still room for improvement. The next step is to work with employers to expand the number of apprentices in these in-demand positions—especially in high growth occupations.

Implications for Virginia's RA Program.

Historically, RA positions are primarily held by White males, and based on the study results, this is also the case for Virginia. Instead of seeing an increase in RA positions held by minorities, Virginia had a decrease in RA positions held by Native Americans, Blacks, and Hispanics from 2015 to 2018, while there was an increase in RA positions held by Whites and Asians. Furthermore, the findings indicate White apprentices are more likely to hold a RA position filling a MS gap occupation than any other race or ethnicity. One of the initiatives of the USDOL RA program is to increase the number of women and minorities in apprenticeship (USDOL-ETA, 2017). The objective of the U.S. apprenticeship system is to increase the skills of American workers, raise their productivity and earnings, and to raise the competitiveness of the United States (Lerman, 2013b). In order to meet those goals, the RA program needs to grow and expand on a national and state level, and diversifying their participant base demographically will help meet the goals of the apprenticeship system.

To continue to meet employer's need for MS labor and to close the MS gap, Virginia should expand and diversify its RA program. Although Virginia's RA program is making progress with female participants, it lacks diversity. Expanding Virginia's RA program demographically will help businesses meet their needs to fill MS occupations (e.g., attract and retain talent, close skills gaps, to compete globally, etc.).

Public policy and practitioners can be instrumental with diversifying Virginia's RA program as well as help with expanding its occupational base. Practitioners can develop RA programs and initiatives that targets and recruits women and minorities to participate in Virginia's RA programs, especially in occupations that would address the MS gap. Policymakers can provide the funding, incentives, and policy to help support these programs. Educators and high school counselors can play their part by exposing students to RA program opportunities, thus helping to develop a diverse pipeline of students for RA positions.

Virginia also needs to expand and diversify its RA program by targeting the occupations and occupational groups with the largest skills gaps. Per the study results, a majority of Virginia's RA positions are not filling MS occupations with the largest skills gaps. This is an opportunity for Virginia to align its RA program in the areas where the skills gaps need to be closed. Furthermore, the data results provide information for Virginia's RA programs (practitioners) to target employers and industries for RA opportunities with the largest skills gaps. Targeting areas where the largest MS gaps will help RA practitioners expand and diversify Virginia's RA program.

The Virginia RA program is showing signs of growth with its apprenticeable occupations by having a majority represented on the Virginia In-demand Occupations List, but a majority of Virginia's RA positions are still in the traditional industry sectors and occupations (e.g., construction, production, and installation, maintenance, and repair). Expanding Virginia's apprenticeable occupation list and developing more RA positions in the nontraditional or emerging areas of healthcare, information technology, and skilled services is an area of opportunity for Virginia's RA program (and RA practitioners) to meet employer demands for MS labor. Again, this will also help RA practitioners expand its outreach to employers in non-

traditional or emerging areas, and for policymakers to provide incentives in these non-traditional RA areas.

The descriptive data on Virginia's RA program characteristics provided a more in-depth understanding of the program's landscape and contributed to the RA body of literature, especially with the occupational data findings concerning (a) identifying the occupations where Virginia's registered apprenticeships are mostly represented, (b) the RA impact on cybersecurity and information technology occupations after the implementation of VA Executive Order 49 and c) the extent to which Virginia's RA positions represent occupations from the state's In-Demand Occupation List. The data derived from this research can be used to support state and local policies that seek to strengthen and expand Virginia's RA programs and to close the skills gap.

A Majority of Virginia's RA Positions Are Filling MS Gap Occupations

This research study was able to ascertain that Virginia's registered apprenticeships are filling MS gap occupations and are having an impact on the MS gap. Over 80% of the total RA positions in Virginia were filling MS gap occupations in both 2015 and 2018. Furthermore, there was an increase (14.1%) in the actual number of RA positions filling MS gap occupations from 2015 to 2018 (from 12,390 to 14,139) indicating registered apprenticeships are having an impact on the MS gap.

An exhaustive review of the literature has not yielded studies that have measured the impact or the extent of RA filling MS gap occupations. One contribution of this research to the body of literature is that the study findings show a relationship or an association between registered apprenticeships and MS occupations, specifically MS occupations with a skills gap. According to Fuller (2016), the RA model is structured for developing middle-level skill employees and the study results validates that the RA work-based learning training model not

only develops middle-level skill employees but is also filling MS gap occupations to a large extent in Virginia. Furthermore, registered apprenticeships appear to be an effective strategy because the number of RA positions filling MS gap occupations increased from 2015 to 2018.

The fact that there is an increase in RA positions filling MS gap occupations bears further investigation. The question becomes whether the increase is due to policy economic conditions (e.g., tighter labor market), or other factors. One important factor to note is that while the overall number of RA positions (the denominator) only increased by 4.6% from 2015 to 2018, the number of RA positions filling MS gap occupations (the numerator) had a much larger increase of 14%. Therefore, the proportion of RA positions filling MS gap occupations increased.

Another factor impacting patterns in Virginia could be an increase in RA apprpenticeable occupations from 2015 to 2018. According to the Fuller and Sigelman (2017) study, if registered apprenticeships became the standard training approach in the United States and registered apprenticeships increased their 27 core occupations to 74, there could be up to 3.2 million job openings filled because of registered apprenticeships. Currently, Virginia has 178 active RA apprenticeable occupations (a list of occupations officially recognized as available for registered apprenticeships). While it is not possible to definitively conclude that Virginia's increase in registered apprenticeships filling MS gap occupations from 2015 to 2018 is due to an increase in RA apprenticeable occupations during that time period, it suggests that Virginia's growth in RA positions is worth further analysis to ascertain whether the trends in Virginia align with the trends noted by Fuller and Sigelman (2017).[15]

[15] A list of 2015 apprenticeable occupations was requested from VDOLI to determine if Virginia expanded its apprenticeable occupation list from 2015 to 2018. VDOLI was not able to provide that data because the agency does not keep a "static report" on apprenticeable occupations—they only keep a "snapshot" of that information up to 365 days. This research is unable to determine if the Virginia's RA program apprenticeable occupations expanded from 2015 to 2018 and if this had an impact on RA positions filling more MS gap occupations in 2018.

In summary, Virginia's registered apprenticeships are filling MS gap occupations, and there was an increase in the actual number of RA positions filling MS gap occupations after the implementation of VA Executive Order 49 (2015).

Implications for Registered Apprenticeships Filling MS Gap Occupations.

By filling MS gap occupations, this means Virginia's RA program is addressing employers demand for MS labor, and thus potentially, closing the MS gap. Filling MS gap occupations also implies that Virginia should continue using RA as a strategy to address its MS gap. Since registered apprenticeships are having an impact on the MS gap, there should be a continued (additional) policy focus on registered apprenticeships in Virginia. Registered apprenticeships address both the demand and supply side of the labor market (Lerman, 2018) and it is considered a tool employers can use to help address their demand for labor (and help workers build their skills for an in-demand occupation and obtain a credential). Having policy to help build the capacity of registered apprenticeships can be beneficial to Virginia economically and in terms of workforce development. RA practitioners and policymakers should continue to build the capacity of the RA program via implementing more policies and incentives to expand registered apprenticeships as a strategy to close the MS gap in Virginia.

Impact of Registered Apprenticeships on the MS Gap in Virginia

Previous registered apprenticeship studies assessed the effectiveness of RA programs by conducting cost benefit analysis from a participant (Hollenbeck, 2008; Hollenbeck & Huang, 2016; Reed et al., 2012) and employer perspective (Helper et al., 2016), but this is the first study (to the researcher's knowledge) to specifically conduct an analysis on the impact of registered apprenticeships on the MS gap. This research contributes to the academic literature by examining

RA positions in relation to MS gap occupations and examining whether factors (e.g., urban location, unemployment rate, and number of businesses) influence or contribute to the likelihood of registered apprenticeships filling MS gap occupations. The research findings revealed (a) apprentices holding RA positions in 2018 are less likely to fill MS gap occupations than apprentices holding 2015 RA positions, and (b) urban location and unemployment rate influence RA positions filling MS gap occupations, whereas number of businesses did not make a statistically significant impact.

Likelihood of RA Positions Filling MS Gap Occupations.

While the descriptive results for this study indicate that Virginia's RA programs have made progress with filling MS gap occupations and consequently on the MS gap, the regression analysis results raise questions. The findings signified that Virginia's 2018 RA positions have a lower likelihood of filling MS gap occupations than Virginia's 2015 RA positions. In other words, holding all other factors constant, RA positions are more likely to fill a MS gap occupation prior to the implementation of VA Executive Order 49 than afterwards. These results did not support H_1, which was based on the premise that implementing VA Executive Order 49 (2015) would result in an increase or expansion of registered apprenticeships in Virginia between 2015 and 2018.

Thus, the question becomes why the descriptive analysis (which indicates an increase in RA positions in MS gap occupations) and the regression results (indicating a higher likelihood of 2015 positions filling MS gap occupations than 2018) seem to contradict each other. The regression results suggest the story is complex. The differential effects of urban/rural location and unemployment rate across the two time periods may be influencing the likelihood outcomes. There could also be interactions between the variables that could help explain the differences.

Finally, there could be unobserved factors outside the independent variables utilized in this study such as program related factors (in government regulations or organizational structure at VDOLI), economic factors (wages, interest rates, governmental activity), or policy effects (laws and tax rates). While it is beyond the scope of this dissertation to fully explore why registered apprenticeships are less likely to fill MS gap occupations after VA Executive Order 49, this research can conclude that urban location and unemployment rate have a significant influence.

Urban Location.

Given Young's (2013) assertion that there is a decline of MS jobs in urban areas and rural workers are more likely to hold middle-skill jobs, one would expect RA positions that fill MS gap occupations to be more likely in rural areas. However, in contrast to the study hypotheses (H_2), this research shows that being located in an urban area (compared to rural) increases the likelihood of a RA position filling a MS gap occupation in Virginia. Furthermore, urban location had the strongest influence among the independent variables and that influence was greater in 2018 than in 2015. These results suggest there may be a mismatch between where MS jobs are located and where RA in occupations that fill the MS gap are being created. This mismatch warrants further research.

One might not have expected a substantial number of RA positions to be located in urban areas considering the decline of MS jobs in urban areas (Autor, 2019; Young, 2013) compared to the relatively stability of MS jobs in rural areas (Young, 2013). One potential explanation could be businesses with MS jobs are having difficulty finding skilled workers due to the changing nature of MS jobs requirements (from traditional MS jobs to newer MS jobs that require more technical skills). These businesses may be using work-based learning tools such as registered apprenticeships to meet their demand for skilled labor.

This could explain the disproportionate number of RA positions in urban areas despite the job trends.

This study is not aware of any literature or data regarding the impact of a RA location on the skills gap. The research findings from this study contributes to the RA literature by demonstrating that RA location (urban) is an influencer on the likelihood of RA positions filling MS gap occupations—thus potentially having an impact on the MS gap.

With only 5% of Virginia's RA positions located in rural areas and 4% are filling MS gap occupations in rural areas, this could mean many MS gap occupations in rural areas are not being adequately addressed. This could be an area of opportunity to expand or target more registered apprenticeships in rural areas to help address the MS gap, especially areas that have occupations with a MS gap. Based on these findings in relation to the literature, there needs to be further research on the location of MS jobs and location of registered apprenticeships. Understanding where MS jobs are located can help RA practitioners target employers for future RA positions (build capacity) to help address the MS gap.

Unemployment Rate.

The unemployment rate also had an impact on RA positions filling MS gap occupations. The research findings show that RA positions located in areas of higher unemployment decreases the odds of a RA position filling a MS gap occupation which supported H_3. Accordingly, areas with lower levels of unemployment increases the likelihood of a RA position filing a MS gap occupation.

Based on the study findings, the unemployment rate has a negative relationship with RA positions filling MS gap occupations (odds ratio was less than one and the log-odds was

negative). Therefore, when the unemployment rate increases, the likelihood of a RA position filling a MS gap occupation decreases. This finding is in agreement with research that apprenticeships are strongly pro-cyclical (Bilginsoy, 2018; Brunello, 2009; Sharpe & Gibson, 2005) and RA enrollment is associated with the unemployment rate trends (Sharpe & Gibson, 2005)—registered apprenticeships increase with economic growth (low unemployment rate) and decreases during recessions or economic downturns (high unemployment rate).

As unemployment rates decline, the availability of skilled workers diminishes because those with the most desirable skills are the first hired —the remaining jobseekers are less likely to meet employer requirements. During an economic recession (higher unemployment rates), employers tend not to invest in training such as registered apprenticeships (Brunello, 2009). Thus, during an economic decline (higher unemployment rates), the odds of a RA position filling a MS gap occupation is lower, because less RA positions are being filled.

Additionally, these findings are consistent with reports that shows the unemployment rate can impact occupations in term of labor supply. For example, if there is a shortage of workers in a particular occupation, this may be attributable to a low unemployment rate, and if an occupation has a low unemployment rate, this may imply there is a skills gap (demand for workers exceeds the supply) (Veneri, 1999). Furthermore, occupational skills mismatches can contribute to the rise in the unemployment rate (Sahin et al., 2014). Thus, if the unemployment rate is high, it could be due to a surplus of workers with skills that are not aligned with occupational requirements (due to vertical or horizontal mismatches).

The unemployment rate made a statistically significant contribution to the combined model and the 2015 model but not to the 2018 regression model. Furthermore, the 2018 regression model had an unemployment ratio close to 1 (.99), which essentially means the

unemployment rate had minimal impact on RA positions filling MS gap occupations in 2018. Virginia had lower unemployment rates in 2018 and this could have been a factor as to why the unemployment rate did not have a statistically significant impact (essentially no impact) in the 2018 model. In 2015, the economy was still recovering from the 2007 recession and the unemployment rates in Virginia were much higher than 2018. Specifically, the research results show the 2015 unemployment rate in Virginia's localities ranged from 2.8% to 9.2%; whereas in 2018, the unemployment rate ranged from 2% to 6.1%. Overall, the fluctuations or changes in the unemployment rate effected registered apprenticeships filling MS gap occupations and fundamentally the MS gap.

In general, if the economy is doing well, the unemployment rate is low, then the likelihood of a RA position filling a MS gap occupation is higher because employers are more willing to invest in training (such as registered apprenticeships) during a tight labor market to find the skilled labor they need to meet their employment needs. This concept aligns with the human capital theory that employers are willing to invest in training as long as the investment is meeting their needs—in this case it would be an employer using registered apprenticeships to develop skilled labor in a tight labor market.

Implications—Impact of Registered Apprenticeships on the MS Gap.

Virginia's registered apprenticeships are having an impact on the MS gap, however the impact was not as extensive in 2018 as 2015 because the results for Hypothesis 1 show Virginia's RA positions are less likely to fill a MS gap occupation in 2018. Although registered apprenticeships are less likely to fill a MS gap occupation after the implementation of VA Executive Order 49 (2015), Virginia should continue to implement policy and incentives to help expand and diversify registered apprenticeships. Virginia's RA program is

addressing the growing employer demand for middle-skill workers because a large degree of registered apprenticeships (over 80%) are filling MS jobs in 2015 and 2018, based on the descriptive results from RQ2. Consequently, registered apprenticeships are having an impact on MS gap occupations and therefore, helping Virginia close its MS gap. Registered apprenticeships having an impact on the MS gap (by filling MS gap occupations) demonstrates that Virginia has a tool to address the MS gap and to help employers meet their demand for middle-skilled labor. As a result, policymakers should implement additional policy or regulations to further support registered apprenticeships as a strategy to address the MS gap—build capacity and further expand registered apprenticeships. If it is working—build upon it—expand registered apprenticeships.

Practitioners need to understand why RA positions in 2018 (as compared to 2015) are less likely to fill MS gap occupations. The fact that the likelihood of a registered apprenticeship filling a MS gap occupation is less in 2018 than 2015 is disconcerting or perplexing because research results show Virginia's RA program made progress in filling MS gap occupations from 2015 to 2018 (there was a 14% increase). Yet some of that progress diminished in 2018 because the likelihood of filling a MS gap occupation was less in 2018 than 2015. Identifying and understanding the factors that contribute to RA positions in 2018 being less likely to fill a MS gap occupation will help Virginia's RA program (and RA practitioners) increase its capacity to fill more MS gap occupations, thus helping to further close Virginia's MS gap. Furthermore, factors such as location and the unemployment rate should also be considered in developing RA policy (e.g., targeting registered apprenticeships in areas with lower unemployment rates) because they influence or contribute to RA positions filling MS gap occupations.

Although the likelihood of a RA position filling a MS gap occupation did not increase after the implementation of VA Executive Order 49 (2015), this information may provide practitioners an understanding of how to implement or improve similar policy and regulation in the future. For example, the results relating to VA Executive Order 49 provides valuable information to practitioners there is a need to improve the current process of expanding information technology and cybersecurity registered apprenticeships because the current process or methodology does not appear to be effective based on the findings from this study. Learning from current policy implementation will help increase the return on public dollars invested in future programs like VA Executive Order 49 and registered apprenticeships.

Recommendations for Future Research

This dissertation examined the impact of registered apprenticeships on the MS gap by answering research questions—is there a MS gap in Virginia, are registered apprenticeships filling MS gap occupations, what is the likelihood of registered apprenticeships filling MS gap occupations, and how do factors (e.g., urban location, unemployment rate, and number of businesses) impact the likelihood of registered apprenticeships filling MS gap occupations. This research established that registered apprenticeships are having an impact on the MS gap but not as much in 2018 as compared to 2015. The next step is to examine the extent of the registered apprenticeship impact on the MS gap.

We know there is a MS gap in Virginia and over 80% of registered apprenticeships are filling MS gap occupations. However, we do not know to what extent Virginia's registered apprenticeships help close the Commonwealth's MS gap. Was Virginia's overall MS gap decrease due to registered apprenticeships filling MS gap occupations and are there other factors that contributed to Virginia's MS gap decrease from 2015 to 2018. This information will provide

a more in-depth analysis and further inform stakeholders (e.g., policymakers, practitioners, businesses) about the effectiveness of registered apprenticeships on addressing the MS gap in the Commonwealth.

This research demonstrated there is a supply and demand gap for MS jobs in Virginia—the current labor supply is not meeting future employer demand for particular MS occupations and occupational groups (SOC-Code Major Group). Thus, the next recommendation for future research is to understand why the supply is not meeting the employer demand? Is it supply side factors (e.g., candidates do not have the experience due to automation or lack of certifications and training), demand side factors (employers have unattractive wages, work hours or geographic location, overstated job requirements, decline in employer training) or both.

Similarly, this research identified the occupational groups and occupations most impacted by the MS gap in terms of gap size and the frequency. A recommendation for future research is to examine why these particular occupational groups have the largest skills gaps or the highest number of occupations (within these SOC Code Major Groups) with a skills gap in Virginia. Again, is this due to supply side or demand side factors? Is the gap in these particular occupations the result of some other factors that is specific to the occupational group or industry (e.g., specific training requirements, industry standards)? Occupational research is an area that could provide data to help direct future programming for registered apprenticeships and help them expand in Virginia and nationally. Answers to those questions will further inform our policymakers and stakeholders to develop policies or strategies to address the MS gap in Virginia and nationally.

Conclusion

Overall, there has been a lack of literature evaluating the effectiveness of RA programs and their impact on workforce issues (such as the skills gap) in Virginia and the United States as a whole. Previous RA studies assessed the effectiveness of RA programs by conducting cost benefit analysis from a participant (Hollenbeck, 2008; Hollenbeck & Huang, 2016; Reed et al., 2012) and employer perspective (Helper et al., 2016), but not the effectiveness of registered apprenticeships with addressing workforce issues such as the MS gap. This research contributes to the academic literature on registered apprenticeships and the MS gap in a number of ways.

First, this is the first study (to the researcher's knowledge) to conduct an analysis regarding the impact of registered apprenticeships on the MS gap. This research contributes to the academic literature by examining (a) MS gap occupations in relationship to Virginia's RA positions and (b) the factors (e.g., urban location and unemployment rate) that influenced registered apprenticeships filling MS gap occupations. Second, this research described the landscape of Virginia's RA program and the MS gap. Due to the limited data available on these programs, this study added to the literature by providing information on the programs apprentice demographics, program characteristics, employer characteristics, and occupational data (e.g. occupations most represented by registered apprenticeships) that can be used for analysis in future research.

Third, this study contributes to the MS gap literature regarding whether a MS gap exists. Using a supply and demand methodology, this study demonstrated that a MS gap exists in Virginia but it is not considered substantial because the labor supply shortage was less than 19% and the size of the gap was less than 100 for a majority of the occupations. Additionally, this study added to the literature by providing data on the trajectory of Virginia's MS gap (decreased

from 2015 to 2018), and identifying the occupational groups and 6-digit-detailed occupations most impacted by Virginia's MS gap. Furthermore, providing MS gap information at the 6-digit detailed occupation level provides academics data and results to use in future studies.

Overall, the research findings revealed that Virginia's registered apprenticeships are having an impact on MS gap occupations but the impact of VA Executive Order 49 (2015) was limited. Virginia does have a MS gap and a majority (over 80%) of RA positions were filling MS gap occupations prior to and after VA Executive Order 49. Notably, Virginia had a 19% increase in RA sponsors and a 14% increase in actual RA positions filling MS gap occupations from 2015 to 2018. However, the results also revealed that Virginia's RA positions in 2018 (as compared RA positions in 2015) have a lower likelihood of filling a MS gap occupation, holding all factors constant. Thus, Virginia's 2015 RA positions are more likely to fill a MS gap occupation than a 2018 RA position. The lower likelihood of a 2018 RA position filling a MS gap occupation is influenced by factors such as location of RA positions (urban or rural) and economic conditions (unemployment rate).

Based on the findings, it is recommended there should be a policy focus on the following areas to help address the MS gap in Virginia: provide funding to scale successful models that address occupational groups and occupations most impacted by the MS gap; increase the certifications and credentials of Virginia's workforce to meet employer demands for MS labor; align Virginia's RA program with MS occupations that have the largest skills gaps; continue to expand Virginia's RA program into non-traditional or emerging areas (e.g. healthcare, information technology, and skilled services); continue to diversify Virginia's RA program demographically to help businesses meet their needs to fill MS occupations (e.g. attract and

retain talent, close the skills gap, and compete globally); and consider factors (e.g. location and unemployment rate) in developing RA policy to address Virginia's MS gap.

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Appendix A

Apprenticeable Occupations

1. USDOL-ETA List of Apprenticeable Occupations
   - 1,215 Occupations as of June 1, 2020
   - List of occupations located at the following website: https://www.doleta.gov/oa/occupations.cfm

2. Virginia List of Apprenticeable Occupations*[16]
   - 178 Occupations as of June 1, 2020
   - List of occupations located at the following website: https://www.doli.virginia.gov/apprenticeship/active-virginia-occupations/

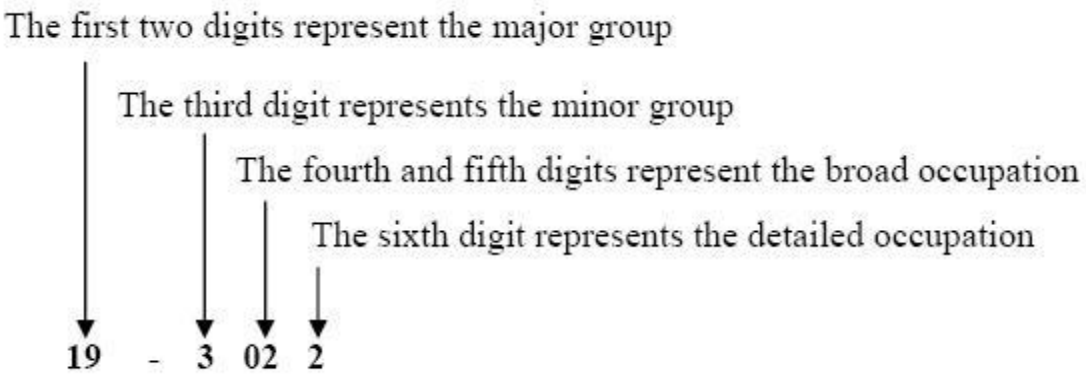
[16] Virginia apprenticeable occupations are a subset of the USDOL apprenticeable occupations. They only represent the apprenticeable occupations (jobs) that are present in Virginia.

Appendix B

2018 Standard Occupational Classification System

Standard Occupation Classification (SOC) System: A federal statistical standard used by federal agencies to classify workers and jobs into occupational categories and covers all jobs in the national economy including occupations in the public, private and military sectors (U.S. Office of Management and Budget, 2018). The 2018 SOC system contains 867 detailed occupations, aggregated into 459 broad occupations which are combined into 98 minor groups and 23 major groups.

SOC System	Example
23 Major Groups	29-0000 Healthcare Practitioners and Technical Occupations
98 Minor Groups	29-1000 Health Diagnosing or Treating Practitioners
459 Broad Occupations	29-1020 Dentists
867 Detailed Occupations	29-1022 Oral and Maxillofacial Surgeons



Source: U.S. Office of Management and Budget (2018). Standard Occupational Classification Manual. Pages 11-12. Retrieved from https://www.bls.gov/soc/2018/soc_2018_manual.pdf

Appendix B - continued

2018 Standard Occupational Classification System—23 Major Groups

Each occupation in the 2018 SOC System is placed within one of these 23 major groups.

2018 Standard Occupational Classification (SOC) System	
11-0000	Management Occupations
13-0000	Business and Financial Operations Occupations
15-0000	Computer and Mathematical Occupations
17-0000	Architecture and Engineering Occupations
19-0000	Life, Physical, and Social Science Occupations
21-0000	Community and Social Service Occupations
23-0000	Legal Occupations
25-0000	Educational Instruction and Library Occupations
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations
29-0000	Healthcare Practitioners and Technical Occupations
31-0000	Healthcare Support Occupations
33-0000	Protective Service Occupations
35-0000	Food Preparation and Serving Related Occupations
37-0000	Building and Grounds Cleaning and Maintenance Occupations
39-0000	Personal Care and Service Occupations
41-0000	Sales and Related Occupations
43-0000	Office and Administrative Support Occupations
45-0000	Farming, Fishing, and Forestry Occupations
47-0000	Construction and Extraction Occupations
49-0000	Installation, Maintenance, and Repair Occupations
51-0000	Production Occupations
53-0000	Transportation and Material Moving Occupations
55-0000	Military Specific Occupations

Source: U.S. Department of Labor, Bureau of Labor Statistics (2020, April 17). Standard Occupational Classification System. Retrieved from https://www.bls.gov/soc/2018/major_groups.ht

Appendix C

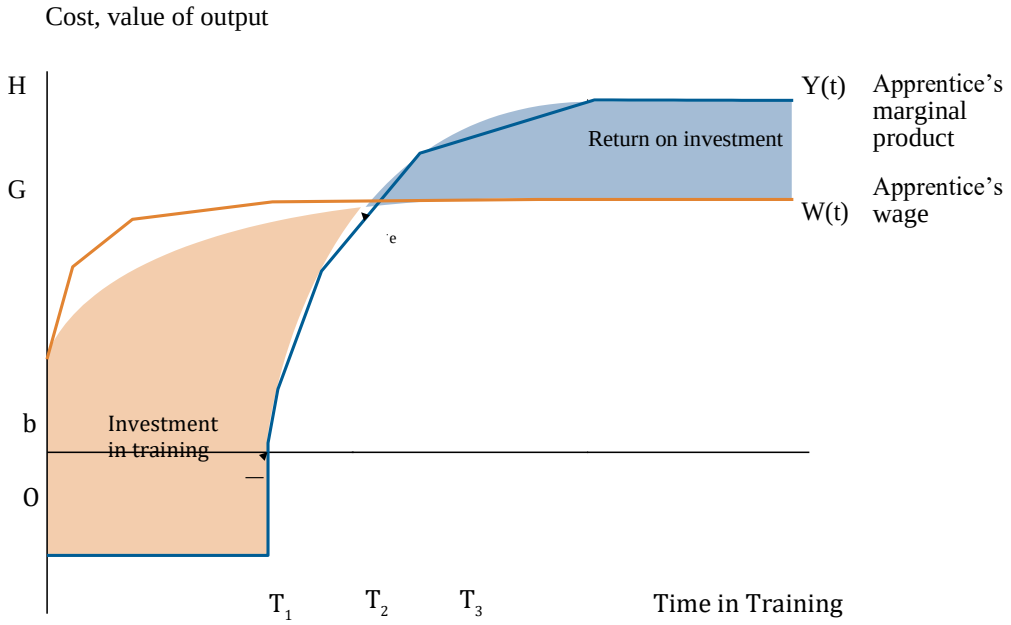
Skills Mismatch Summary of Concepts

Skill Mismatches are measured at the level of the individual circumstance and at firm-level aggregates (McGuinness et al., 2017). A *skills mismatch* is the misalignment between workers skills (supply) and the skills needs needed to perform the job (demand).	
Individual (human capital)	**Organizational**
Over/Under education (Vertical) One's education is more or less than what is required to perform a job	**Skill Shortages** = employers are unable to fill vacancies due to lack of qualified candidates; not enough people with the right skills (Richardson, 2007); an expressed difficulty in recruiting individuals from the external labor market due to the following reasons: lack of required skills; lack of work experience or qualifications a company demands (Schwalje, 2011)
Over/Under Skilling (Vertical) One's skill is more or less than what is required to perform a job (overqualified/underqualified)	**Skill Gaps** = employers believe that workers do not possess adequate skills and competencies to successfully implement their job; sufficient people, but missing some qualities or skills employers seek (Richardson, 2007); refers to the skills gap internally within an organization (Schwalje, 2011).
Horizontal Mismatch=workers (typically college graduate) are employed in jobs that are not relevant to their principal field of study	
Skill Obsolescence=workers possess skills that are no longer required by the employer; workers skills become obsolete.	
Surplus Human Capital = over education and over skilling (Overqualified) **Deficit Human Capital =** Under education and under skilling (Underqualified)	

Primary Source: McGuinness, S., Pouliakas, K. & Redmond, P. (2017). *How Useful is the Concept of Skills Mismatch?* International Labour Organization. Other Sources: Richardson (2007) and Schwalje (2011).

Appendix D

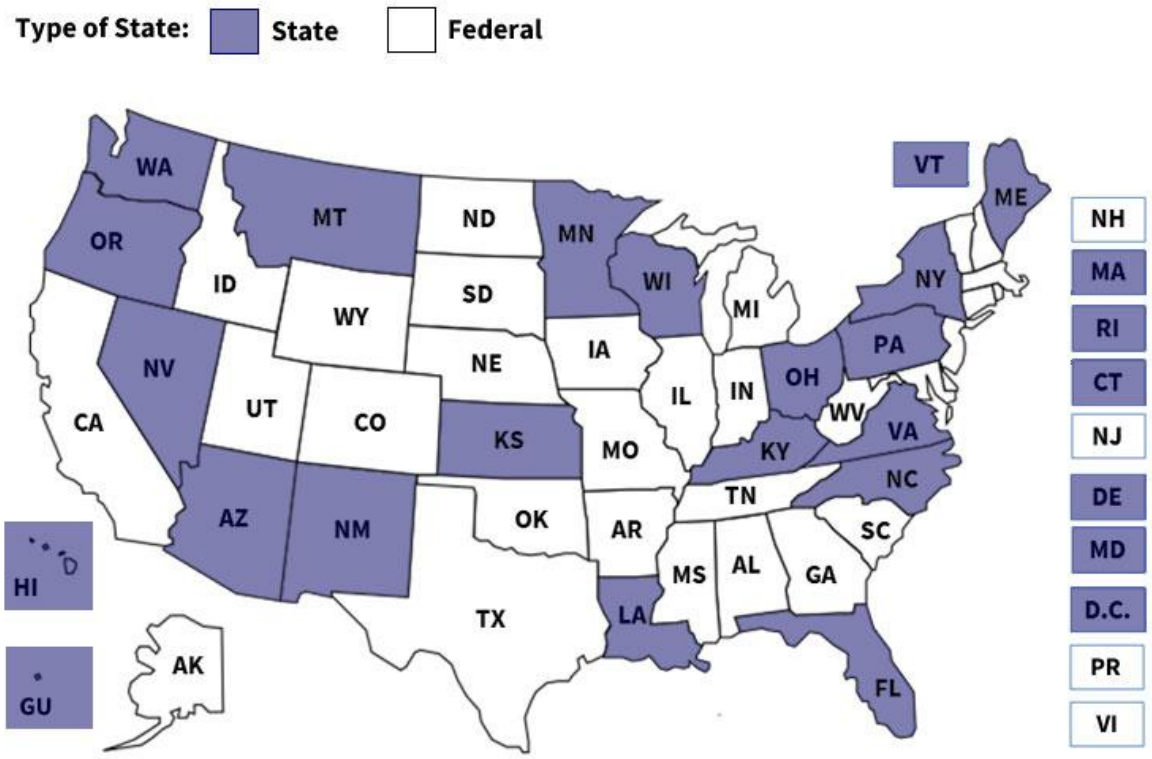
The Time Paths of Marginal Product and Wages for Apprentices



Source: Lewis, P. A. (2014). The Simple Economics of Apprenticeship, Kings College of London, Gatsby Foundation p. 5.

Appendix E

Map of DOL-ETA Office of Apprenticeship (Federal) and State Apprenticeship Agencies in the United States



Source: U.S. Department of Labor. (2018e). Retrieved from https://doleta.gov/OA/contactlist.cfm

Appendix F

Virginia Demand Occupations List

Virginia Demand Occupations. A list of high-demand (or high growth) occupations in Virginia developed by the Virginia Board of Workforce Development at the direction of the 2016 Virginia Assembly.

The VBWD Demand Occupation Taskforce selected the following major occupation groups for inclusion in the Demand Occupations List for 2018-2019 year based on the degree to which they support Virginia's economic development strategy.

15-0000 Computer and Mathematical Occupations
17-0000 Architecture and Engineering Occupations
19-0000 Life, Physical, and Social Science Occupations
25-0000 Education, Training, and Library Occupations
29-0000 Healthcare Practitioners and Technical Occupations
31-0000 Healthcare Support Occupations
43-0000 Office and Administrative Support Occupations
47-0000 Construction and Extraction Occupations
49-0000 Installation, Maintenance, and Repair Occupations
51-0000 Production Occupations
53-0000 Transportation and Material Moving Occupations

2018-2019 Virginia Demand Occupations List

The following list represents the occupations within the 11 identified priority fields endorsed by the Virginia Board of Workforce Development as identified by the Demand Occupations Taskforce. Inclusion on this list makes approved related noncredit workforce training activities eligible for funding through the New Economy Workforce Credential Grant Program.

Source: Virginia Board of Workforce Development (2018b). 2018-2019 Demand Occupations List.

Appendix F - continued

15-0000 Computer and Mathematical Occupations

151121 Computer Systems Analysts
511122 Information Security Analysts
151131 Computer Programmers
151132 Software Developers, Applications
151133 Software Developers, Systems Software
151134 Web Developers
151141 Database Administrators
151142 Network & Computer Systems Admin.
151143 Computer Network Architects
151151 Computer User Support Specialists
151152 Computer network Support Specialists
151199 Computer Occupations, All Other
152031 Operations Research Analysts

17-0000 Architecture and Engineering Occupations

172051 Civil Engineers
172071 Electrical Engineers
172072 Electronics Engineers, Except Computer
172112 Industrial Engineers
172141 Mechanical Engineers
173023 Electrical & Electronic Engineering Tech

19-0000 Life, Physical & Social Science Occupations

192041 Environmental Scientists & Specialists, including Health

25-0000 Education, Training, and Library Occupations

252011 Preschool Teachers, Except Special Ed
251012 Kindergarten Teachers, Except Special Ed
252021 Elementary School Teachers, Except Special Ed
252022 Middle School Teachers, Except Special and Career/Technical Education
252031 Secondary School Teachers, Except Special and Career/Technical Education
252052 Special Education Teachers, Kindergarten & Elementary School.
252054 Special Education Teacher, Secondary School
253021 Self-Enrichment Education Teachers
253097 Teachers & Instructors, All Others, Except Substitute Teachers
253098 Substitute Teachers
254031 Library Technicians
259041 Teacher Assistants

29-0000 Healthcare Practitioners and Technical Occupations

291141 Registered Nurse
292011 Medical & Clinical Laboratory Technologists
292012 Medical & Clinical Laboratory Technicians
292021 Dental Hygienists
292034 Radiologic Technologists
292041 Emergency Med Tech & Paramedics
292052 Pharmacy Technicians
292061 Licensed Practical & Licensed Vocational Nurses
292071 Med. Records & Health Information Tech
292081 Opticians, Dispensing

Appendix F – continued

31-0000 Healthcare Support Occupations

311014 Nursing Assistants
312021 Physical Therapist Assistants
319011 Massage Therapists
319091 Dental Assistants
319092 Medical Assistants
319096 Veterinary Assistants & Laboratory Animal Caretakers
319097 Phlebotomists

43-0000 Office and Administrative Support Occupations

431011 First-Line Supervisors of Office & Administrative Support Workers
433011 Bill & Account Collectors
433021 Billing & Posting Clerks
433031 Bookkeeping, Accounting, & Auditing Clerks
433071 Tellers
434171 Receptionists & Information Clerks
434199 Information & Record Clerks, All Other
435032 Dispatchers, Except Police, Fire, & Ambulance
435052 Postal Service Mail Carriers
435061 Production, Planning, & Expediting Clerks
436011 Executive Secretaries & Executive Administrative Assistants.
434051 Customer Service Representatives
434081 Hotel, Motel, and Resort Desk Clerks
434111 Interviewers, Except Eligibility & Loan
434121 Library Assistants, Clerical
434131 Loan Interviewers & Clerks
434151 Order Clerks
436013 Medical Secretaries
436014 Secretaries & Administrative Assistants, Except Legal, Medical, and Executive
439041 Insurance Claims & Policy Processing Clerks
439061 Office Clerks, General
439199 Office & Administrative Support Workers, All Other

47-0000 Construction and Extraction Occupations

471011 First-Line Supervisors of Construction Trades & Extraction Workers
472031 Carpenters
472073 Operating Engineers & Other Construction Equipment Operators
472111 Electricians
472151 Pipelayer
472152 Plumbers, Pipefitters, & Steamfitters
472211 Sheet Metal Workers
474011 Construction & Building Inspectors
474051 Highway Maintenance Workers

49-0000 Installation, Maintenance, and Repair Occupations

491011 First-Line Supervisors of Mechanics & Installers
492098 Security & Fire Alarm Systems Installers
493021 Automotive Body & Related Repairers
499021 Heating, Air Conditioning, & Refrigeration Mechanics, Repairers, and Installers
499041 Industrial Machinery Mechanics
499051 Electrical Power-Line Installers & Repairers

Appendix F - continued

49-0000 Installation, Maintenance, and Repair Occupations - continued

493023 Automotive Service Technicians & Mechanics
493031 Bus & Truck Mechanics & Diesel Engine Specialists
49952 Telecommunications Line Installers & Repairers
499071 Maintenance & Repair Workers, General
499098 Helpers--Installation, Maintenance, & Repair Workers

51-0000 Production Occupations

511011 First-Line Supervisors of Production & Operating Workers
518031 Water & Wastewater Treatment Plant & Systems Operators
512092 Team Assemblers
512099 Assemblers & Fabricators, All Other
514041 Machinists
514121 Welders, Cutters, Solderers, & Brazers
519061 Inspectors, Testers, Sorters, Samplers, and Weighers
519111 Packaging and Filling Machine Operators & Tenders
519199 Production Workers, All Other

53-0000 Transportation and Material Moving Occupations

531021 First-Line Supervisors of Helpers, Laborers, and Material Movers, Hand
531031 First-Line Supervisors of Transportation & Material Moving Machine & Vehicle Operators
533021 Bus Drivers, Transit and Intercity
533022 Bus Drivers, School or Special Client
533031 Driver/Sales Workers
533032 Heavy & Tractor-Trailer Truck Drivers
533033 Light Truck or Delivery Services Drivers

Appendix G

Registered Apprenticeship FOIA Request for Data

The following data were requested from the VDOLI for this research.

1. Apprentice, RA Program, and RA Sponsor/Employer Information for FY2015 and FY2018

Apprentice information	Data field type
Apprentice	De-Identification Number
Birthdate	Date
Gender	Male/Female
Ethnicity	Caucasian, African American, Latino, Asian, etc.
Veteran Status	Veteran, Nonveteran
Position SOC Code	SOC Code Number
Position SOC Code Title	SOC Code Title
Position Name	Position Name Per Employer
Position Start and End Date	Date
Apprenticeship Location	FIPS Code/Zip Code/City
Certificate of Completion Issued	Date
Type of Certificate	Name of Credential
RA Sponsor/Employer	Name or ID Number
RA Sponsor/Employer Industry	NAIC or SIC Code
RA Sponsor/Employer Address	City and Zip Code
RA Sponsor/Employer FIPS Code	FIPS Code
RA Sponsor Number of Active Apprentices	Number
RA Sponsor Number of Establishments	Number

2. Aggregate Data for FY2015 and FY2018

Aggregate Data for FY2015 and FY2018
Total Number of Active Programs
Total Number of Active Apprentices
Total Number of New Programs
Total Number of New Apprentices
Total Number of Completers
Total Number of Employers Served
Total Number of Programs by Type of Training (Competency, Time, Hybrid)
Total Number of RA Active Apprentices by Detailed SOC Code

Appendix H

Definitions of Descriptive and Control Variables

Descriptive and control variables included apprentice demographic characteristics (gender, ethnicity, and age); employer characteristics (industry type and number of RA positions per employer); program characteristics (number of RA positions: by SOC Code Major Group, by urban location, filling a MS gap occupation, filling Executive Order 49 Occupations (Cybersecurity and Information Technology occupations), on the Virginia Demand Occupations List); and variables used to control for local economic conditions (number of businesses and number of jobs). The following is a list of the descriptive and control variables with definitions.

Apprentice Demographics: *gender, ethnicity and age*

Registered Apprenticeship Employer Characteristics: *industry type (based on NAICs or SIC)* and *number of apprentices per employer.*

- ***Industry Type.*** The industry of a RA employer or RA sponsor that is based on the NAICS (North American Industry Classification System) two digit code. See Appendix J for the 20 NAICS industries.

Registered Apprenticeship Program Characteristics:

SOC Code Major Group: The Standard Occupation Classification (SOC) System is a federal statistical standard used by federal agencies to classify workers and jobs into occupational categories and covers all jobs in the national economy including occupations in the public, private and military sectors (U.S. Office of Management and Budget, 2018). The 2018 SOC system contains 867 detailed occupations, aggregated into 459 broad occupations which are combined into 98 minor groups and 23 major groups. RA positions will be examined and

Appendix H - continued

classified based on the Standard Occupation Classification (SOC) System 23 Major Groups (e.g. number of RA positions per SOC Code Major Group). See Appendix B for the 23 Major groups.

Urban Location. Represents the location of a RA position which is reported in the VDOLI RA database as a county FIPS code (Federal Information Processing Standards code is a geographic code which uniquely identified counties and county equivalents in the United States). Urban location was based on the CDC 2013 NHCS Urban-Rural Classification Scheme for Counties (U.S. Dept. of Health, 2014) and the Virginia Department of Health Rural (Non-Metropolitan Areas) as defined by the Office of Management and Budget (VDH, 2019). Urban areas were coded as a 1 = yes or 0 = no. *Represents the number of RA positions in an urban location.*

RA Position Filling a MS Gap Occupation. A dichotomous variable indicating whether a Registered Apprenticeship position is filling a middle-skills occupation with a skills gap. 2015RAPMSGO was coded as 1 = yes or 0 = no. *Represents the number of RA positions filling a MS gap occupation.*

Executive Order 49 Occupations: Cybersecurity and Information Technology are occupations identified in Executive Order 49 to expand registered apprenticeships and address the skills gap. This dichotomous variable was coded as 0=no or 1=yes.

- ***Cybersecurity***. Cyber Security was be measured based on whether an apprentice has a position with an Information Security Analyst SOC code of 15-1122 (2018 SOC) or 15-1212 (2010 SOC) from the VDOLI RA database. This nominal variable with be coded as 0=no or 1=yes.

- ***Information Technology***. Information technology was measured based on whether an apprentice has a position with a Computer Operation SOC Code in the minor groups of 15-1200 (SOC 2018) or 15-1100 (SOC 2010) from the VDOLI RA database. This nominal variable was coded as 0=no or 1=yes.

Appendix H - continued

Virginia Demand Occupations List. A list of high-demand (or high growth) occupations in Virginia developed by the Virginia Board of Workforce Development at the direction of the 2016 Virginia Assembly. See Appendix F. If a RA position has a middle-skill occupational code from this list, it was coded as a 0=no and 1=yes.

Variables to control for local economic conditions:

Number of Businesses. Represents the number of businesses in a Virginia location based on the FIPS code. This information was derived from the U.S. Census Bureau County Business Patterns statistical data.

Descriptive and Control Variables

Variable name	Scales of measurement	Variable type	Coding	Source
Apprentice Demographics (gender, ethnicity, age)	Nominal/Ordinal	Control	Various	VDOLI RA Database
Industry Type	Nominal	Independent	See Appendix J	VDOLI NAIC or SIC Code
VA Executive Order 49 Occupations (cybersecurity, information technology)	Dichotomous	Independent	0=No 1=Yes	VDOLI-Apprentice SOC Code
Virginia Demand Occupations	Nominal	Independent	0=No 1=Yes	Virginia Board of Workforce Development
Number of Businesses	Interval	Independent (Control)	N/A	U.S. Census Bureau, County Business Patterns

Appendix I

286 MS Occupations Identified for the Study

SOC code	SOC code description-occupation	Education	Training
111021	General and Operations Managers	Associate's degree	None
113011	Administrative Services Managers	High school diploma or equivalent	None*
113071	Transportation, Storage, and Distribution Managers	High school diploma or equivalent	None*
119013	Farmers, Ranchers, and Other Agricultural Managers	High school diploma or equivalent	None*
119021	Construction Managers	Associate's degree	None
119051	Food Service Managers	High school diploma or equivalent	None*
119061	Funeral Service Managers	Associate's degree	None
119131	Postmasters and Mail Superintendents	High school diploma or equivalent	Moderate-term on-the-job training
119141	Property, Real Estate, and Community Association Managers	High school diploma or equivalent	None*
131023	Purchasing Agents, Except Wholesale, Retail, and Farm Production	High school diploma or equivalent	Long-term on-the-job training
131031	Claims Adjusters, Examiners, and Investigators	High school diploma or equivalent	Long-term on-the-job training
131032	Insurance Appraisers, Auto Damage	Postsecondary non-degree award	Moderate-term on-the-job training
131111	Management Analysts	Postsecondary non-degree award	None
131199	Business Operations Specialists, All Other	High school diploma or equivalent	Long-term on-the-job training
132021	Appraisers and Assessors of Real Estate	High school diploma or equivalent	Apprenticeship
132072	Loan Officers	High school diploma or equivalent	Moderate-term on-the-job training
132082	Tax Preparers	High school diploma or equivalent	Moderate-term on-the-job training
151134	Web Developers	Postsecondary non-degree award	None
151151	Computer User Support Specialists	High school diploma or equivalent	Moderate-term on-the-job training
172071	Electrical Engineers	Postsecondary non-degree award	Moderate-term on-the-job training
173011	Architectural and Civil Drafters	Associate's degree	None

Appendix I - continued

SOC code	SOC code description-occupation	Education	Training
173012	Electrical and Electronics Drafters	Associate's degree	None
173013	Mechanical Drafters	Associate's degree	None
173019	Drafters, All Other	Associate's degree	None
173021	Aerospace Engineering and Operations Technicians	Associate's degree	None
173022	Civil Engineering Technicians	Associate's degree	None
173023	Electrical and Electronics Engineering Technicians	Associate's degree	None
173024	Electro-Mechanical Technicians	Associate's degree	None
173025	Environmental Engineering Technicians	Associate's degree	None
173026	Industrial Engineering Technicians	Associate's degree	None
173027	Mechanical Engineering Technicians	Associate's degree	None
173029	Engineering Technicians, Except Drafters, All Other	Associate's degree	None
173031	Surveying and Mapping Technicians	High school diploma or equivalent	Moderate-term on-the-job training
194011	Agricultural and Food Science Technicians	Associate's degree	Moderate-term on-the-job training
194031	Chemical Technicians	Associate's degree	Moderate-term on-the-job training
194051	Nuclear Technicians	Associate's degree	Moderate-term on-the-job training
194061	Social Science Research Assistants	Associate's degree	None
194091	Environmental Science and Protection Technicians, Including	Associate's degree	Moderate-term on-the-job training
194093	Forest and Conservation Technicians	Associate's degree	None
194099	Life, Physical, and Social Science Technicians, All Other	Associate's degree	Moderate-term on-the-job training
211011	Substance Abuse and Behavioral Disorder Counselors	High school diploma or equivalent	Moderate-term on-the-job training
232093	Title Examiners, Abstractors, and Searchers	High school diploma or equivalent	Moderate-term on-the-job training
232099	Legal Support Workers, All Other	Associate's degree	None
252011	Preschool Teachers, Except Special Education	Associate's degree	None
254031	Library Technicians	Postsecondary non-degree award	None
271013	Fine Artists, Including Painters, Sculptors, and Illustrator	High school diploma or equivalent	Long-term on-the-job training
271019	Artists and Related Workers, All Other	High school diploma or equivalent	Long-term on-the-job training

Appendix I - continued

SOC code	SOC code description-occupation	Education	Training
271023	Floral Designers	High school diploma or equivalent	Moderate-term on-the-job training
272011	Actors	Some college, no degree	Long-term on-the-job training
272021	Athletes and Sports Competitors	High school diploma or equivalent	Long-term on-the-job training
272022	Coaches and Scouts	High school diploma or equivalent	Long-term on-the-job training
272023	Umpires, Referees, and Other Sports Officials	High school diploma or equivalent	Long-term on-the-job training
272042	Musicians and Singers	High school diploma or equivalent	Long-term on-the-job training
274011	Audio and Video Equipment Technicians	Postsecondary non-degree award	Moderate-term on-the-job training
274012	Broadcast Technicians	Associate's degree	Short-term on-the-job training
274021	Photographers	High school diploma or equivalent	Long-term on-the-job training
274099	Media and Communication Equipment Workers, All Other	High school diploma or equivalent	Moderate-term on-the-job training
291124	Radiation Therapists	Associate's degree	None
291126	Respiratory Therapists	Associate's degree	None
292012	Medical and Clinical Laboratory Technicians	Associate's degree	None
292021	Dental Hygienists	Associate's degree	None
292031	Cardiovascular Technologists and Technicians	Associate's degree	None
292032	Diagnostic Medical Sonographers	Associate's degree	None
292033	Nuclear Medicine Technologists	Associate's degree	None
292034	Radiologic Technologists	Associate's degree	None
292035	Magnetic Resonance Imaging Technologists	Associate's degree	None
292041	Emergency Medical Technicians and Paramedics	Postsecondary non-degree award	None
292051	Dietetic Technicians	High school diploma or equivalent	Moderate-term on-the-job training
292052	Pharmacy Technicians	High school diploma or equivalent	Moderate-term on-the-job training
292053	Psychiatric Technicians	Postsecondary non-degree award	Short-term on-the-job training
292055	Surgical Technologists	Postsecondary non-degree award	None
292056	Veterinary Technologists and Technicians	Associate's degree	None
292061	Licensed Practical and Licensed Vocational Nurses	Postsecondary non-degree award	None

Appendix I - continued

SOC code	SOC code description-occupation	Education	Training
292071	Medical Records and Health Information Technicians	Postsecondary non-degree award	None
292081	Opticians, Dispensing	High school diploma or equivalent	Long-term on-the-job training
292092	Hearing Aid Specialists	High school diploma or equivalent	Moderate-term on-the-job training
292099	Health Technologists and Technicians, All Other	Postsecondary non-degree award	None
299012	Occupational Health and Safety Technicians	High school diploma or equivalent	Moderate-term on-the-job training
299099	Healthcare Practitioners and Technical Workers, All Other	Postsecondary non-degree award	None
312011	Occupational Therapy Assistants	Associate's degree	None
312021	Physical Therapist Assistants	Associate's degree	None
312022	Physical Therapist Aides	High school diploma or equivalent	Moderate-term on-the-job training
319011	Massage Therapists	Postsecondary non-degree award	None
319091	Dental Assistants	Postsecondary non-degree award	None
319092	Medical Assistants	Postsecondary non-degree award	None
319093	Medical Equipment Preparers	High school diploma or equivalent	Moderate-term on-the-job training
319094	Medical Transcriptionists	Postsecondary non-degree award	None
319097	Phlebotomists	Postsecondary non-degree award	None
331011	First-Line Supervisors of Correctional Officers	High school diploma or equivalent	Moderate-term on-the-job training
331012	First-Line Supervisors of Police and Detectives	High school diploma or equivalent	Moderate-term on-the-job training
331021	First-Line Supervisors of Fire Fighting and Prevention Worker	Postsecondary non-degree award	None
331099	First-Line Supervisors of Protective Service Workers, All Other	High school diploma or equivalent	None*
332011	Firefighters	Postsecondary non-degree award	Long-term on-the-job training
333011	Bailiffs	High school diploma or equivalent	Moderate-term on-the-job training
333012	Correctional Officers and Jailers	High school diploma or equivalent	Moderate-term on-the-job training
333021	Detectives and Criminal Investigators	High school diploma or equivalent	Moderate-term on-the-job training
333051	Police and Sheriff's Patrol Officers	High school diploma or equivalent	Moderate-term on-the-job training

Appendix I - continued

SOC code	SOC code description-occupation	Education	Training
339011	Animal Control Workers	High school diploma or equivalent	Moderate-term on-the-job training
339093	Transportation Security Screeners	High school diploma or equivalent	Moderate-term on-the-job training
351011	Chefs and Head Cooks	High school diploma or equivalent	None*
351012	First-Line Supervisors of Food Preparation and Serving Workers	High school diploma or equivalent	None*
371011	First-Line Supervisors of Housekeeping and Janitorial Worker	High school diploma or equivalent	None*
371012	First-Line Supervisors of Landscaping, Lawn Service, and…	High school diploma or equivalent	None*
373012	Pesticide Handlers, Sprayers, and Applicators, Vegetation	High school diploma or equivalent	Moderate-term on-the-job training
391021	First-Line Supervisors of Personal Service Workers	High school diploma or equivalent	None*
392011	Animal Trainers	High school diploma or equivalent	Moderate-term on-the-job training
394011	Embalmers	Associate's degree	Long-term on-the-job training
394031	Morticians, Undertakers, and Funeral Directors	Associate's degree	Long-term on-the-job training
395012	Hairdressers, Hairstylists, and Cosmetologists	Postsecondary non-degree award	None
395092	Manicurists and Pedicurists	Postsecondary non-degree award	None
395094	Skincare Specialists	Postsecondary non-degree award	None
396012	Concierges	High school diploma or equivalent	Moderate-term on-the-job training
399041	Residential Advisors	Some college, no degree	Short-term on-the-job training
411011	First-Line Supervisors of Retail Sales Workers	High school diploma or equivalent	None*
411012	First-Line Supervisors of Non-Retail Sales Workers	High school diploma or equivalent	None*
413011	Advertising Sales Agents	High school diploma or equivalent	Moderate-term on-the-job training
413021	Insurance Sales Agents	High school diploma or equivalent	Moderate-term on-the-job training
413041	Travel Agents	High school diploma or equivalent	Moderate-term on-the-job training
414012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	High school diploma or equivalent	Moderate-term on-the-job training

Appendix I - continued

SOC code	SOC code description-occupation	Education	Training
419022	Real Estate Sales Agents	High school diploma or equivalent	Moderate-term on-the-job training
431011	First-Line Supervisors of Office and Administrative Support	High school diploma or equivalent	None*
433011	Bill and Account Collectors	High school diploma or equivalent	Moderate-term on-the-job training
433021	Billing and Posting Clerks	High school diploma or equivalent	Moderate-term on-the-job training
433031	Bookkeeping, Accounting, and Auditing Clerks	High school diploma or equivalent	Moderate-term on-the-job training
433051	Payroll and Timekeeping Clerks	High school diploma or equivalent	Moderate-term on-the-job training
433061	Procurement Clerks	High school diploma or equivalent	Moderate-term on-the-job training
434011	Brokerage Clerks	High school diploma or equivalent	Moderate-term on-the-job training
434031	Court, Municipal, and License Clerks	High school diploma or equivalent	Moderate-term on-the-job training
434061	Eligibility Interviewers, Government Programs	High school diploma or equivalent	Moderate-term on-the-job training
434141	New Accounts Clerks	High school diploma or equivalent	Moderate-term on-the-job training
434161	Human Resources Assistants, Except Payroll and Timekeeping	Associate's degree	None
435031	Police, Fire, and Ambulance Dispatchers	High school diploma or equivalent	Moderate-term on-the-job training
435032	Dispatchers, Except Police, Fire, and Ambulance	High school diploma or equivalent	Moderate-term on-the-job training
435061	Production, Planning, and Expediting Clerks	High school diploma or equivalent	Moderate-term on-the-job training
436011	Executive Secretaries and Executive Administrative Assistant	High school diploma or equivalent	None*
436012	Legal Secretaries	High school diploma or equivalent	Moderate-term on-the-job training
436013	Medical Secretaries	High school diploma or equivalent	Moderate-term on-the-job training
439011	Computer Operators	High school diploma or equivalent	Moderate-term on-the-job training
439021	Data Entry Keyers	High school diploma or equivalent	Moderate-term on-the-job training
439031	Desktop Publishers	Associate's degree	Short-term on-the-job training
439041	Insurance Claims and Policy Processing Clerks	High school diploma or equivalent	Moderate-term on-the-job training
454021	Fallers	High school diploma or equivalent	Moderate-term on-the-job training

Appendix I - continued

SOC code	SOC code description-occupation	Education	Training
454022	Logging Equipment Operators	High school diploma or equivalent	Moderate-term on-the-job training
454023	Log Graders and Scalers	High school diploma or equivalent	Moderate-term on-the-job training
471011	First-Line Supervisors of Construction Trades and Extraction	High school diploma or equivalent	None*
472011	Boilermakers	High school diploma or equivalent	Apprenticeship
472021	Brickmasons and Blockmasons	High school diploma or equivalent	Apprenticeship
472031	Carpenters	High school diploma or equivalent	Apprenticeship
472071	Paving, Surfacing, and Tamping Equipment Operators	High school diploma or equivalent	Moderate-term on-the-job training
472073	Operating Engineers and Other Construction Equipment Operators	High school diploma or equivalent	Moderate-term on-the-job training
472111	Electricians	High school diploma or equivalent	Apprenticeship
472121	Glaziers	High school diploma or equivalent	Apprenticeship
472132	Insulation Workers, Mechanical	High school diploma or equivalent	Apprenticeship
472152	Plumbers, Pipefitters, and Steamfitters	High school diploma or equivalent	Apprenticeship
472171	Reinforcing Iron and Rebar Workers	High school diploma or equivalent	Apprenticeship
472211	Sheet Metal Workers	High school diploma or equivalent	Apprenticeship
472221	Structural Iron and Steel Workers	High school diploma or equivalent	Apprenticeship
474011	Construction and Building Inspectors	High school diploma or equivalent	Moderate-term on-the-job training
474031	Fence Erectors	High school diploma or equivalent	Moderate-term on-the-job training
474041	Hazardous Materials Removal Workers	High school diploma or equivalent	Moderate-term on-the-job training
474051	Highway Maintenance Workers	High school diploma or equivalent	Moderate-term on-the-job training
474061	Rail-Track Laying and Maintenance Equipment Operators	High school diploma or equivalent	Moderate-term on-the-job training
474071	Septic Tank Servicers and Sewer Pipe Cleaners	High school diploma or equivalent	Moderate-term on-the-job training
474099	Construction and Related Workers, All Other	High school diploma or equivalent	Moderate-term on-the-job training
475021	Earth Drillers, Except Oil and Gas	High school diploma or equivalent	Moderate-term on-the-job training

Appendix I - continued

SOC code	SOC code description-occupation	Education	Training
475041	Continuous Mining Machine Operators	High school diploma or equivalent	Moderate-term on-the-job training
475042	Mine Cutting and Channeling Machine Operators	High school diploma or equivalent	Moderate-term on-the-job training
475051	Rock Splitters, Quarry	High school diploma or equivalent	Moderate-term on-the-job training
491011	First-Line Supervisors of Mechanics, Installers, and Repairers	High school diploma or equivalent	None*
492011	Computer, Automated Teller, and Office Machine Repairers	Postsecondary non-degree award	None
492021	Radio, Cellular, and Tower Equipment Installers and Repairer	Associate's degree	Moderate-term on-the-job training
492022	Telecommunications Equipment Installers and Repairers, Except Line Installers	Postsecondary non-degree award	Moderate-term on-the-job training
492091	Avionics Technicians	Postsecondary non-degree award	None
492092	Electric Motor, Power Tool, and Related Repairers	Postsecondary non-degree award	Long-term on-the-job training
492093	Electrical and Electronics Installers and Repairers, Transportation	Postsecondary non-degree award	Long-term on-the-job training
492094	Electrical and Electronics Repairers, Commercial and Industry	Postsecondary non-degree award	Long-term on-the-job training
492095	Electrical and Electronics Repairers, Powerhouse, Substation	Postsecondary non-degree award	Long-term on-the-job training
492096	Electronic Equipment Installers and Repairers, Motor Vehicle	Postsecondary non-degree award	Short-term on-the-job training
492097	Electronic Home Entertainment Equipment Installers and Repairers	Postsecondary non-degree award	None
492098	Security and Fire Alarm Systems Installers	High school diploma or equivalent	Moderate-term on-the-job training
493011	Aircraft Mechanics and Service Technicians	Postsecondary non-degree award	None
493021	Automotive Body and Related Repairers	High school diploma or equivalent	Moderate-term on-the-job training
493023	Automotive Service Technicians and Mechanics	High school diploma or equivalent	Long-term on-the-job training
493031	Bus and Truck Mechanics and Diesel Engine Specialists	High school diploma or equivalent	Long-term on-the-job training
493041	Farm Equipment Mechanics and Service Technicians	High school diploma or equivalent	Long-term on-the-job training
493042	Mobile Heavy Equipment Mechanics, Except Engines	High school diploma or equivalent	Long-term on-the-job training

Appendix I - continued

SOC code	SOC code description-occupation	Education	Training
493043	Rail Car Repairers	High school diploma or equivalent	Long-term on-the-job training
493051	Motorboat Mechanics and Service Technicians	High school diploma or equivalent	Long-term on-the-job training
493052	Motorcycle Mechanics	High school diploma or equivalent	Long-term on-the-job training
493053	Outdoor Power Equipment and Other Small Engine Mechanics	High school diploma or equivalent	Moderate-term on-the-job training
493091	Bicycle Repairers	High school diploma or equivalent	Moderate-term on-the-job training
493093	Tire Repairers and Changers	High school diploma or equivalent	Moderate-term on-the-job training
499011	Mechanical Door Repairers	High school diploma or equivalent	Moderate-term on-the-job training
499012	Control and Valve Installers and Repairers, Except Mechanical	High school diploma or equivalent	Moderate-term on-the-job training
499021	Heating, Air Conditioning, and Refrigeration Mechanics	Postsecondary non-degree award	Long-term on-the-job training
499041	Industrial Machinery Mechanics	High school diploma or equivalent	Long-term on-the-job training
499043	Maintenance Workers, Machinery	High school diploma or equivalent	Moderate-term on-the-job training
499044	Millwrights	High school diploma or equivalent	Long-term on-the-job training
499051	Electrical Power-Line Installers and Repairers	High school diploma or equivalent	Long-term on-the-job training
499062	Medical Equipment Repairers	Associate's degree	Moderate-term on-the-job training
499063	Musical Instrument Repairers and Tuners	Postsecondary non-degree award	Long-term on-the-job training
499069	Precision Instrument and Equipment Repairers, All Other	Associate's degree	Long-term on-the-job training
499071	Maintenance and Repair Workers, General	High school diploma or equivalent	Moderate-term on-the-job training
499092	Commercial Divers	Postsecondary non-degree award	Moderate-term on-the-job training
499094	Locksmiths and Safe Repairers	High school diploma or equivalent	Long-term on-the-job training
499096	Riggers	High school diploma or equivalent	Moderate-term on-the-job training
499098	Helpers--Installation, Maintenance, and Repair Workers	High school diploma or equivalent	Moderate-term on-the-job training
499099	Installation, Maintenance, and Repair Workers, All Other	High school diploma or equivalent	Moderate-term on-the-job training
511011	First-Line Supervisors of Production and Operating Workers	Postsecondary non-degree award	None

Appendix I - continued

SOC code	SOC code description-occupation	Education	Training
512031	Engine and Other Machine Assemblers	High school diploma or equivalent	Moderate-term on-the-job training
512041	Structural Metal Fabricators and Fitters	High school diploma or equivalent	Moderate-term on-the-job training
512091	Fiberglass Laminators and Fabricators	High school diploma or equivalent	Moderate-term on-the-job training
512092	Team Assemblers	High school diploma or equivalent	Moderate-term on-the-job training
512099	Assemblers and Fabricators, All Other	High school diploma or equivalent	Moderate-term on-the-job training
513092	Food Batchmakers	High school diploma or equivalent	Moderate-term on-the-job training
514011	Computer-Controlled Machine Tool Operators, Metal and Plastics	High school diploma or equivalent	Moderate-term on-the-job training
514012	Computer Numerically Controlled Machine Tool Programmers, Metal and Plastic	High school diploma or equivalent	Moderate-term on-the-job training
514021	Extruding and Drawing Machine Setters, Operators, and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
514023	Rolling Machine Setters, Operators, and Tenders, Metal and Plastic	High school diploma or equivalent	Moderate-term on-the-job training
514031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
514032	Drilling and Boring Machine Tool Setters, Operators, and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
514033	Grinding, Lapping, Polishing, and Buffing Machine Tool Setters	High school diploma or equivalent	Moderate-term on-the-job training
514034	Lathe and Turning Machine Tool Setters, Operators, and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
514035	Milling and Planning Machine Setters, Operators, and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
514041	Machinists	High school diploma or equivalent	Long-term on-the-job training
514051	Metal-Refining Furnace Operators and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
514072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
514081	Multiple Machine Tool Setters, Operators, and Tenders, Metal	High school diploma or equivalent	Moderate-term on-the-job training
514111	Tool and Die Makers	High school diploma or equivalent	Long-term on-the-job training
514121	Welders, Cutters, Solderers, and Brazers	High school diploma or equivalent	Moderate-term on-the-job training
514122	Welding, Soldering, and Brazing Machine Setters, Operators,	High school diploma or equivalent	Moderate-term on-the-job training

Appendix I - continued

SOC code	SOC code description-occupation	Education	Training
514191	Heat Treating Equipment Setters, Operators, and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
514192	Layout Workers, Metal and Plastic	High school diploma or equivalent	Moderate-term on-the-job training
514193	Plating and Coating Machine Setters, Operators, and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
514194	Tool Grinders, Filers, and Sharpeners	High school diploma or equivalent	Moderate-term on-the-job training
514199	Metal Workers and Plastic Workers, All Other	High school diploma or equivalent	Moderate-term on-the-job training
515111	Prepress Technicians and Workers	Postsecondary non-degree award	None
515112	Printing Press Operators	High school diploma or equivalent	Moderate-term on-the-job training
515113	Print Binding and Finishing Workers	High school diploma or equivalent	Moderate-term on-the-job training
516041	Shoe and Leather Workers and Repairers	High school diploma or equivalent	Moderate-term on-the-job training
516062	Textile Cutting Machine Setters, Operators, and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
516063	Textile Knitting and Weaving Machine Setters, Operators, and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
516064	Textile Winding, Twisting, and Drawing Out Machine Setters	High school diploma or equivalent	Moderate-term on-the-job training
516091	Extruding and Forming Machine Setters, Operators, and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
516093	Upholsterers	High school diploma or equivalent	Moderate-term on-the-job training
517011	Cabinetmakers and Bench Carpenters	High school diploma or equivalent	Moderate-term on-the-job training
517041	Sawing Machine Setters, Operators, and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
517042	Woodworking Machine Setters, Operators, and Tenders, Except Sawing	High school diploma or equivalent	Moderate-term on-the-job training
517099	Woodworkers, All Other	High school diploma or equivalent	Moderate-term on-the-job training
518012	Power Distributors and Dispatchers	High school diploma or equivalent	Long-term on-the-job training
518013	Power Plant Operators	High school diploma or equivalent	Long-term on-the-job training
518021	Stationary Engineers and Boiler Operators	High school diploma or equivalent	Long-term on-the-job training
518031	Water and Wastewater Treatment Plant and System Operators	High school diploma or equivalent	Long-term on-the-job training
518092	Gas Plant Operators	High school diploma or equivalent	Long-term on-the-job training

Appendix I - continued

SOC code	SOC code description-occupation	Education	Training
518099	Plant and System Operators, All Other	High school diploma or equivalent	Long-term on-the-job training
519011	Chemical Equipment Operators and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
519021	Crushing, Grinding, and Polishing Machine Setters, Operators	High school diploma or equivalent	Moderate-term on-the-job training
519023	Mixing and Blending Machine Setters, Operators, and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
519041	Extruding, Forming, Pressing, and Compacting Machine Setters	High school diploma or equivalent	Moderate-term on-the-job training
519051	Furnace, Kiln, Oven, Drier, and Kettle Operators and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
519061	Inspectors, Testers, Sorters, Samplers, and Weighers	High school diploma or equivalent	Moderate-term on-the-job training
519081	Dental Laboratory Technicians	High school diploma or equivalent	Moderate-term on-the-job training
519082	Medical Appliance Technicians	High school diploma or equivalent	Long-term on-the-job training
519083	Ophthalmic Laboratory Technicians	High school diploma or equivalent	Moderate-term on-the-job training
519111	Packaging and Filling Machine Operators and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
519121	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
519122	Painters, Transportation Equipment	High school diploma or equivalent	Moderate-term on-the-job training
519123	Painting, Coating, and Decorating Workers	High school diploma or equivalent	Moderate-term on-the-job training
519191	Adhesive Bonding Machine Operators and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
519192	Cleaning, Washing, and Metal Pickling Equipment Operators and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
519193	Cooling and Freezing Equipment Operators and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
519194	Etchers and Engravers	High school diploma or equivalent	Moderate-term on-the-job training
519195	Molders, Shapers, and Casters, Except Metal and Plastics	High school diploma or equivalent	Long-term on-the-job training
519196	Paper Goods Machine Setters, Operators, and Tenders	High school diploma or equivalent	Moderate-term on-the-job training
519199	Production Workers, All Other	High school diploma or equivalent	Moderate-term on-the-job training
532012	Commercial Pilots	Postsecondary non-degree award	None
532021	Air Traffic Controllers	Associate's degree	Long-term on-the-job training

Appendix I - continued

SOC code	SOC code description-occupation	Education	Training
532031	Flight Attendants	High school diploma or equivalent	Moderate-term on-the-job training
533021	Bus Drivers, Transit and Intercity	High school diploma or equivalent	Moderate-term on-the-job training
533032	Heavy and Tractor-Trailer Truck Drivers	Postsecondary non-degree award	Short-term on-the-job training
534031	Railroad Conductors and Yardmasters	High school diploma or equivalent	Moderate-term on-the-job training
535021	Captains, Mates, and Pilots of Water Vessels	Postsecondary non-degree award	None
535031	Ship Engineers	Postsecondary non-degree award	None
536041	Traffic Technicians	High school diploma or equivalent	Moderate-term on-the-job training
536051	Transportation Inspectors	Some college, no degree	Short-term on-the-job training
537021	Crane and Tower Operators	High school diploma or equivalent	Moderate-term on-the-job training

*****If a MS Occupation has a “high school diploma or equivalent” and “none” in the training category, this occupation had work experience that satisfied the criteria for a MS occupation (High school diploma or equivalent and work experience)

Appendix J

NAICS Codes

NAICS Code	Industry Title
11	Agriculture, Forestry, Fishing and Hunting
21	Mining
22	Utilities
23	Construction
31-33	Manufacturing
42	Wholesale Trade
44-45	Retail Trade
48-49	Transportation and Warehousing
51	Information
52	Finance and Insurance
53	Real Estate Rental and Leasing
54	Professional, Scientific, and Technical Services
55	Management of Companies and Enterprises
56	Administrative and Support and Waste Management and Remediation Services
61	Educational Services
62	Health Care and Social Assistance
71	Arts, Entertainment, and Recreation
72	Accommodation and Food Services
81	Other Services (except Public Administration)
92	Public Administration

NAICS (North American Industry Classification System) is the standard used for classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy (USDOL-BLS, 2019c, NAICS, 2017).

Appendix K

Table K1. 2015 MS Occupations with a Skills Gap (Total of 238 MS Gap Occupations)

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
131111	Management Analysts	57,824	67,199	-9,375	0.86
111021	General and Operations Managers	53,217	58,217	-5,000	0.91
472031	Carpenters	25,309	29,714	-4,405	0.85
351012	First-Line Supervisors of Food Preparation and Serving Workers	26,253	29,632	-3,379	0.89
499071	Maintenance and Repair Workers, General	32,778	36,115	-3,337	0.91
533032	Heavy and Tractor-Trailer Truck Drivers	44,658	47,838	-3,180	0.93
471011	First-Line Supervisors of Construction Trades and Extraction	20,847	24,022	-3,175	0.87
431011	First-Line Supervisors of Office and Administrative Support	40,762	43,862	-3,100	0.93
319092	Medical Assistants	12,603	15,336	-2,733	0.82
292061	Licensed Practical and Licensed Vocational Nurses	21,668	24,269	-2,601	0.89
151151	Computer User Support Specialists	20,913	23,397	-2,484	0.89
472111	Electricians	18,189	20,619	-2,430	0.88
472152	Plumbers, Pipefitters, and Steamfitters	14,322	16,649	-2,327	0.86
419022	Real Estate Sales Agents	15,247	17,543	-2,296	0.87
131199	Business Operations Specialists, All Other	32,202	34,039	-1,837	0.95
413021	Insurance Sales Agents	12,428	14,193	-1,765	0.88
333051	Police and Sheriff's Patrol Officers	18,887	20,601	-1,714	0.92
499021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	11,876	13,581	-1,705	0.87
395012	Hairdressers, Hairstylists, and Cosmetologists	17,704	19,285	-1,581	0.92

Appendix K: Table K1 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
433021	Billing and Posting Clerks	11,496	13,060	-1,564	0.88
272022	Coaches and Scouts	8,789	10,129	-1,340	0.87
119021	Construction Managers	8,454	9,790	-1,336	0.86
433031	Bookkeeping, Accounting, and Auditing Clerks	42,539	43,845	-1,306	0.97
132072	Loan Officers	9,473	10,716	-1,243	0.88
274021	Photographers	2,978	4,184	-1,206	0.71
319091	Dental Assistants	8,258	9,446	-1,188	0.87
472073	Operating Engineers and Other Construction Equipment Operators	11,173	12,354	-1,181	0.90
519111	Packaging and Filling Machine Operators and Tenders	6,554	7,716	-1,162	0.85
491011	First-Line Supervisors of Mechanics, Installers, and Repairers	13,938	15,027	-1,089	0.93
439041	Insurance Claims and Policy Processing Clerks	6,809	7,864	-1,055	0.87
332011	Firefighters	10,193	11,172	-979	0.91
252011	Preschool Teachers, Except Special Education	9,627	10,565	-938	0.91
391021	First-Line Supervisors of Personal Service Workers	7,441	8,354	-913	0.89
436013	Medical Secretaries	5,256	6,113	-857	0.86
433011	Bill and Account Collectors	7,959	8,804	-845	0.90
511011	First-Line Supervisors of Production and Operating Workers	12,638	13,463	-825	0.94
119051	Food Service Managers	6,296	7,113	-817	0.89
411012	First-Line Supervisors of Non-Retail Sales Workers	10,846	11,657	-811	0.93
499041	Industrial Machinery Mechanics	9,175	9,970	-795	0.92
435061	Production, Planning, and Expediting Clerks	8,654	9,424	-770	0.92
371011	First-Line Supervisors of Housekeeping and Janitorial Workers	7,574	8,338	-764	0.91
319011	Massage Therapists	4,068	4,827	-759	0.84
533021	Bus Drivers, Transit and Intercity	4,897	5,637	-740	0.87

Appendix K: Table K1 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
474011	Construction and Building Inspectors	4,947	5,663	-716	0.87
514121	Welders, Cutters, Solderers, and Brazers	7,671	8,386	-715	0.91
292021	Dental Hygienists	4,990	5,701	-711	0.88
312021	Physical Therapist Assistants	2,575	3,284	-709	0.78
493023	Automotive Service Technicians and Mechanics	23,488	24,180	-692	0.97
119141	Property, Real Estate, and Community Association Managers	4,450	5,115	-665	0.87
492098	Security and Fire Alarm Systems Installers	3,015	3,664	-649	0.82
173023	Electrical and Electronics Engineering Technicians	5,831	6,453	-622	0.90
172071	Electrical Engineers	6,443	7,031	-588	0.92
151134	Web Developers	4,506	5,066	-560	0.89
413041	Travel Agents	2,460	3,010	-550	0.82
472211	Sheet Metal Workers	3,956	4,497	-541	0.88
472021	Brickmasons and Blockmasons	3,674	4,211	-537	0.87
411011	First-Line Supervisors of Retail Sales Workers	41,615	42,133	-518	0.99
292056	Veterinary Technologists and Technicians	1,658	2,150	-492	0.77
292071	Medical Records and Health Information Technicians	5,101	5,576	-475	0.91
499098	Helpers--Installation, Maintenance, and Repair Workers	4,199	4,674	-475	0.90
519199	Production Workers, All Other	4,292	4,765	-473	0.90
532031	Flight Attendants	4,086	4,553	-467	0.90
292041	Emergency Medical Technicians and Paramedics	5,173	5,631	-458	0.92
292052	Pharmacy Technicians	9,067	9,516	-449	0.95
113011	Administrative Services Managers	4,199	4,634	-435	0.91
351011	Chefs and Head Cooks	3,316	3,744	-428	0.89
292034	Radiologic Technologists	4,752	5,171	-419	0.92
514041	Machinists	6,463	6,878	-415	0.94

Appendix K: Table K1 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
371012	First-Line Supervisors of Landscaping, Lawn Service, etc.	4,765	5,163	-398	0.92
319097	Phlebotomists	3,721	4,102	-381	0.91
312022	Physical Therapist Aides	1,283	1,652	-369	0.78
132082	Tax Preparers	2,981	3,337	-356	0.89
493031	Bus and Truck Mechanics and Diesel Engine Specialists	7,047	7,399	-352	0.95
499099	Installation, Maintenance, and Repair Workers, All Other	4,427	4,775	-348	0.93
396012	Concierges	1,908	2,255	-347	0.85
519061	Inspectors, Testers, Sorters, Samplers, and Weighers	9,057	9,400	-343	0.96
131031	Claims Adjusters, Examiners, and Investigators	5,261	5,598	-337	0.94
132021	Appraisers and Assessors of Real Estate	1,926	2,261	-335	0.85
173013	Mechanical Drafters	2,002	2,337	-335	0.86
434061	Eligibility Interviewers, Government Programs	3,974	4,309	-335	0.92
435031	Police, Fire, and Ambulance Dispatchers	3,185	3,514	-329	0.91
435032	Dispatchers, Except Police, Fire, and Ambulance	4,744	5,071	-327	0.94
512092	Team Assemblers	16,199	16,525	-326	0.98
395092	Manicurists and Pedicurists	3,410	3,728	-318	0.91
319094	Medical Transcriptionists	1,944	2,258	-314	0.86
399041	Residential Advisors	3,156	3,464	-308	0.91
211011	Substance Abuse and Behavioral Disorder Counselors	2,972	3,269	-297	0.91
173011	Architectural and Civil Drafters	2,082	2,377	-295	0.88
474099	Construction and Related Workers, All Other	1,924	2,214	-290	0.87
493042	Mobile Heavy Equipment Mechanics, Except Engines	3,774	4,064	-290	0.93
173031	Surveying and Mapping Technicians	2,095	2,380	-285	0.88
292012	Medical and Clinical Laboratory Technicians	4,114	4,396	-282	0.94

Appendix K: Table K1 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
312011	Occupational Therapy Assistants	1,043	1,324	-281	0.79
331099	First-Line Supervisors of Protective Service Workers, All Other	2,432	2,707	-275	0.90
291126	Respiratory Therapists	2,498	2,760	-262	0.91
519122	Painters, Transportation Equipment	2,199	2,460	-261	0.89
131023	Purchasing Agents, Except Wholesale, Retail, and Farm Production	13,073	13,332	-259	0.98
173022	Civil Engineering Technicians	2,077	2,336	-259	0.89
292099	Health Technologists and Technicians, All Other	2,087	2,336	-249	0.89
434161	Human Resources Assistants, Except Payroll and Timekeeping	4,439	4,687	-248	0.95
499051	Electrical Power-Line Installers and Repairers	2,972	3,220	-248	0.92
292055	Surgical Technologists	2,450	2,689	-239	0.91
254031	Library Technicians	2,286	2,523	-237	0.91
493011	Aircraft Mechanics and Service Technicians	2,226	2,462	-236	0.90
292081	Opticians, Dispensing	2,280	2,509	-229	0.91
493021	Automotive Body and Related Repairers	4,643	4,870	-227	0.95
173029	Engineering Technicians, Except Drafters, All Other	3,441	3,656	-215	0.94
274011	Audio and Video Equipment Technicians	1,705	1,920	-215	0.89
519081	Dental Laboratory Technicians	983	1,194	-211	0.82
472221	Structural Iron and Steel Workers	1,307	1,515	-208	0.86
474051	Highway Maintenance Workers	4,595	4,799	-204	0.96
492094	Electrical and Electronics Repairers, Commercial and Industry	2,230	2,429	-199	0.92
472071	Paving, Surfacing, and Tamping Equipment Operators	1,709	1,898	-189	0.90
519196	Paper Goods Machine Setters, Operators, and Tenders	2,488	2,676	-188	0.93

Appendix K: Table K1 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
292032	Diagnostic Medical Sonographers	1,638	1,823	-185	0.90
331012	First-Line Supervisors of Police and Detectives	2,710	2,891	-181	0.94
272042	Musicians and Singers	1,245	1,405	-160	0.89
474041	Hazardous Materials Removal Workers	1,360	1,520	-160	0.89
472132	Insulation Workers, Mechanical	1,198	1,355	-157	0.88
232099	Legal Support Workers, All Other	9,432	9,588	-156	0.98
434031	Court, Municipal, and License Clerks	2,193	2,349	-156	0.93
113071	Transportation, Storage, and Distribution Managers	2,105	2,258	-153	0.93
331021	First-Line Supervisors of Fire Fighting and Prevention Workers	1,608	1,760	-152	0.91
499096	Riggers	1,290	1,441	-151	0.90
518031	Water and Wastewater Treatment Plant and System Operators	3,143	3,292	-149	0.95
499043	Maintenance Workers, Machinery	1,557	1,696	-139	0.92
173027	Mechanical Engineering Technicians	1,165	1,297	-132	0.90
333021	Detectives and Criminal Investigators	3,623	3,755	-132	0.96
472121	Glaziers	950	1,082	-132	0.88
392011	Animal Trainers	984	1,104	-120	0.89
395094	Skincare Specialists	1,256	1,375	-119	0.91
272023	Umpires, Referees, and Other Sports Officials	724	842	-118	0.86
514122	Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders	1,776	1,892	-116	0.94
537021	Crane and Tower Operators	933	1,048	-115	0.89
194031	Chemical Technicians	1,254	1,367	-113	0.92
434011	Brokerage Clerks	1,363	1,472	-109	0.93
272011	Actors	783	891	-108	0.88
474031	Fence Erectors	822	925	-103	0.89
492011	Computer, Automated Teller, and Office Machine Repairers	4,120	4,221	-101	0.98

Appendix K: Table K1 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
472171	Reinforcing Iron and Rebar Workers	616	714	-98	0.86
513092	Food Batchmakers	3,355	3,451	-96	0.97
173024	Electro-Mechanical Technicians	618	711	-93	0.87
194099	Life, Physical, and Social Science Technicians, All Other	1,722	1,814	-92	0.95
292031	Cardiovascular Technologists and Technicians	1,631	1,723	-92	0.95
499044	Millwrights	727	819	-92	0.89
493053	Outdoor Power Equipment and Other Small Engine Mechanics	1,103	1,194	-91	0.92
499012	Control and Valve Installers and Repairers, Except Mechanical	1,096	1,186	-90	0.92
194091	Environmental Science and Protection Technicians, Including Health	699	788	-89	0.89
514031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders	2,197	2,281	-84	0.96
519083	Ophthalmic Laboratory Technicians	645	727	-82	0.89
474071	Septic Tank Servicers and Sewer Pipe Cleaners	787	867	-80	0.91
271013	Fine Artists, Including Painters, Sculptors, and Illustrators	643	718	-75	0.90
299099	Healthcare Practitioners and Technical Workers, All Other	968	1,042	-74	0.93
173026	Industrial Engineering Technicians	886	959	-73	0.92
519191	Adhesive Bonding Machine Operators and Tenders	1,309	1,379	-70	0.95
292053	Psychiatric Technicians	3,642	3,710	-68	0.98
173012	Electrical and Electronics Drafters	495	562	-67	0.88
131032	Insurance Appraisers, Auto Damage	546	612	-66	0.89
433051	Payroll and Timekeeping Clerks	3,438	3,503	-65	0.98
173025	Environmental Engineering Technicians	413	477	-64	0.87

Appendix K: Table K1 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
299012	Occupational Health and Safety Technicians	418	481	-63	0.87
514011	Computer-Controlled Machine Tool Operators, Metal and Plastics	1,421	1,484	-63	0.96
499094	Locksmiths and Safe Repairers	885	947	-62	0.93
517042	Woodworking Machine Setters, Operators, and Tenders, Except Sawing	1,937	1,999	-62	0.97
519121	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	1,363	1,423	-60	0.96
319093	Medical Equipment Preparers	928	986	-58	0.94
232093	Title Examiners, Abstractors, and Searchers	1,182	1,238	-56	0.95
499011	Mechanical Door Repairers	470	526	-56	0.89
536041	Traffic Technicians	398	453	-55	0.88
519021	Crushing, Grinding, and Polishing Machine Setters, Operators	672	725	-53	0.93
292033	Nuclear Medicine Technologists	762	814	-52	0.94
292051	Dietetic Technicians	695	747	-52	0.93
532012	Commercial Pilots	591	642	-51	0.92
492095	Electrical and Electronics Repairers, Powerhouse, Substation	841	891	-50	0.94
535021	Captains, Mates, and Pilots of Water Vessels	2,328	2,377	-49	0.98
514081	Multiple Machine Tool Setters, Operators, and Tenders	1,318	1,366	-48	0.96
194051	Nuclear Technicians	366	413	-47	0.89
517041	Sawing Machine Setters, Operators, and Tenders	2,405	2,452	-47	0.98
173019	Drafters, All Other	325	371	-46	0.88
493051	Motorboat Mechanics and Service Technicians	484	530	-46	0.91
514192	Layout Workers, Metal and Plastic	557	602	-45	0.93
434141	New Accounts Clerks	985	1,029	-44	0.96

Appendix K: Table K1 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
519023	Mixing and Blending Machine Setters, Operators, and Tenders	1,929	1,972	-43	0.98
119061	Funeral Service Managers	533	574	-41	0.93
339011	Animal Control Workers	376	417	-41	0.90
272021	Athletes and Sports Competitors	203	241	-38	0.84
518021	Stationary Engineers and Boiler Operators	751	789	-38	0.95
339093	Transportation Security Screeners	1,837	1,873	-36	0.98
514033	Grinding, Lapping, Polishing, and Buffing Machine Tool Setter	791	826	-35	0.96
333011	Bailiffs	514	548	-34	0.94
472011	Boilermakers	425	459	-34	0.93
475041	Continuous Mining Machine Operators	771	804	-33	0.96
292035	Magnetic Resonance Imaging Technologists	871	902	-31	0.97
394031	Morticians, Undertakers, and Funeral Directors	661	692	-31	0.96
475021	Earth Drillers, Except Oil and Gas	322	353	-31	0.91
512099	Assemblers and Fabricators, All Other	3,823	3,853	-30	0.99
514012	Computer Numerically Controlled Machine Tool Programmers, Metal and Plastic	257	287	-30	0.90
519195	Molders, Shapers, and Casters, Except Metal and Plastic	1,030	1,060	-30	0.97
292092	Hearing Aid Specialists	195	221	-26	0.88
433061	Procurement Clerks	1,984	2,009	-25	0.99
519193	Cooling and Freezing Equipment Operators and Tenders	133	155	-22	0.86
535031	Ship Engineers	1,617	1,639	-22	0.99
274012	Broadcast Technicians	697	718	-21	0.97
532021	Air Traffic Controllers	1,148	1,169	-21	0.98
291124	Radiation Therapists	433	453	-20	0.96
499092	Commercial Divers	202	222	-20	0.91

Appendix K: Table K1 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
492093	Electrical and Electronics Installers and Repairers, Transportation	674	693	-19	0.97
492097	Electronic Home Entertainment Equipment Installers and Repairers	436	454	-18	0.96
514199	Metal Workers and Plastic Workers, All Other	280	298	-18	0.94
517099	Woodworkers, All Other	289	307	-18	0.94
518013	Power Plant Operators	572	590	-18	0.97
499069	Precision Instrument and Equipment Repairers, All Other	328	345	-17	0.95
492091	Avionics Technicians	178	194	-16	0.92
499062	Medical Equipment Repairers	1,028	1,044	-16	0.98
514051	Metal-Refining Furnace Operators and Tenders	194	210	-16	0.92
514193	Plating and Coating Machine Setters, Operators, and Tenders,	497	513	-16	0.97
519123	Painting, Coating, and Decorating Workers	221	235	-14	0.94
194061	Social Science Research Assistants	906	919	-13	0.99
516091	Extruding and Forming Machine Setters, Operators, and Tenders	761	773	-12	0.98
194093	Forest and Conservation Technicians	287	298	-11	0.96
518092	Gas Plant Operators	357	368	-11	0.97
519011	Chemical Equipment Operators and Tenders	1,259	1,269	-10	0.99
519194	Etchers and Engravers	273	283	-10	0.96
173021	Aerospace Engineering and Operations Technicians	154	163	-9	0.94
519192	Cleaning, Washing, and Metal Pickling Equipment Operators and Tenders	288	296	-8	0.97
274099	Media and Communication Equipment Workers, All Other	669	676	-7	0.99
519082	Medical Appliance Technicians	317	324	-7	0.98
394011	Embalmers	181	187	-6	0.97

Appendix K: Table K1 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
475042	Mine Cutting and Channeling Machine Operators	720	726	-6	0.99
492021	Radio, Cellular, and Tower Equipment Installers and Repairers	544	550	-6	0.99
512091	Fiberglass Laminators and Fabricators	116	121	-5	0.96
519051	Furnace, Kiln, Oven, Drier, and Kettle Operators and Tenders	737	741	-4	0.99
271019	Artists and Related Workers, All Other	306	308	-2	0.99
439031	Desktop Publishers	185	186	-1	0.99
475051	Rock Splitters, Quarry	238	239	-1	1.00
514191	Heat Treating Equipment Setters, Operators, and Tenders	125	126	-1	0.99
518012	Power Distributors and Dispatchers	467	468	-1	1.00
518099	Plant and System Operators, All Other	124	125	-1	0.99

Appendix K

Table K2. 2018 MS Occupations with a Skills Gap (Total of 216 MS Gap Occupations)

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
131111	Management Analysts	60,790	68,510	-7,720	0.89
111021	General and Operations Managers	54,957	59,316	-4,359	0.93
319092	Medical Assistants	13,741	16,955	-3,214	0.81
292061	Licensed Practical and Licensed Vocational Nurses	22,728	25,462	-2,734	0.89
131199	Business Operations Specialists, All Other	33,216	35,751	-2,535	0.93
533032	Heavy and Tractor-Trailer Truck Drivers	45,676	48,164	-2,488	0.95
351012	First-Line Supervisors of Food Preparation and Serving Worker	27,182	29,528	-2,346	0.92
499071	Maintenance and Repair Workers, General	33,702	35,994	-2,292	0.94
151151	Computer User Support Specialists	21,714	23,585	-1,871	0.92
431011	First-Line Supervisors of Office and Administrative Support	41,508	43,318	-1,810	0.96
411011	First-Line Supervisors of Retail Sales Workers	42,277	43,892	-1,615	0.96
319091	Dental Assistants	8,810	10,297	-1,487	0.86
433021	Billing and Posting Clerks	12,044	13,460	-1,416	0.89
395012	Hairdressers, Hairstylists, and Cosmetologists	18,256	19,629	-1,373	0.93
333051	Police and Sheriff's Patrol Officers	19,397	20,656	-1,259	0.94
471011	First-Line Supervisors of Construction Trades and Extraction	21,347	22,578	-1,231	0.95

Appendix K: Table K2 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
272022	Coaches and Scouts	9,229	10,367	-1,138	0.89
472152	Plumbers, Pipefitters, and Steamfitters	14,743	15,787	-1,044	0.93
414012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	31,534	32,560	-1,026	0.97
472031	Carpenters	25,727	26,734	-1,007	0.96
436013	Medical Secretaries	5,620	6,604	-984	0.85
499021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	12,268	13,245	-977	0.93
132072	Loan Officers	9,854	10,825	-971	0.91
493023	Automotive Service Technicians and Mechanics	23,890	24,857	-967	0.96
292052	Pharmacy Technicians	9,421	10,320	-899	0.91
413021	Insurance Sales Agents	12,782	13,664	-882	0.94
292021	Dental Hygienists	5,362	6,230	-868	0.86
319097	Phlebotomists	4,030	4,892	-862	0.82
391021	First-Line Supervisors of Personal Service Workers	7,798	8,627	-829	0.90
491011	First-Line Supervisors of Mechanics, Installers, and Repairers	14,268	15,083	-815	0.95
472111	Electricians	18,495	19,230	-735	0.96
319011	Massage Therapists	4,341	5,075	-734	0.86
292041	Emergency Medical Technicians and Paramedics	5,485	6,210	-725	0.88
332011	Firefighters	10,474	11,166	-692	0.94
312021	Physical Therapist Assistants	2,814	3,495	-681	0.81
472073	Operating Engineers and Other Construction Equipment Operator	11,445	12,113	-668	0.94
371011	First-Line Supervisors of Housekeeping and Janitorial Worker	7,831	8,478	-647	0.92

Appendix K: Table K2 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
232099	Legal Support Workers, All Other	9,689	10,327	-638	0.94
211011	Substance Abuse and Behavioral Disorder Counselors	3,236	3,848	-612	0.84
533021	Bus Drivers, Transit and Intercity	5,152	5,751	-599	0.90
411012	First-Line Supervisors of Non-Retail Sales Workers	11,087	11,672	-585	0.95
439041	Insurance Claims and Policy Processing Clerks	7,038	7,612	-574	0.92
419022	Real Estate Sales Agents	15,485	16,052	-567	0.96
252011	Preschool Teachers, Except Special Education	9,852	10,409	-557	0.95
493031	Bus and Truck Mechanics and Diesel Engine Specialists	7,269	7,823	-554	0.93
172071	Electrical Engineers	6,663	7,215	-552	0.92
292071	Medical Records and Health Information Technicians	5,326	5,854	-528	0.91
119051	Food Service Managers	6,506	7,030	-524	0.93
435061	Production, Planning, and Expediting Clerks	8,864	9,385	-521	0.94
151134	Web Developers	4,728	5,242	-514	0.90
292012	Medical and Clinical Laboratory Technicians	4,327	4,824	-497	0.90
292034	Radiologic Technologists	4,943	5,428	-485	0.91
532031	Flight Attendants	4,269	4,736	-467	0.90
499041	Industrial Machinery Mechanics	9,359	9,808	-449	0.95
474011	Construction and Building Inspectors	5,122	5,562	-440	0.92
119021	Construction Managers	8,634	9,070	-436	0.95
399041	Residential Advisors	3,323	3,759	-436	0.88
371012	First-Line Supervisors of Landscaping, Lawn Service, and Grounds Keeping Workers	4,931	5,350	-419	0.92

Appendix K: Table K2 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
173023	Electrical and Electronics Engineering Technicians	5,990	6,384	-394	0.94
291126	Respiratory Therapists	2,643	3,024	-381	0.87
492098	Security and Fire Alarm Systems Installers	3,161	3,536	-375	0.89
132082	Tax Preparers	3,124	3,493	-369	0.89
292056	Veterinary Technologists and Technicians	1,790	2,156	-366	0.83
113011	Administrative Services Managers	4,349	4,703	-354	0.92
493021	Automotive Body and Related Repairers	4,784	5,133	-349	0.93
499098	Helpers--Installation, Maintenance, and Repair Workers	4,333	4,665	-332	0.93
514121	Welders, Cutters, Solderers, and Brazers	7,807	8,137	-330	0.96
351011	Chefs and Head Cooks	3,443	3,766	-323	0.91
119141	Property, Real Estate, and Community Association Managers	4,578	4,897	-319	0.93
499099	Installation, Maintenance, and Repair Workers, All Other	4,554	4,871	-317	0.93
312022	Physical Therapist Aides	1,396	1,712	-316	0.82
274021	Photographers	3,104	3,398	-294	0.91
292032	Diagnostic Medical Sonographers	1,744	2,026	-282	0.86
434061	Eligibility Interviewers, Government Programs	4,084	4,355	-271	0.94
396012	Concierges	2,012	2,282	-270	0.88
395092	Manicurists and Pedicurists	3,517	3,784	-267	0.93
292081	Opticians, Dispensing	2,382	2,644	-262	0.90
312011	Occupational Therapy Assistants	1,136	1,398	-262	0.81

Appendix K: Table K2 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
292099	Health Technologists and Technicians, All Other	2,187	2,445	-258	0.89
435031	Police, Fire, and Ambulance Dispatchers	3,284	3,532	-248	0.93
499051	Electrical Power-Line Installers and Repairers	3,071	3,318	-247	0.93
292055	Surgical Technologists	2,546	2,788	-242	0.91
173029	Engineering Technicians, Except Drafters, All Other	3,534	3,763	-229	0.94
132021	Appraisers and Assessors of Real Estate	2,019	2,240	-221	0.90
433031	Bookkeeping, Accounting, and Auditing Clerks	42,641	42,861	-220	0.99
519081	Dental Laboratory Technicians	1,058	1,262	-204	0.84
493042	Mobile Heavy Equipment Mechanics, Except Engines	3,857	4,059	-202	0.95
333021	Detectives and Criminal Investigators	3,697	3,878	-181	0.95
254031	Library Technicians	2,358	2,538	-180	0.93
392011	Animal Trainers	1,050	1,228	-178	0.86
474051	Highway Maintenance Workers	4,665	4,834	-169	0.97
331012	First-Line Supervisors of Police and Detectives	2,777	2,941	-164	0.94
519199	Production Workers, All Other	4,359	4,519	-160	0.96
274011	Audio and Video Equipment Technicians	1,768	1,927	-159	0.92
472211	Sheet Metal Workers	4,020	4,175	-155	0.96
113071	Transportation, Storage, and Distribution Managers	2,166	2,319	-153	0.93
319094	Medical Transcriptionists	2,005	2,155	-150	0.93
472021	Brickmasons and Blockmasons	3,737	3,887	-150	0.96

Appendix K: Table K2 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
331099	First-Line Supervisors of Protective Service Workers, All Other	2,493	2,642	-149	0.94
173031	Surveying and Mapping Technicians	2,152	2,292	-140	0.94
493011	Aircraft Mechanics and Service Technicians	2,281	2,419	-138	0.94
535021	Captains, Mates, and Pilots of Water Vessels	2,385	2,523	-138	0.95
173022	Civil Engineering Technicians	2,131	2,266	-135	0.94
339093	Transportation Security Screeners	1,891	2,026	-135	0.93
194099	Life, Physical, and Social Science Technicians, All Other	1,775	1,908	-133	0.93
492094	Electrical and Electronics Repairers, Commercial and Industrial Equipment	2,284	2,417	-133	0.94
434011	Brokerage Clerks	1,412	1,535	-123	0.92
514041	Machinists	6,513	6,631	-118	0.98
292031	Cardiovascular Technologists and Technicians	1,677	1,792	-115	0.94
331021	First-Line Supervisors of Fire Fighting and Prevention Workers	1,653	1,766	-113	0.94
434031	Court, Municipal, and License Clerks	2,239	2,352	-113	0.95
519122	Painters, Transportation Equipment	2,247	2,356	-109	0.95
435032	Dispatchers, Except Police, Fire, and Ambulance	4,790	4,896	-106	0.98
535031	Ship Engineers	1,660	1,766	-106	0.94
395094	Skincare Specialists	1,298	1,403	-105	0.93
173011	Architectural and Civil Drafters	2,124	2,227	-103	0.95
474041	Hazardous Materials Removal Workers	1,401	1,503	-102	0.93
413011	Advertising Sales Agents	2,534	2,635	-101	0.96

Appendix K: Table K2 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
472071	Paving, Surfacing, and Tamping Equipment Operators	1,750	1,849	-99	0.95
272042	Musicians and Singers	1,287	1,381	-94	0.93
292053	Psychiatric Technicians	3,679	3,768	-89	0.98
299099	Healthcare Practitioners and Technical Workers, All Other	1,002	1,086	-84	0.92
532021	Air Traffic Controllers	1,182	1,266	-84	0.93
474071	Septic Tank Servicers and Sewer Pipe Cleaners	819	900	-81	0.91
519083	Ophthalmic Laboratory Technicians	675	753	-78	0.90
493053	Outdoor Power Equipment and Other Small Engine Mechanics	1,133	1,209	-76	0.94
472221	Structural Iron and Steel Workers	1,338	1,412	-74	0.95
493041	Farm Equipment Mechanics and Service Technicians	996	1,069	-73	0.93
292035	Magnetic Resonance Imaging Technologists	900	972	-72	0.93
519111	Packaging and Filling Machine Operators and Tenders	6,583	6,654	-71	0.99
173013	Mechanical Drafters	2,030	2,097	-67	0.97
272023	Umpires, Referees, and Other Sports Officials	751	818	-67	0.92
292033	Nuclear Medicine Technologists	788	853	-65	0.92
493091	Bicycle Repairers	455	517	-62	0.88
319093	Medical Equipment Preparers	952	1,013	-61	0.94
434161	Human Resources Assistants, Except Payroll and Timekeeping	4,463	4,518	-55	0.99
499043	Maintenance Workers, Machinery	1,580	1,635	-55	0.97
513092	Food Batchmakers	3,377	3,431	-54	0.98

Appendix K: Table K2 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
272011	Actors	807	860	-53	0.94
292051	Dietetic Technicians	716	769	-53	0.93
499012	Control and Valve Installers and Repairers, Except Mechanical	1,118	1,171	-53	0.95
454022	Logging Equipment Operators	2,007	2,059	-52	0.97
517042	Woodworking Machine Setters, Operators, and Tenders, Except Sawing	1,959	2,009	-50	0.98
472121	Glaziers	969	1,015	-46	0.95
517011	Cabinetmakers and Bench Carpenters	3,310	3,356	-46	0.99
517041	Sawing Machine Setters, Operators, and Tenders, Wood	2,424	2,469	-45	0.98
194091	Environmental Science and Protection Technicians, Including	717	761	-44	0.94
292092	Hearing Aid Specialists	211	255	-44	0.83
474099	Construction and Related Workers, All Other	1,942	1,981	-39	0.98
299012	Occupational Health and Safety Technicians	436	474	-38	0.92
373012	Pesticide Handlers, Sprayers, and Applicators, Vegetation	856	894	-38	0.96
173025	Environmental Engineering Technicians	428	465	-37	0.92
499062	Medical Equipment Repairers	1,043	1,080	-37	0.97
474031	Fence Erectors	837	873	-36	0.96
537021	Crane and Tower Operators	948	984	-36	0.96
194061	Social Science Research Assistants	921	956	-35	0.96
472171	Reinforcing Iron and Rebar Workers	630	663	-33	0.95

Appendix K: Table K2 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
536051	Transportation Inspectors	706	739	-33	0.96
475021	Earth Drillers, Except Oil and Gas	334	366	-32	0.91
499044	Millwrights	741	773	-32	0.96
519082	Medical Appliance Technicians	329	361	-32	0.91
274099	Media and Communication Equipment Workers, All Other	681	712	-31	0.96
536041	Traffic Technicians	411	442	-31	0.93
433011	Bill and Account Collectors	7,973	8,003	-30	1.00
194031	Chemical Technicians	1,266	1,295	-29	0.98
493093	Tire Repairers and Changers	1,966	1,995	-29	0.99
173012	Electrical and Electronics Drafters	507	535	-28	0.95
492011	Computer, Automated Teller, and Office Machine Repairers	4,132	4,160	-28	0.99
492021	Radio, Cellular, and Tower Equipment Installers and Repairer	556	584	-28	0.95
499096	Riggers	1,302	1,330	-28	0.98
514012	Computer Numerically Controlled Machine Tool Programmers, Metal and Plastic	269	297	-28	0.91
532012	Commercial Pilots	603	631	-28	0.96
472132	Insulation Workers, Mechanical	1,210	1,237	-27	0.98
291124	Radiation Therapists	444	470	-26	0.94
339011	Animal Control Workers	387	413	-26	0.94
474061	Rail-Track Laying and Maintenance Equipment Operators	395	421	-26	0.94
492093	Electrical and Electronics Installers and Repairers, Transportation	684	707	-23	0.97
499011	Mechanical Door Repairers	479	502	-23	0.95

Appendix K: Table K2 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
514011	Computer-Controlled Machine Tool Operators, Metal and Plastics	1,430	1,453	-23	0.98
517099	Woodworkers, All Other	298	320	-22	0.93
173019	Drafters, All Other	334	355	-21	0.94
492092	Electric Motor, Power Tool, and Related Repairers	547	567	-20	0.96
173024	Electro-Mechanical Technicians	626	645	-19	0.97
194093	Forest and Conservation Technicians	293	312	-19	0.94
519194	Etchers and Engravers	280	299	-19	0.94
173027	Mechanical Engineering Technicians	1,173	1,191	-18	0.98
271013	Fine Artists, Including Painters, Sculptors, and Illustrators	651	669	-18	0.97
271019	Artists and Related Workers, All Other	314	332	-18	0.95
472011	Boilermakers	432	450	-18	0.96
119061	Funeral Service Managers	539	556	-17	0.97
131032	Insurance Appraisers, Auto Damage	552	569	-17	0.97
492095	Electrical and Electronics Repairers, Powerhouse, Substation	848	864	-16	0.98
492091	Avionics Technicians	183	197	-14	0.93
518021	Stationary Engineers and Boiler Operators	757	771	-14	0.98
493051	Motorboat Mechanics and Service Technicians	489	501	-12	0.98
232093	Title Examiners, Abstractors, and Searchers	1,186	1,196	-10	0.99
433051	Payroll and Timekeeping Clerks	3,442	3,452	-10	1.00

Appendix K: Table K2 - continued

S0C code	MS occupation description	Supply	Demand	MS gap amount	Supply/Demand ratio
173021	Aerospace Engineering and Operations Technicians	158	167	-9	0.95
272021	Athletes and Sports Competitors	209	218	-9	0.96
518099	Plant and System Operators, All Other	127	136	-9	0.93
194011	Agricultural and Food Science Technicians	487	495	-8	0.98
394031	Morticians, Undertakers, and Funeral Directors	665	673	-8	0.99
516093	Upholsterers	1,130	1,138	-8	0.99
499069	Precision Instrument and Equipment Repairers, All Other	331	338	-7	0.98
514192	Layout Workers, Metal and Plastic	560	567	-7	0.99
518092	Gas Plant Operators	360	367	-7	0.98
511011	First-Line Supervisors of Production and Operating Workers	12,638	12,644	-6	1.00
333011	Bailiffs	516	521	-5	0.99
499092	Commercial Divers	204	209	-5	0.98
519123	Painting, Coating, and Decorating Workers	223	228	-5	0.98
492097	Electronic Home Entertainment Equipment Installers and Repairer	438	442	-4	0.99
519192	Cleaning, Washing, and Metal Pickling Equipment Operators and Tenders	289	293	-4	0.99
518013	Power Plant Operators	574	577	-3	0.99
519121	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	1,366	1,369	-3	1.00
493043	Rail Car Repairers	353	355	-2	0.99
519193	Cooling and Freezing Equipment Operators and Tenders	133	134	-1	0.99

Appendix L

Hypotheses and Statistical Test for the Binary Logistic Regression Models for 2015 and 2018

Hypothesis
• Hypothesis 2: RA positions located in an urban area decreases the likelihood a RA position filling a MS Gap Occupation • Hypothesis 3: RA positions located in areas with higher levels of unemployment decreases the likelihood of a RA position filling a middle-skills gap occupation.
Binary Logistic Equation for 2015 and 2018
2018 Regression Model: $Z_i = ln\ (P(2018RAPMSGO) / 1 - P(2018RAPMSGO)) = b_0 + b_1 UrbanLocation + b_2 UnemploymentRate + b_3 Businesses$ **2015 Regression Model:** $Z_i = ln\ (P(2015RAPMSGO) / 1 - P(2015RAPMSGO)) = b_0 + b_1 UrbanLocation + b_2 UnemploymentRate + b_3 Businesses$
Variables
2018RAPMSGO=RA positions filling MS gap occupations in 2018 2015RAPMSGO =RA positions filling MS Gap occupations in 2015 • Y=2018 RAPMSGO (1=yes, 0=no) • Y=2015 RAPMSGO (1=yes, 0=no) • X_1=Urban Location (Binary Categorical Variable, 1=yes, 0=no) • X_2=Unemployment Rate (Ratio) • X_3=No. of Businesses (Interval and Control Variable)

Appendix M

Table M1. Number of MS Gap Occupations by SOC Code Major Group

SOC Code Major Group	2015 MS gap	%	2018 MS gap	%
11-0000 Management Occupations	7	2.9	7	3.2
13-0000 Business and Financial Operations Occupations	8	3.4	6	2.8
15-0000 Computer and Mathematical Occupations	2	0.8	2	0.9
17-0000 Architecture and Engineering Occupations	14	5.9	13	6.0
19-0000 Life, Physical, and Social Science Occupations	6	2.5	6	2.8
21-0000 Community and Social Service Occupations	1	0.4	1	0.5
23-0000 Legal Occupations	2	0.8	2	0.9
25-0000 Educational Instruction and Library Occupations	2	0.8	2	0.9
27-0000 Arts, Design, Entertainment, Sports, and Media Occupations	11	4.6	10	4.6
29-0000 Healthcare Practitioners and Technical Occupations	22	9.2	22	10.2
31-0000 Healthcare Support Occupations	9	3.8	9	4.2
33-0000 Protective Service Occupations	9	3.8	9	4.2
35-0000 Food Preparation and Serving Related Occupations	2	0.8	2	0.9
37-0000 Building and Grounds Cleaning and Maintenance Occupations	2	0.8	3	1.4
39-0000 Personal Care and Service Occupations	9	3.8	8	3.7
41-0000 Sales and Related Occupations	5	2.1	6	2.8
43-0000 Office and Administrative Support Occupations	17	7.1	14	6.5
45-0000 Farming, Fishing, and Forestry Occupations	0	0.0	1	0.5
47-0000 Construction and Extraction Occupations	23	9.7	21	9.7
49-0000 Installation, Maintenance, and Repair Occupations	31	13.0	35	16.2
51-0000 Production Occupations	47	19.7	27	12.5
53-0000 Transportation and Material Moving Occupations	9	3.8	10	4.6
Total	**238**	**100.0**	**216**	**100.0**

Appendix M

Table M2. Registered Apprenticeship (RA) Positions by Gender and Ethnicity in 2015 & 2018

	2015					2018			
Ethnicity	**Female**	**%**	**Male**	**%**		**Female**	**%**	**Male**	**%**
White	1,407	9.2	7,658	50.3		1,479	9.3	8,563	53.8
Black	916	6.0	2,576	16.9		785	4.9	2,430	15.3
Hispanic	333	2.2	1,004	6.6		307	1.9	1,023	6.4
Asian	137	0.9	274	1.8		139	0.9	279	1.8
Native American	44	0.3	103	0.7		13	0.1	63	0.4
Other	220	1.4	557	3.7		234	1.5	614	3.9
Total	**3,057**	**20.1**	**12,172**	**79.9**		**2,957**	**18.6**	**12,972**	**81.4**

Appendix M

Table M3. Number of RA Positions by RA Sponsor—Top 3 RA Sponsors in 2015 and 2018

RA Sponsor Name	No. of RA Positions	% of Total RA Positions	NAICS Code	NAICS Code Industry
2015				
U.S. Military Apprenticeship	6,487	42.6	92	Public Administration
Norfolk Naval Shipyard	859	5.6	31-33	Manufacturing
Newport News Shipbuilding	607	4.0	31-33	Manufacturing
2018				
U.S. Military Apprenticeship	3,707	23.3	92	Public Administration
Norfolk Naval Shipyard	1,003	6.3	31	Manufacturing
Newport News Shipbuilding	983	6.2	31	Manufacturing

Appendix M

Table M4. Number of RA Positions by Industry

	2015		2018	
Industry	**Frequency***	**%**	**Frequency***	**%**
Public Administration	**7,571**	**49.7**	**4,729**	**29.7**
Construction	**3,757**	**24.7**	**5,500**	**34.5**
Manufacturing	**2,151**	**14.1**	**3,230**	**20.3**
Other Services except Public Admin.	808	5.3	1,175	7.4
Educational Services	269	1.8	273	1.7
Retail Trade	190	1.2	272	1.7
Information	187	1.2	0	0.0
Utilities	162	1.1	298	1.9
Healthcare and Social Assistance	64	0.4	149	0.9
Administrative/Support/Waste Mgmt. and Remediation Services	22	0.1	27	0.2
Wholesale Trade	12	0.1	158	1.0
Professional, Scientific, and Technical Services	10	0.1	54	0.3
Accommodation/Food Services	9	0.1	21	0.1
Transportation and Warehousing	7	0.0	20	0.1
Arts, Entertainment, and Recreation	4	0.0	5	0.0
Agriculture, Forestry, Fishing and Hunting	2	0.0	1	0.0
Mining	2	0.0	10	0.1
Finance and Insurance	2	0.0	1	0.0
Real Estate Rental and Leasing	0	0.0	6	0.0
Total	**15,229**	**100.0**	**15,929**	**100.0**

*Frequency = Number of RA positions

Appendix M

Table M5. Number of RA Positions by SOC Code Major Group

RA Positions in 2015			RA Positions in 2018		
SOC Code Major Groups	**Frequency***	**Percent**	**SOC Code Major Groups**	**Frequency***	**Percent**
47-0000 Construction and Extraction Occupations	**4,830**	**31.7**	**47-0000 Construction and Extraction Occupations**	**6,646**	**41.7**
49-0000 Installation, Maintenance, and Repair Occupations	**3,567**	**23.4**	**49-0000 Installation, Maintenance, and Repair Occupations**	**3,592**	**22.6**
51-0000 Production Occupations	**1,371**	**9.0**	**51-0000 Production Occupations**	**1,794**	**11.3**
43-0000 Office and Administrative Support Occupations	1,350	8.9	39-0000 Personal Care and Service Occupations	1,267	8.0
39-0000 Personal Care and Service Occupations	850	5.6	17-0000 Architecture and Engineering Occupations	932	5.9
17-0000 Architecture and Engineering Occupations	679	4.5	29-0000 Healthcare Practitioners and Technical Occupations	389	2.4
11-0000 Management Occupations	415	2.7	35-0000 Food Preparation and Serving Related Occupations	204	1.3
33-0000 Protective Service Occupations	361	2.4	15-0000 Computer and Mathematical Occupations	185	1.2
29-0000 Healthcare Practitioners and Technical Occupations	302	2.0	11-0000 Management Occupations	183	1.1
35-0000 Food Preparation and Serving Related Occupations	290	1.9	43-0000 Office and Administrative Support Occupations	135	0.8
15-0000 Computer and Mathematical Occupations	245	1.6	41-0000 Sales and Related Occupations	121	0.8
41-0000 Sales and Related Occupations	192	1.3	27-0000 Arts, Design, Entertainment, Sports, and Media Occupations	109	0.7
53-0000 Transportation and Material Moving Occupations	179	1.2	25-0000 Educational Instruction and Library Occupations	89	0.6
27-0000 Arts, Design, Entertainment, Sports, and Media Occupations	141	0.9	33-0000 Protective Service Occupations	55	0.3

Appendix M: Table M5 - continued

RA Positions in 2015			RA Positions in 2018		
SOC Code Major Groups	**Frequency***	**Percent**	**SOC Code Major Groups**	**Frequency***	**Percent**
21-0000 Community and Social Service Occupations	81	0.5	13-0000 Business and Financial Operations Occupations	53	0.3
13-0000 Business and Financial Operations Occupations	79	0.5	53-0000 Transportation and Material Moving Occupations	43	0.3
37-0000 Building and Grounds Cleaning and Maintenance Occupations	79	0.5	19-0000 Life, Physical, and Social Science Occupations	42	0.3
19-0000 Life, Physical, and Social Science Occupations	76	0.5	37-0000 Building and Grounds Cleaning and Maintenance Occupations	40	0.3
31-0000 Healthcare Support Occupations	72	0.5	21-0000 Community and Social Service Occupations	32	0.2
25-0000 Educational Instruction and Library Occupations	58	0.4	31-0000 Healthcare Support Occupations	11	0.1
23-0000 Legal Occupations	11	0.1	23-0000 Legal Occupations	6	0.0
45-0000 Farming, Fishing, and Forestry Occupations	1	0.0	45-0000 Farming, Fishing, and Forestry Occupations	1	0.0
Total	**15,229**	**100.0**	**Total**	**15,929**	**100.0**

* Frequency= Number of RA positions**.**

Appendix M

Table M6. The 10 Occupations with the Most RA Positions in 2015 and 2018

Rank	SOC code	SOC code description	*F**	%**	RAPMSGO***
		2015			
1.	472111	Electricians	2,682	17.6	Yes
2.	472152	Plumbers, Pipefitters, & Steamfitters	1,440	9.5	Yes
3.	499041	Industrial Machinery Mechanics	957	6.3	Yes
4.	439011	Computer Operators	955	6.3	No
5.	395012	Hairdressers, Hairstylists, & Cosmetologists	737	4.8	Yes
6.	499021	Heating, Air Conditioning, & Refrigeration Mechanics	627	4.1	Yes
7.	173023	Electrical & Electronics Engineering Technicians	557	3.7	Yes
8.	514041	Machinists	470	3.1	Yes
9.	492011	Computer, Automated Teller, & Office Machine Repairers	395	2.6	Yes
10.	113011	Administrative Services Managers	336	2.2	Yes
		2018			
1.	472111	Electricians	3,564	22.4	Yes
2.	472152	Plumbers, Pipefitters, & Steamfitters	2,119	13.3	Yes
3.	395012	Hairdressers, Hairstylists, & Cosmetologists	1,037	6.5	Yes
4.	499041	Industrial Machinery Mechanics	894	5.6	Yes
5.	499021	Heating, Air Conditioning, & Refrigeration Mechanics	762	4.8	Yes
6.	514041	Machinists	615	3.9	Yes
7.	173023	Electrical & Electronics Engineering Technicians	509	3.2	Yes
8.	492011	Computer, Automated Teller, & Office Machine Repairers	365	2.3	Yes
9.	292081	Opticians, Dispensing	315	2.0	Yes
10.	514121	Welders, Cutters, Solderers, & Brazers	284	1.8	Yes

*Frequency = Number of RA positions. **The 10 RA positions with the most occupations represents 60% of Virginia's Total RA positions in 2015. *** RAPMSGO = the occupation is in a RA position filling a MS Gap occupation

Appendix M

Table M7. RA Positions Filling MS Gap Occupations (RAPMSGO) in Urban Areas

	2015		2018	
Urban	**RAPMSGO**	**%**	**RAPMSGO**	**%**
Yes	11,908	96.1	13,618	96.3
No	482	3.9	521	3.7
Total	**12,390**	**100.0**	**14,319**	**100.0**

Appendix M

Table M8a. RA Positions Filling MS Gap Occupations (RAPMSGO) by Gender

Gender	2015 RAPMSGO	%	2018 RAPMSGO	%
Male	10,171	82.1	11,691	82.7
Female	2,219	17.9	2,448	17.3
Total	**12,390**	**82.1**	**14,139**	**82.7**

Table M8b. RA Positions Filling MS Gap Occupations (RAPMSGO) by Ethnicity

	RA Position Filling a MS Gap Occupation			
Ethnicity	**No**	**Yes**	**Total**	**% RAPMSGO***
White	2,443	16,664	19,107	62.8
Black	1,353	5,354	6,707	20.2
Hispanic	403	2,264	2,667	8.5
Asian	103	726	829	2.7
Native American	53	170	223	0.6
Other	274	1,351	1,625	5.1
Total	**4,629**	**26,529**	**31,158**	**100.0**

* Percent of RA positions filling a MS gap occupation

Appendix M

Table M9. RA Positions Filling MS Gap Occupations by Industry

NAICS Industry	2015	%	2018	%
Public Administration	5,387	43.50%	3,992	28%
Construction	3,554	28.70%	5,237	37%
Manufacturing	2,035	16.40%	2,865	20%
Other Services except Public Admin.	808	6.50%	1,173	8%
Retail Trade	189	1.50%	271	2%
Utilities	154	1.20%	231	2%
Educational Services	154	1.20%	174	1%
Healthcare and Social Assistance	50	0.40%	58	0%
Administrative/Support/Waste Mgmt. and Remediation Services	22	0.20%	25	0%
Wholesale Trade	12	0.10%	59	0%
Transportation and Warehousing	7	0.10%	20	0%
Professional, Scientific, and Technical Services	4	0.00%	6	0%
Arts, Entertainment, and Recreation	4	0.00%	3	0%
Agriculture, Forestry, Fishing and Hunting	2	0.00%	1	0%
Mining	2	0.00%	10	0%
Information	2	0.00%	1	0%
Finance and Insurance	2	0.00%	6	0%
Accommodation/Food Services	2	0.00%	7	0%
Total	**12,390**	**100%**	**14,139**	**100%**

Appendix M

Table M10. RA Positions Filling MS Gap Occupations (RAPMSGO) by SOC Code Group

SOC-Code Group	2015 RAPMSGO*	2015 %	2018 RAPMSGO*	2018 %
11-0000 Management Occupations	410	3.3%	182	1.3%
13-0000 Business and Financial Operations Occupations	38	0.3%	4	0.0%
15-0000 Computer and Mathematical Occupations	2	0.0%	8	0.1%
17-0000 Architecture and Engineering Occupations	657	5.3%	869	6.1%
19-0000 Life, Physical, and Social Science Occupations	59	0.5%	23	0.2%
21-0000 Community and Social Service Occupations	0	0.0%	0	0.0%
23-0000 Legal Occupations	11	0.1%	6	0.0%
25-0000 Educational Instruction and Library Occupations	2	0.0%	8	0.1%
27-0000 Arts, Design, Entertainment, Sports, and Media Occupations	128	1.0%	97	0.7%
29-0000 Healthcare Practitioners and Technical Occupations	294	2.4%	372	2.6%
31-0000 Healthcare Support Occupations	22	0.2%	7	0.0%
33-0000 Protective Service Occupations	281	2.3%	40	0.3%
35-0000 Food Preparation and Serving Related Occupations	0	0.0%	0	0.0%
37-0000 Building and Grounds Cleaning and Maintenance Occupations	7	0.1%	1	0.0%
39-0000 Personal Care and Service Occupations	843	6.8%	1,197	8.5%
41-0000 Sales and Related Occupations	192	1.5%	121	0.9%
43-0000 Office and Administrative Support Occupations	129	1.0%	40	0.3%

Appendix M: Table M10 – continued

SOC-Code Group	2015 RAPMSGO*	2015 %	2018 RAPMSGO*	2018 %
45-0000 Farming, Fishing, and Forestry Occupations	0	0.0%	0	0.0%
47-0000 Construction and Extraction Occupations	**4,714**	**38.0%**	**6,500**	**46.0%**
49-0000 Installation, Maintenance, and Repair Occupations	**3,373**	**27.2%**	**3,396**	**24.0%**
51-0000 Production Occupations	1,128	9.1%	1,240	8.8%
53-0000 Transportation and Material Moving Occupations	100	0.8%	28	0.2%
Total	12,390	100.0%	14,139	100.0%

* Represents number of RA positions

Appendix M

Table M11. Correlation Matrix of Independent Variables

Independent variables	Constant	2018 RA positions	Urban location	Unemployment rate	No. of businesses
Constant	1.000	-0.810	-0.505	-0.931	-0.360
2018 RA Positions	-0.810	1.000	0.181	0.809	0.291
Urban Location	-0.505	0.181	1.000	0.205	-0.175
Unemployment Rate	-0.931	0.809	0.205	1.000	0.379
No. of Businesses	-0.360	0.291	-0.175	0.379	1.000

Table M12. Collinearity Statistics for the Independent Variables

Independent variables	Collinearity statistics	
	Tolerance	VIF
(Constant)		
2018	0.328	3.053
Urban Location	0.929	1.076
Unemployment Rate	0.281	3.553
No. of Businesses	0.731	1.369

Vita

Yolanda Macklin Crewe was born in Emporia, Virginia and graduated from Greensville County High School in 1984. She received her Bachelor of Science degree in Accounting from Hampton University in 1988 and a Master of Education in Higher Education Administration from Temple University in 1996.

She is the Director of the WIOA (Workforce Innovation and Opportunity Act) Title I Programs at the Virginia Community College System. She oversees the Adult, Dislocated Worker, Youth and Rapid Response programs for the Commonwealth Virginia. In this role, she develops administrative guidance related to WIOA Title I programs, develops strategic partnerships with workforce partners, and coordinates the Sector Strategies and Career Pathways Academy, a statewide initiative to provide professional development for Virginia's workforce professionals.

In previous work, she cultivated and expanded internship and job opportunities for college students by fostering relationships with employers, alumni, parents, community organizations and university departments as the Director of Career Services at Virginia State University and Associate Director of Employer Relations at the University of Richmond Career Development Center.