# MODELLING OCCUPATIONAL CHANGES IN AUSTRALIA

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## Data collection and cleaning

Data for quarterly employment totals by occupation unit as defined by ANZSCO (2013) were extracted from the ABS quarterly labour force survey table EQ08 for the dates ranging August 1991 to August 2015.[1] Next data from the U.S. Bureau of Labour Statistics concerning work activities performed in each O*Net occupation was collected.[2] The work activities data listed a mix of up to 41 activities performed in each American occupation as well as the importance of these activities and the skill level required to perform them.

O*Net occupations were next manually matched to ANZSCO occupation units, creating a list of work activities for the Australian data. There are many more O*Net occupations than ANZSCO ones, resulting in a number of many-to-one matches. For these many-to-one matches, the averages of the work activity importance and skill level scores were taken. For each occupation, work activities with low importance scores were discounted from the analysis, as low importance activities were often not ubiquitous across occupations resulting in overly small sample sizes.

Some occupations, notably the ANZSCO's miscellaneous occupations, could not be accurately matched. Additionally, a small number of professions did not have complete employment data. In both situations, these professions were not included in the final data set.

## Work activities

Principal component analysis was used to reduce the 41 work activity skill scores down to a manageable number. To do this, a correlation matrix of the 41 variables was constructed and their eigenvalues observed via screen-plots. Eigenvalues with a correlation matrix greater than 1 were considered for factor extraction. Any eigenvalue with magnitude less than or equal to 1 was considered to represent the residual floor in the Eigen-decomposition. Six eigenvalues greater than one were found, however the fifth and the sixth eigenvalues were very close to one. These final two factors were given particular attention during the examination of factor loadings.

Factor loadings were computed to examine the contribution of each variable to a given factor. A factor loading with magnitude greater than or equal to 0.4 was considered to have a significant contribution. Variables were then classified according to their corresponding factor loadings, resulting in the discovery of a set of disjoint factors. Our 41 variables were classified into the first four factors. The fifth and the sixth factors were considered redundant as their variables had non-significant factor loadings. Upon examination, the combinations of work activity variables within the four factors could be described as: knowledge; influencing people; machines and movement; and personal service. These factors accounted for 76% of the variation across the original 41 variables (Table 1).

**Table 1 Work activity with the description**

| WORK ACTIVITY | O*NET DESCRIPTION |
|---|---|
| **Factor 1 (Knowledge)** | |
| Getting information | Observing, receiving, and otherwise obtaining information from all relevant sources. |
| Monitor processes, materials, or surroundings | Monitoring and reviewing information from materials, events, or the environment, to detect or assess problems. |
| Identifying objects, actions, and events | Identifying information by categorizing, estimating, recognizing differences or similarities, and detecting changes in circumstances or events. |
| Estimating the quantifiable characteristics of products, events, or information | Estimating sizes, distances, and quantities; or determining time, costs, resources, or materials needed to perform a work activity. |
| Judging the qualities of things, services, or people | Assessing the value, importance, or quality of things or people. |
| Processing information | Compiling, coding, categorizing, calculating, tabulating, auditing, or verifying information or data. |
| Evaluating information to determine compliance with standards | Using relevant information and individual judgment to determine whether events or processes comply with laws, regulations, or standards. |
| Analysing data or information | Identifying the underlying principles, reasons, or facts of information by breaking down information or data into separate parts. |
| Making decisions and solving problems | Analysing information and evaluating results to choose the best solution and solve problems. |
| Thinking creatively | Developing, designing, or creating new applications, ideas, relationships, systems, or products, including artistic contributions. |
| Updating and using relevant knowledge | Keeping up-to-date technically and applying new knowledge to your job. |
| Developing objectives and strategies | Establishing long-range objectives and specifying the strategies and actions to achieve them. |
| Scheduling work and activities | Scheduling events, programs, and activities, as well as the work of others. |
| Organizing, planning, and prioritizing work | Developing specific goals and plans to prioritize, organize, and accomplish your work. |

| WORK ACTIVITY | O*NET DESCRIPTION |
|---|---|
| Interacting with computers | Using computers and computer systems (including hardware and software) to program, write software, set up functions, enter data, or process information. |
| Interpreting the meaning of information for others | Translating or explaining what information means and how it can be used. |
| Communicating with supervisors, peers, or subordinates | Providing information to supervisors, co-workers, and subordinates by telephone, in written form, e-mail, or in person. |
| Communicating with persons outside organization | Communicating with people outside the organization, representing the organization to customers, the public, government, and other external sources. This information can be exchanged in person, in writing, or by telephone or e-mail. |
| Establishing and maintaining interpersonal relationships | Developing constructive and cooperative working relationships with others, and maintaining them over time. |
| Performing administrative activities | Performing day-to-day administrative tasks such as maintaining information files and processing paperwork. |
| Documenting/recording information | Entering, transcribing, recording, storing, or maintaining information in written or electronic/magnetic form. |
| **Factor 2 (Influencing people)** | |
| Selling or influencing others | Convincing others to buy merchandise/goods or to otherwise change their minds or actions. |
| Resolving conflicts and negotiating with others | Handling complaints, settling disputes, and resolving grievances and conflicts, or otherwise negotiating with others. |
| Coordinating the work and activities of others | Getting members of a group to work together to accomplish tasks. |
| Developing and building teams | Encouraging and building mutual trust, respect, and cooperation among team members. |
| Training and teaching others | Identifying the educational needs of others, developing formal educational or training programs or classes, and teaching or instructing others. |
| Guiding, directing, and motivating subordinates | Providing guidance and direction to subordinates, including setting performance standards and monitoring performance. |
| Coaching and developing others | Identifying the developmental needs of others and coaching, mentoring, or otherwise helping others to improve their knowledge or skills. |
| Provide consultation and advice to others | Providing guidance and expert advice to management or other groups on technical, systems-, or process-related topics. |
| Staffing organizational units | Recruiting, interviewing, selecting, hiring, and promoting employees in an organization. |
| Monitoring and controlling resources | Monitoring and controlling resources and overseeing the spending of money. |
| **Factor 3 (Machines and movement)** | |
| Inspecting equipment, structures, or material | Inspecting equipment, structures, or materials to identify the cause of errors or other problems or defects. |
| Performing general physical activities | Performing physical activities that require considerable use of your arms and legs and moving your whole body, such as climbing, lifting, balancing, walking, stooping, and handling of materials. |
| Handling and moving objects | Using hands and arms in handling, installing, positioning, and moving materials, and manipulating things. |
| Controlling machines and processes | Using either control mechanisms or direct physical activity to operate machines or processes (not including computers or vehicles). |
| Operating vehicles, mechanized devices, or equipment | Running, manoeuvring, navigating, or driving vehicles or mechanized equipment, such as forklifts, passenger vehicles, aircraft, or water craft. |
| Drafting, laying out, and specifying technical devices, parts, and equipment | Providing documentation, detailed instructions, drawings, or specifications to tell others about how devices, parts, equipment, or structures are to be fabricated, constructed, assembled, modified, maintained, or used. |
| Repairing and maintaining mechanical equipment | Servicing, repairing, adjusting, and testing machines, devices, moving parts, and equipment that operate primarily on the basis of mechanical (not electronic) principles. |
| Repairing and maintaining electronic equipment | Servicing, repairing, calibrating, regulating, fine-tuning, or testing machines, devices, and equipment that operate primarily on the basis of electrical or electronic (not mechanical) principles. |
| **Factor 4 (Personal service )** | |
| Assisting and caring for others | Providing personal assistance, medical attention, emotional support, or other personal care to others such as co-workers, customers, or patients. |
| Performing for or working directly with the public | Performing for people or dealing directly with the public. This includes serving customers in restaurants and stores, and receiving clients or guests. |

## Model construction

The time series employment data was first indexed to August 1991 so as to analyse the relative change in each occupation. An augmented Dicky-Fuller test rejected the existence of any unit root in the indexed employment change time series data. Also, the Levin-Lin-Chu test rejected the existence of panel unit root in the indexed panel time series data.[3]

Both a random effect and fixed effect linear model were considered. A Hausman test for panel models was applied to test the inconsistency of one model against the other. The null hypothesis was not rejected for the fixed effect model, indicating it was inconsistent when contrasted to the random effect model. This result is mostly owing to the heterogeneity of data across different job categories as well as the time trend relationship among employment numbers. As variation was occurring due to a time trend as well as variation across job types, data heteroscedasticity was considered. Use of the Breusch-Pagan test strongly supports the existence of heteroscedasticity. To account for this the standard errors were estimated using heteroscedasticity consistent estimators (sandwich estimators).

The chosen model was a mixed effect linear regression fitted across 341 occupations over 96 quarterly time periods. The independent variables were the four factors identified in the principal components analysis (knowledge and communication, guiding and influencing, machines and movement, and service), the skill level of each occupation as defined by ANZSCO (on a scale from 1-5, with 1 representing the highest skill level) and time. Skill was tested both as a numerical ordinal and a categorical variable. The dependent variable was employment indexed to 1991.

## Model results

The first model considered skill as an ordinal variable and the four work activity factors. Skill was significantly associated with employment growth, with more highly skilled occupations showing stronger growth. Those occupations in which factor 2 activities (which can be broadly characterised as involving guiding and influencing people) are relatively important were associated with significantly higher employment growth. Occupations in which factor 3 activities (which include physical movement and the maintenance and operation of machinery) were important grew at a significantly lower rate. Factors 1 (knowledge related activities) and 4 (personal service) had no significant relationship with employment growth (Table 2). Time proved significant, reflecting the general trend of employment growth. Model one was extended to test for interactions between skill and the work activity factors; none proved statistically significant.

**Table 2 Regression model parameter estimates for employment growth by occupation. Skill level is an ordinal variable.**

| MODEL 1 | ESTIMATE | STD. ERROR | SIGNIFICANCE |
|---|---|---|---|
| Intercept | 123.58 | 10.48 | *** |
| Skill | -12.39 | 3.78 | ** |
| Factor 1 (knowledge) | -5.85 | 5.26 | |
| Factor 2 (influencing people) | 9.21 | 4.45 | * |
| Factor 3 (machines & movement) | -17.77 | 3.62 | *** |
| Factor 4 (personal service) | 2.32 | 6.10 | |
| Time | 1.23 | 0.16 | *** |
| *Variance Estimates:* | | | |
| $\sigma^2_\varepsilon$: Idiosyncratic | 5746.10 | | |
| $\sigma^2_u$: Job | 7007.24 | | |
| $\theta$: Transformation | 0.91 | | |

*Significant at 0.05; **significant at 0.01; ***significant at 0.001

The second model explored the impact of skill in more detail by considering it as a categorical variable. While the five skill levels can be considered to represent a continuum of skills, they also reflect different training pathways. For example, skill level one is typically associated with a university degree, level two a diploma and levels three and four a vocational training certificate (II to IV). Model two shows that employment growth was significantly lower for occupations at skill levels three, four and five, compared to level one; the effect was most pronounced for skill levels three and five. By contrast employment growth for skill level two was not significantly different from level one (the most skilled jobs) (Table 3). Again, occupations involving physical movement and the maintenance and operation of machinery were found to have grown significantly less than other occupations, while those involving higher level people skills grew faster.

**Table 3 Regression model parameter estimates for employment growth by occupation. Skill level is a categorical variable, with level one as the reference level.**

| MODEL 2 | ESTIMATE | STD. ERROR | SIGNIFICANCE |
|---|---|---|---|
| Intercept | 109.83 | 6.38 | *** |
| Skill 2 | 11.52 | 24.48 | |
| Skill 3 | -38.69 | 10.55 | *** |
| Skill 4 | -27.05 | 11.73 | * |
| Skill 5 | -53.31 | 12.79 | *** |
| Factor 1 (knowledge) | -7.01 | 5.10 | |
| Factor 2 (influencing people) | 8.79 | 4.56 | ^ |
| Factor 3 (machines & movement) | -16.38 | 3.76 | *** |
| Factor 4 (personal service) | 2.05 | 5.85 | |
| Time | 1.23 | 0.12 | *** |
| *Variance Estimates:* | | | |
| $\sigma^2_\varepsilon$: Idiosyncratic | 5746.10 | | |
| $\sigma^2_u$: Job | 7007.24 | | |
| $\theta$: Transformation | 0.91 | | |

*Significant at 0.05; **significant at 0.01; ***significant at 0.001; ^significant at 0.1

To explore the impacts of digital technology in more detail a further model focussed on the relative importance of the work activity 'interacting with computers'. Skill was again considered as a categorical variable with skill level one (the most skilled occupations) as the reference level. The main effect of computer use was associated with increased employment growth. However, there were large and statistically significant interactions with skill level. Among lower skilled occupations (levels 3-5), those in which interacting with computers is relatively important showed much lower growth (and in many cases declined) compared to other occupations with similar overall skill levels (Table 4). This is likely to reflect the impacts of offshoring and automation on clerical and administrative jobs. Only among the most highly skilled occupations was computer use associated with increased employment growth.

**Table 4 Regression model parameter estimates for employment growth by occupation. Skill level is a categorical variable, with level one as the reference level; x denotes the interaction term between skill and computer use.**

| MODEL 3 | ESTIMATE | STD. ERROR | SIGNIFICANCE |
|---|---|---|---|
| Intercept | 88.16 | 13.08 | *** |
| Skill 2 | 88.47 | 61.77 | |
| Skill 3 | -15.29 | 15.32 | |
| Skill 4 | 36.52 | 24.65 | |
| Skill 5 | -30.36 | 13.90 | * |
| Computers | 9.09 | 3.97 | * |
| Skill 2 x computers | -27.26 | 16.98 | |
| Skill 3 x computers | -14.20 | 5.90 | * |
| Skill 4 x computers | -31.18 | 8.56 | *** |
| Skill 5 x computers | -11.01 | 5.46 | * |
| Time | 1.23 | 0.12 | *** |
| *Variance Estimates:* | | | |
| $\sigma^2_\varepsilon$: Idiosyncratic | 5746.10 | | |
| $\sigma^2_u$: Job | 7007.24 | | |
| $\theta$: Transformation | 0.91 | | |

*Significant at 0.05; **significant at 0.01; ***significant at 0.001

1 ABS 6291.0.55.003 - Labour Force, Australia, Detailed, Quarterly, Aug 2015. Australian Bureau of Statistics, Canberra.

2 O*Net 20.1 Data Dictionary - Work Activities. 2015, National Center for O*NET Development: Washington.

3 Levin A., Lin C.F. and Chu C.S.J. (2002). Unit root test in panel data: Asymptotic and finite sample properties. *Journal of Econometrics*, 108: 1-24.


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