UNIVERSITY
OF TECHNOLOGY
SYDNEY

Changing Labour Market Dynamics in Australia: Skill Shortages, Job Transitions, and Artificial Intelligence Technology Adoption

by Nikolas Dawson

Thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

under the supervision of
Distinguished Professor Mary-Anne Williams,
Dr Marian-Andrei Rizoiu, and
Dr Benjamin Johnston

University of Technology Sydney
Faculty of Engineering & IT

June 2021

Certificate of original authorship

I, *Nikolas Dawson* declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the *School of Computer Science*, *Faculty of Engineering & IT* at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis. This document has not been submitted for qualifications at any other academic institution. This research is supported by the Australian Government Research Training Program.

Production Note:
SIGNATURE: Signature removed prior to publication.

[Nikolas Dawson]

DATE: 27th June, 2021

PLACE: Sydney, Australia

Abstract

The Australian labour market is in the midst of significant structural changes. Emerging technologies, such as Artificial Intelligence (AI), are changing the demands for skills and tasks within jobs. Additionally, the economic crisis induced by COVID-19, in conjunction with other factors, have accelerated these adjustments. Three major issues for the Australian labour market are (1) skill shortages, (2) job transitions, and (3) AI adoption at the firm-level. This thesis by compilation addresses each of these issues in a series of four standalone papers. The first paper puts forward a range of indicators to detect skill shortages from a longitudinal dataset of online job advertisements (ads). The second paper develops a machine learning model that accurately predicts skill shortages from job ads data and employment statistics. The third paper conducts an in-depth case study of the journalism jobs crisis in Australia, examining both the changes in labour demand (using job ads) and labour supply (using employment statistics) from 2012-2020. Last, the fourth paper develops a novel method to measure the similarity between sets of skills from real-time job ads data. These similarity measures are then combined with other labour market variables to build a 'Job Transitions Recommender System' that accurately predicts transition pathways between occupations, validated against a longitudinal household survey. The same skills set similarity method is then used to construct a measure of new technology adoption in labour markets, showcasing AI.

DEDICATION

To my wife, Emma, for her ongoing love, patience, and support.

Acknowledgments

Undertaking doctoral research has been both the hardest and most rewarding endeavour of my career thus far. It has been a marathon to complete and a roller-coaster of emotions. While working towards my doctorate has developed skills and knowledge that I'll carry forward in my career, it has also taught me a significant lesson: *the most important thing to do is to think for yourself.* This is the foundation of great research or creating anything new of lasting value. A lesson that is simple to preach but difficult to practice.

I underestimated the amount of support required for completing a Ph.D. when I began my research. Thankfully, I have had plenty, for whom I would like to acknowledge here. First, to my principal supervisor, Mary-Anne Williams, who made my candidacy possible. Mary-Anne has enabled opportunities throughout my Ph.D. Most notably, arranging a research assistant position with the United Nations in Geneva for a project on the 'Economic Impacts of Artificial Intelligence'. I thank Mary-Anne for the opportunities and support she has provided – these opportunities have shaped me professionally and personally. I would also like to thank Benjamin Johnston, one of my co-supervisors, for some technical assistance and valuable feedback he provided early in my Ph.D.

To Marian-Andrei Rizoiu (Andrei), my other co-supervisor, I express my deepest gratitude. The research presented in this thesis and their corresponding publications would not have been possible without Andrei's guidance. Andrei is among the most intelligent and capable people I know. It has been a rare privilege to work with and learn from Andrei. I hope that we get the opportunity to work together in the future again.

Central to all of the research papers that I present in this thesis are job advertisements data, which have been generously provided by Burning Glass Technologies (BGT). Therefore, I would like to acknowledge and thank BGT for granting access to these data that enabled this research. Specifically, I would like to thank Bledi Taska and Davor Miskulin from BGT for establishing the data sharing agreement and for their valuable feedback on the various papers.

Last, I would like to thank my family and friends for being a constant source of support during this process. To my mother, Annmaree, who has created a foundation of support that has given me every chance to succeed. To my uncle, Berto, whose editing and feedback has been invaluable for the research papers presented in this thesis and other pieces of writing. And to my wife, Emma, whose love and support has been unwavering, even during the stresses of deadlines. Thank you for centring and helping me on this journey.

List of Publications & Statement of Contribution

Related to the Thesis (Published):

1. Dawson, N., MA. Rizoiu, B. Johnston, and MA. Williams. 2019. “Adaptively Selecting Occupations to Detect Skill Shortages from Online Job Ads.” In *2019 IEEE International Conference on Big Data (Big Data)*, 1637–43 [120].

2. Dawson, N., MA. Rizoiu, B. Johnston, and MA. Williams. 2020. “Predicting Skill Shortages in Labor Markets: A Machine Learning Approach.” In *The 4th IEEE Workshop on Human-in-the-Loop Methods and Future of Work in BigData* (Co-located with 2020 IEEE International Conference on Big Data) [121].

3. Dawson, N., S. Molitorisz, MA. Rizoiu, and P. Fray. 2021. “Layoffs, Inequity and COVID-19: A Longitudinal Study of the Journalism Jobs Crisis in Australia from 2012 to 2020.” *Journalism* [118].

Related to the Thesis (Under Review):

4. Dawson, N., MA. Rizoiu,and MA. Williams. 2021. “Skill-driven Recommendations for Job Transition Pathways.” – submitted to *PLOS ONE* and awaiting second round of peer reviews as of the 25th of June 2021.

Not included in the Thesis (Published):

5. Gromov, A., A. Maslennikov, N. Dawson, K. Musial, and K. Kitto. 2020. “Curriculum profile: modelling the gaps between curriculum and the job market.” In *Proceedings of The 13th International Conference on Educational Data Mining (EDM 2020)*, pp. 610-614 [168].

6. Dawson, N., and MA Rizoiu. 2020. "Coronavirus Infecting Australian Jobs: Vacancy Rates down since Early February." The Conversation, March 22, 2020. http://theconversation.com/coronavirus-infecting-australian-jobs-vacancy-rates-down-since-early-february-134234.

Table 1: Papers and contributions by co-authors.

Title	Lead Author	Co-Author 1	Co-Author 2	Co-Author 3
Adaptively Selecting Occupations to Detect Skill Shortages from Online Job Ads.	Nikolas Dawson	**Dr. Marian-Andrei Rizoiu**, Lecturer at UTS and Ph.D. co-supervisor – assisted with the design of the research, data analysis, and manuscript editing.	**Dr. Benjamin Johnston**, Senior Lecturer at UTS and Ph.D. co-supervisor – provided feedback and technical assistance.	**Distinguished Professor Mary-Anne Williams**, UTS and Ph.D. supervisor – assisted with data collection and provided feedback.
Predicting Skill Shortages in Labor Markets: A Machine Learning Approach.	Nikolas Dawson	**Dr. Marian-Andrei Rizoiu**, Lecturer at UTS and Ph.D. co-supervisor – assisted with the design of the research, data analysis, and manuscript editing.	**Dr. Benjamin Johnston**, Senior Lecturer at UTS and Ph.D. co-supervisor – provided feedback and technical assistance.	**Distinguished Professor Mary-Anne Williams**, UTS and Ph.D. supervisor – assisted with data collection and provided feedback.
Layoffs, Inequity and COVID-19: A Longitudinal Study of the Journalism Jobs Crisis in Australia from 2012 to 2020.	Nikolas Dawson	**Dr. Sacha Molitorisz**, Lecturer at UTS – assisted with the design of the research, preparation of the manuscript, and journalism-specific expertise.	**Dr. Marian-Andrei Rizoiu**, Lecturer at UTS and Ph.D. co-supervisor – assisted with the design of the research, data analysis, and manuscript editing.	**Peter Fray**, Managing Editor at Private Media – assisted with the design of the research.
Skill-driven Recommendations for Job Transition Pathways.	Nikolas Dawson	**Dr. Marian-Andrei Rizoiu**, Lecturer at UTS and Ph.D. co-supervisor – assisted with the design of the research, data analysis, and manuscript editing.	**Distinguished Professor Mary-Anne Williams**, UTS and Ph.D. supervisor – assisted with data collection and provided feedback.	

THE ABOVE STATED INFORMATION IS CORRECT:

Production Note:
Signature removed prior to publication.

SIGNATURE: ____________________

[Marian-Andrei Rizoiu]

Production Note:

SIGNATURE: Signature removed prior to publication.

[Mary-Anne Williams]

Production Note:

SIGNATURE: Signature removed prior to publication.

[Benjamin Johnston]

Production Note:

SIGNATURE: Signature removed prior to publication.

[Sacha Molitorisz]

Production Note:

SIGNATURE: Signature removed prior to publication.

[Peter Fray]

TABLE OF CONTENTS

List of Figures

List of Tables