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## Robots at Work: Automatable and Non Automatable Jobs

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DISCUSSION PAPER SERIES

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# **Robots at Work: Automatable and Non Automatable Jobs**

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## ABSTRACT

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### **Robots at Work: Automatable and Non Automatable Jobs\***

This study builds on Autor and Dorn's (2013) classification of automatable work at the three-digit occupation code level to identify additional jobs that will be automatable in the next decade by drawing on patent data. Based on this new classification the study provides estimates of the share of jobs that we expect to be automatable in the EU and across 25 individual countries. The study highlights that aspects of 47% of jobs will be automatable over the next decade, with 35% of all jobs being fully automatable. It also provides some evidence that 'thinking' and 'people' skills will become increasingly important for the fourth industrial revolution. The study puts emphasis on the fact that these estimates are based on static models. Assuming that some of the rents from labor technology will filter back into the economy it is expected that other occupations will expand in number as people consume more goods and services.

**JEL Classification:** J23, J24, O20

**Keywords:** robots, labor markets, skills

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## **Introduction and Background:**

Research on automation and the future of work has brought contributions that seek to determine the exact jobs that have been lost in the past, and also those that may be lost in the future. The critical component of this body of research is how ‘automatable’ work is defined. The seminal work in this regard is owed to Autor and Dorn (2013) and Autor et al. (2015) who define a job as automatable if it is high in routine task-intensity where routine task-intensity is measured by the level of routine, abstract and manual task content by occupation using the US *Dictionary of Occupation Titles*. Their work looks backwards and highlights clearly that the last three decades of automation have caused a hollowing out of jobs in the middle of the occupation distribution. To this end the types of occupations available to workers have become more polarized, with the majority of occupations falling into high and low skill categories, and mid skill jobs disappearing in large numbers. A second study by Frey and Osborne (2013) provides an alternative definition of automatable work based on ONET data on skills, knowledge and ability within three-digit occupation codes. Given this data, they develop an algorithm which estimates the probability of automation. The authors argue that their definition captures the jobs that will be automatable over the next decade. Based on their work they estimate that 47% of total US employment is at risk of computerization, with service jobs also being susceptible to automation (In the study computerization is defined as automation through computer-controlled equipment).

This study is complementary to these two studies. Specifically, its first contribution to the literature is to introduce a new classification of automatable work at the three-digit occupation code level based on patent data, rather than taking a task-based approach. By focusing on patent data it is argued that the strategy ‘follows the money’ and has a good chance of correctly identifying the jobs that will be automatable in the next decade if extensive patent activity in that area is recorded. Taking the jobs defined by Autor and Dorn (2013) and Autor et al. (2015) as automatable as accurate (given that it is backward

looking and captures the jobs already automated well), the new classification involves studying the remaining occupations which they classify as non-automatable, with a view to re-classifying these jobs as automatable as appropriate. In essence, the Autor and Dorn (2013) and Autor et al. (2015) classifications are taken as adequately summarizing changes in jobs for the third industrial revolution, and this study amends this classification to account for new technologies coming on stream for the fourth industrial revolution. The estimates from this study should then be compared to Frey and Osborne (2013) who pursued a similar exercise.

The new classifications distinguish between two types of automatable jobs. First, there are jobs that are expected to be fully automatable within the next decade. A fully automatable job is a job where technology is at a stage of development whereby it is a viable substitute for a particular job (for example driverless car). The second type are jobs, which that are expected to be polarized automatable over the next decades. Polarized automatable jobs arise where patent technology has had some success, but it is envisaged that these developments will progress to a polarization, with human employees being needed where a personal interaction holds real value and robots being utilized where it does not. An example here is wait staff where the patents may have some success in replacing the service at budget or quirky establishments but are unlikely to displace waiters offering a fine dining experience.

The second contribution of this study is to provide estimates of the share of jobs that are expected to be automatable in the EU, and across 25 countries. This is achieved by matching the new classification of automatable work to the EU-LFS data from 2013-2016. The final contribution of this study is to provide some evidence that abstract thinking and people skills will become increasingly important for the fourth Industrial revolution. It is noted that the estimates that comprise the second and third contribution of this work have also subsequently been documented in two reports to the European Commission on the future of work where a working paper version of this chapter is referenced (see Lordan 2018b, and Lordan 2019).

The importance of understanding the type of work that will be automatable going forward is echoed in Lordan (2018a) and Lordan and Neumark (2018) who suggest that new jobs are now being automated, and highlight that there is already evidence of successful pilots of robots in industry whose purpose is to replace jobs traditionally held by low skilled individuals. Both of these studies also identify negative employment effects for the UK and US, respectively, caused by interactions between the minimum

wage and automatable employment. Both pieces of research also rely on the definitions of automation laid out by Autor and Dorn (2013) and Autor et al. (2015) when drawing their conclusions, and emphasize larger effects for older low skilled workers.

Also related to this study are other studies that attempt to estimate the effects of automation on employment retrospectively. For example, Acemoglu and Restrepo (2018) investigate this phenomenon linking data on robot usage to local US labor market data. Overall, they find that an increase of one robot reduces the employment to population ratio by 0.18%-0.37% in the average commuting zone. Graetz and Michaels (2016) consider the effect of robot use (measured as actual robot use within countries by industry) on employment by skill for 17 countries from 1993-2007. They find no overall employment effects, however, they do identify a reduction in the low-skill shares of employment. Greenhalgh et al (2001) examine the relationship between technology and employment using UK company data from 1987-1994. In their work, technology is proxied by investments in research and development, intellectual property and trademarks at the firm-level. This work highlights overall positive effects of technology on employment, with particularly substantive increases in the technology sector. Finally, Piva and Vivarelli (2005) examine the effects of technology on employment, with a proxy that captures innovative investments in manufacturing firms in Italy for the period 1992-1997. The authors identify a small positive correlation between technology adoption and employment.

Overall, the literature reviewed suggests that in the past technology has had little effect on employment overall but has had some negative impacts on individuals of low and medium skill. In contrast, the effects suggested by Frey and Osborne (2013) for the future are substantively larger and predict some erosion of jobs in the services industry. Overall, the shares of employment analysis in this study, based on the refined classification of automatable work, emphasizes that 47% of all current jobs are automatable over the next decade, with 35% of these jobs being fully automatable. This compares well to the estimates of 42% by Frey and Osborne (2013). It is noteworthy that the jobs that are safe from automation are those that involve abstract, strategic or creative thinking, and in particular jobs that involve this type of thinking alongside people interactions.

The findings in this study that 47% of jobs can be automated with technology becoming available shortly, with 35% of these being fully automatable may seem glib. However, these estimates are based on static models. Intuitively, if firms do automate it should stimulate growth, assuming that some of the rents from this new technology are

recycled back into the economy, it is reasonable to expect other occupations will expand in number as people consume more goods and services. While it is hard to say what new occupations may come on stream, this work suggests that people and ‘thinking’ (the ability to problem solve, think strategically and navigate around problems) skills are the ones that will hold value for the fourth industrial revolution.

### **New Classification of Automatable Work:**

To arrive at the new classification the definition of an occupation being automatable by Autor and Dorn (2013) is taken as given. That is, it is viewed that their definition describes well occupations that have been disappearing retrospectively. Specifically, they argue that jobs high in routine task-intensity are automatable given they are codifiable, with routine task-intensity in each three-digit occupation defined as:

$$RTI_k = \ln(T_k^R) - \ln(T_k^M) - \ln(T_k^A) \quad (1)$$

where  $T_k^R$ ,  $T_k^M$ , and  $T_k^A$  are the levels of routine, manual, and abstract task inputs for occupation  $k$ . These levels are defined using variables from versions of the *Dictionary of Occupation Titles*, where incumbent workers are asked to grade the level of their occupation with respect to particular attributes. Overall, equation (1) is increasing in the absolute and relative quantity of tasks that are routine (i.e. codifiable) within any occupation. Given the values from equation 1, Autor and Dorn (2013) define the top tertile of three-digit occupation codes as automatable. These definitions are derived based on classifications put forward by Dorn (2009) which is a classification system that can be used to crosswalk US census codes across time. Overall there are 323 occupation codes, which implies that 201 codes are classified as non-automatable. This study relies on patent data to evaluate whether any one of these remaining 201 occupations are going to be automatable over the next decade. It is argued that a significant amount of promising research and development that is searching for a substitute for a particular job, defined as having filed a relevant patent, signals that this job is highly likely to be automatable. This work complements these classifications with information on whether a substitute for a specific three-digit occupation has been successfully piloted, and there are no major changes to the conclusions drawn in this work. To determine the level of patent activity Google Patents is drawn upon. Specifically, Google Patents covers over 87 million patent publications from the following patent offices: United



States, Europe, Japan, China, South Korea, WIPO, Russia, Germany, United Kingdom, Canada, France, Spain, Belgium, Denmark, Finland, Luxembourg and the Netherlands. Patents that are non-English have been translated by Google Patents and indexed. For the 201 three-digit occupations labelled as non-automatable according to Autor and Dorn (2013), (in summer 2017) Google Patents was searched to determine if a technology is actively being developed as a substitute for that occupation. a total of 216 3-digit occupations are revised. Specifically, the search is for variants of the occupation name, plus either the term ‘robot’, ‘automation’ or ‘artificial intelligence’. For example, for registered nurses the search is for ‘nurse’ and ‘robot’ or ‘automation’ or ‘artificial intelligence’. In this case there is one patent. For truck-driver the search is for ‘truck’ and ‘driverless’ or ‘robot’ or ‘automation’ or ‘artificial intelligence’. In this case there are many patents. A record is kept of the top five. Finally, for waiter the search is for ‘waiter’ and ‘robot’ or ‘automation’ or ‘artificial intelligence’. In this case five patents are found. The search is restricted to patents issued after 2002 given that older patents with an average duration of 15 years are likely to have expired or have already been implemented. Patents that have been abandoned, had expired or had been rejected are excluded. Results were grouped and sorted by relevance. Content was identified as relevant if it related directly to the automation of the respective job occupation searched for. Information on the relevant patents were documented in a separate document such that readers can replicate the search results. Information is recorded on up to five of the most informative patents.

Based on the the number of patents filed and the content of those patent descriptions it is possible to classify occupations as automatable, polarized automatable or non- automatable. Full details of how each occupation is classified is displayed in Table 1. Details of the top five associated patents can be provided by contacting the authors.

The overall aim is for the classifications of jobs outlined in Table 1 to capture well the jobs that will be automated within the next decade. To stress test the classification information is gathered on whether there have been successful pilots of a technology that substitutes for a worker, at a three-digit occupation level, or not. This was achieved by searching for a variant of the occupation name + ‘robot’ OR ‘automation’ OR ‘artificial intelligence’ in Google News. Google News is a computer-generated news site that aggregates headlines from news sources worldwide and groups similar stories together. How an article appears in a Google News search is determined by key word matching, alongside an automated evaluation of how popular a particular story is. In all cases, where it is determined that a viable patent exists, a link to the article is recorded which describes the trial

of the new technology. Therefore, if a technology is classified as automatable or polarised automatable based on the Google patent review, but details of a successful pilot in the Google News review has not been found, they are classified as non-automatable in the second stress test definition. However, if a technology is classified as automatable or polarised automatable based on the Google patent review, and a successful pilot in our Google News review has been found, they are classified as automatable in the second definition. The correlation of these two measures is very high at 0.8526 and the conclusions of this work do not change substantively with this alternate definition.

Returning to Table 1, a few stylized facts are worth highlighting. First, jobs where interpersonal skills are required in order to gauge the specific tasks that are needed to be carried out are unlikely to be automated and are classified as non-automatable. These jobs involve interaction with people whether it be to provide strategic leadership (for example CEOs), provide care to patients or children (for example nurses and childcare workers) grooming customers (for example hairdressers), and fixing objects (for example a plumber or a mechanic). In all cases, engagement with people is required in unpredictable sequences, which are not easily replicated by machines and cannot be easily substituted by the customer themselves (i.e. a person cannot indicate on an app the haircut that they desire, and have a robot carry out the task of cutting the style). In all these examples people also care about who carries out the task because the quality of the work can be highly variable, and in many cases the interaction with the person gives utility in and of itself.

Second, some client facing occupations are labelled as polarized automatable in Table 1. This arises because there is a lot of R&D into technology for jobs that historically require interpersonal interactions but there is a more predictable sequence of events. These jobs include waiting tables and bar tending. Here technology has had some success, with a few examples of successful substitution by robots. It is envisaged, however, that these developments will progress to a polarization, with, for example, human employees being kept in establishments where a personal interaction with a waiter or bar tender holds some value, and robots being utilized where it does not. A second type of polarization occurs for jobs that are comprised of reading large volumes of writing, and also involves interaction with people in an unpredictable sequence of events. An example here are lawyers where systems, such as for example Kira, can scan contracts and substitute for some of the work historically carried out by these professionals, giving them more time to interact with clients and engage in strategic thinking or decision making. In this case, all else equal (including quality and

demand for these services) it is expected that there will be fewer lawyers in absolute number.

Third, there is considerable R&D in areas that customers may care less about whether the job is done by a robot or a human. These include delivery drivers and brick layers. So, the value to the customer of having a human carry out these roles is zero. In both of these areas there have been significant developments to the extent that a cull of jobs in the next decade is expected, assuming that legislation and infrastructure allow roll out of the new technologies.

Overall, Table 1 indicates that there are roughly three types of occupations with respect to automation potential. The first group are jobs where empathy and other non-cognitive skills are valued and a person cares about who carries out the work. Many of these occupations also leverage abstract, creative or strategic thinking. These occupations are unlikely to be automated in the next decade, and it is expected that they will increase in absolute number if the rents of technology are captured by society.

The second are occupations where in some cases a person may care who carries out the service, whereas in others they do not. Alternatively, they are occupations where some of the tasks that historically comprised them have been fully automated, leaving tasks that relate to abstract, strategic or creative thinking. Again, people and thinking skills will be of great value for the jobs that remain. It is envisaged that some of these jobs will be automated. However, at the same time they may be required in increased numbers if the rents from technology are shared within the economy and people demand more goods and services.

Third, are the jobs where there is no added value whether the work is carried out by a robot or a human. These are the jobs that will decline most sharply, with the main barrier to automation being laws and/or physical infrastructure. For example, in most countries driverless cars will need a legislation change, and a re-think of the infrastructure of cities.

Therefore, rather than sticking to the dichotomy of Autor and Dorn (2013) it is proposed that occupations have three distinct groupings. The first group are occupations where empathy and other soft skills are valued and a person cares about who carries out the work, and they often involve abstract/strategic/creative thinking. These occupations are classified as non-automatable. The second are occupations where in some cases a person may care who carries out the service, whereas in others they do not. These occupations are classified as polarized automatable. Third, are the jobs where there is no added value whether the work is carried out by a robot or a human. These are the jobs that are expected to decline the most sharply. Of course this decline also depends on other such as the costs of the technology as compared to the human labour, and also on preferences to substitute traditional

labor with technology that can vary across countries (for example: self-checkout cashiers have been around for a while in the UK but are refused by customers in Germany as they prefer the human interaction).

### **Shares of Automatable Work:**

In order to calculate the share of jobs that are at risk of being automated over the next decade the study utilizes the EU-LFS data from 2013-2016. These data are matched to the new classifications of automatable (fully automatable and polarized automatable combined), fully automatable and polarized automatable work based on cross walks from Lordan (2019). Shares of automatable employment are documented in Table 2, alongside the Autor and Dorn (2013) shares as a comparison.

From Table 2 it is noted that the new classifications suggest that a much larger share of jobs in the EU is at risk of being automated as compared to the Autor and Dorn (2013) classification (47% versus 27%). This compares well to the estimates of 42% by Frey and Osborne (2013). It is also noted that for every country the share of jobs that are fully automatable are significantly larger than the shares that are polarized automatable. In the EU these figures are 35% versus 12%. Finland is the country with the lowest share of jobs that are classified as automatable overall (approximately 21%), fully automatable (15%) and polarized automatable (6%). The Autor and Dorn (2013) shares of automatable employment stand at 11% for Finland. For the remaining Scandinavian countries (Norway, Sweden and Denmark), Table 2 suggests that about 37% of the jobs are automatable, similar to the shares for the Netherlands and Iceland. This is roughly 17% larger than the Autor and Dorn (2013) shares. In contrast, for Croatia, the Czech Republic, Italy and Latvia more than 50% of the jobs are automatable in the next decade, and the gap between these shares and Autor and Dorn (2013) is 20%+. Overall, Table 2 highlights that there is a lot of variation to automation across EU countries.

### **Methodology Main Analysis:**

It is interesting to probe empirically the conclusions drawn from Table 1. That is, jobs that are high on people and abstract skills are less likely to be automated. To consider this the ONET database version 15 is retrieved with focus on the 79 items describing the work activities and context of a person's occupation. This study follows Lordan and Pischke (2016) and relies on exploratory factor analysis to reduce the dimensionality of these 79

variables and also retrieve a clear structure of three correlated latent factors which emerges in the first rotation. Consistent with Lordan and Pischke (2016) these latent factors can be labelled ‘people’ ‘brains’ and ‘brawn’. In essence:

1. ‘People’ is a proxy variable which distils the information from the domains in the ONET activities and skills data that relate to having interactions with people on a day to day basis.
2. ‘Brains’ is a proxy variable which distils the information from the domains in the ONET activities and skills data that relate to thinking that is strategic, creative or abstract.
3. ‘Brawn’ is a proxy variable which distils the information from the domains in the ONET activities and skills data that relate to interacting physically with objects, including making them on a daily basis.

By regressing the dummy indicator variable representing whether a job is automatable (combining fully automatable and polarized automatable- see column (1) in Table 2) on the ‘people’ ‘brains’ and ‘brawn’ proxy variables it is possible to directly assess how they relate to the new classification of automatable work. Additionally, interactions between these three proxies and each other are included in the regression i.e people\*brains, people\*brawn and brains\*brawn. This allows an empirical test of whether, for example, jobs that are high in *both* people and abstract content are more likely to be automated as compared to those that are high in people and brawn content. The regressions also control for country fixed effects and yearly fixed effects in our regression, and exclude jobs that were denoted by Autor and Dorn (2013) as automatable. These jobs are excluded given that the Autor and Dorn (2013) classifications are already task based (see equation 1), so finding a relationship would be mechanical. Essentially, the analysis is trying to relate the new occupations classified as automatable using the patent data in this work to the three proxies representing people, brains and brawn. This is represented by the difference between columns (4) and columns (1) in Table 2. The results from this analysis are documented in Table 3.

From Table 3, 42% of the variation in our automatable employment indicator is explained by the variables in the regression. Noteworthy is how substantive the coefficient is on the ‘brains’ factor, strongly implying that jobs which require thinking (abstract/strategic or creative) are those that are the safest in the 4<sup>th</sup> industrial revolution. In addition, the interaction between the ‘people’ and ‘brains’ factors is negative and significant. This

highlights that jobs, which require thinking and social interactions are safer in the most recent wave of automation as compared to those that simply involve people interactions (as evidenced by the positive significant coefficient on the ‘people’ factor). This is more nuanced than the jobs conclusions that drawn from Table 1, but makes sense given the jobs that are classified as fully automatable, such as driver, also involve interaction with people. It is noted that the estimates in Table 3 imply that jobs that are high on ‘Brawn’ content are those that are most likely to be automated in the most recent wave of automation. These jobs include making objects and physically lifting items, for example, brick layer.

### **Summary:**

The primary aim of this study is to improve the understanding of the scope for the future automation of work. The work builds directly on Autor and Dorn’s (2013) classification of automatable work at the three-digit occupation code level by using patent data. By focusing on patent data, it is argued that the strategy ‘follows the money’ and can identify the jobs that will be automatable in the next decade. The new classification system introduced in this study distinguishes between three types of jobs: jobs that are fully automatable, jobs that are polarized automatable and jobs that are not expected to be automated. The second contribution of this study is to provide estimates of the share of jobs that are expected to be automatable in the EU and across 25 countries based on this new classification. Overall, it is highlighted that aspects of 47% of jobs are automatable over the next decade, with 35% of all jobs being fully automatable. This is relatively similar to the estimates of 42% by Frey and Osborne (2013). The final contribution of this study is to provide some evidence that ‘thinking’ and ‘people’ skills will become increasingly important for the fourth industrial revolution.

While the finding that aspects of 47% of jobs will be automatable in the near future, with 35% of these being fully automatable may seem gloomy, emphasis is put on the fact that these estimates are based on static models. It follows that if firms do automate, growth will be stimulated. Moreover, assuming that some of the rents from the technology adopted filter back into the economy (i.e. that they are not fully taken by large companies), it is expected that other occupations will expand in number as people consume more goods and services. It is very difficult to say what the new jobs will be. However, this study suggests that ‘people’ and ‘thinking’ skills will become more valuable in the fourth industrial revolution. The high value of people skills in terms of adult outcomes has become a topic of recent writings in

economics (for example Heckman and Kautz (2014); Kautz et al., (2014) and Lordan and McGuire, 2019). The intuition that jobs that require high level thinking are safe from automation is also embedded directly in the definitions by Autor and Dorn (2013) and Autor et al. (2015) (see equation 1 which highlights that jobs are less likely to be classified as automatable if they are high in abstract tasks). Overall, this study concludes that people and thinking skills are worth emphasizing as necessary for individuals looking to job proof themselves for the advent of the fourth industrial revolution.

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**Table 1: Occupations Classified by Autor and Dorn (2013) and Measure Proposed by this Work**

| <b>Occupation</b>  | <b>Autor and Dorn</b> | <b>Proposed Measure</b> |
|--|-----------------------|-------------------------|
| Chief executives, public administrators, and legislators | Non-Automatable       | Non- Automatable        |
| Financial managers                                       | Automatable           | Automatable             |
| Human resources and labour relations managers            | Non-Automatable       | Polarized Automatable   |
| Managers and specialists in marketing, advert., PR       | Non-Automatable       | Polarized Automatable   |
| Managers in education and related fields                 | Non-Automatable       | Non- Automatable        |
| Managers of medicine and health occupations              | Non-Automatable       | Non- Automatable        |
| Managers of properties and real estate                   | Non-Automatable       | Non- Automatable        |
| Funeral directors  | Automatable           | Fully Automatable       |
| Managers and administrators, n.e.c.                      | Non-Automatable       | Non- Automatable        |
| Accountants and auditors                                 | Automatable           | Fully Automatable       |
| Insurance underwriters                                   | Automatable           | Fully Automatable       |
| Other financial specialists                              | Automatable           | Fully Automatable       |
| Management analysts                                      | Non-Automatable       | Non- Automatable        |
| Personnel, HR, training, and labour rel. specialists     | Non-Automatable       | Polarized Automatable   |
| Purchasing agents and buyers of farm products            | Automatable           | Fully Automatable       |
| Buyers, wholesale and retail trade                       | Non-Automatable       | Non- Automatable        |
| Purchasing managers, agents, and buyers, n.e.c.          | Non-Automatable       | Non- Automatable        |
| Business and promotion agents                            | Non-Automatable       | Non- Automatable        |
| Construction inspectors                                  | Non-Automatable       | Non- Automatable        |
| Inspectors and compliance officers, outside              | Non-Automatable       | Non- Automatable        |
| Management support occupations                           | Non-Automatable       | Polarized Automatable   |

| <b>Occupation</b>                                 | <b>Author and Dorn</b> | <b>Lordan and Josten</b> |
|---|------------------------|--------------------------|
| Architects  | Automatable            | Non- Automatable         |
| Aerospace engineers                               | Non-Automatable        | Non- Automatable         |
| Metallurgical and materials engineers             | Non-Automatable        | Non- Automatable         |
| Petroleum, mining, and geological engineers       | Non-Automatable        | Non- Automatable         |
| Chemical engineers                                | Non-Automatable        | Non- Automatable         |
| Civil engineers                                   | Non-Automatable        | Non- Automatable         |
| Electrical engineers                              | Non-Automatable        | Non- Automatable         |
| Industrial engineers                              | Non-Automatable        | Non- Automatable         |
| Mechanical engineers                              | Non-Automatable        | Non- Automatable         |
| Engineers and other professionals, n.e.c.         | Non-Automatable        | Non- Automatable         |
| Computer systems analysts and computer scientists | Non-Automatable        | Non- Automatable         |
| Operations and systems researchers and analysts   | Non-Automatable        | Non- Automatable         |
| Actuaries   | Automatable            | Fully Automatable        |
| Mathematicians and statisticians                  | Non-Automatable        | Non- Automatable         |
| Physicists and astronomers                        | Non-Automatable        | Non- Automatable         |
| Chemists  | Non-Automatable        | Non- Automatable         |
| Atmospheric and space scientists                  | Automatable            | Non- Automatable         |
| Geologists  | Non-Automatable        | Non- Automatable         |
| Physical scientists, n.e.c.                       | Automatable            | Fully Automatable        |
| Agricultural and food scientists                  | Non-Automatable        | Non- Automatable         |
| Biological scientists                             | Non-Automatable        | Non- Automatable         |
| Foresters and conservation scientists             | Non-Automatable        | Non- Automatable         |

| <b>Occupation</b>                        | <b>Author and Dorn</b> | <b>Lordan and Josten</b> |
|--|------------------------|--------------------------|
| Medical scientists                       | Non-Automatable        | Non- Automatable         |
| Physicians                               | Non-Automatable        | Non- Automatable         |
| Dentists                                 | Non-Automatable        | Non- Automatable         |
| Veterinarians                            | Automatable            | Non- Automatable         |
| Optometrists                             | Automatable            | Polarized Automatable    |
| Podiatrists                              | Non-Automatable        | Non- Automatable         |
| Other health and therapy occupations     | Non-Automatable        | Non- Automatable         |
| Registered nurses                        | Non-Automatable        | Non- Automatable         |
| Pharmacists                              | Automatable            | Polarized Automatable    |
| Dieticians and nutritionists             | Automatable            | Fully Automatable        |
| Respiratory therapists                   | Non-Automatable        | Non- Automatable         |
| Occupational therapists                  | Non-Automatable        | Non- Automatable         |
| Physical therapists                      | Non-Automatable        | Non- Automatable         |
| Speech therapists                        | Non-Automatable        | Polarized Automatable    |
| Therapists, n.e.c.                       | Non-Automatable        | Non- Automatable         |
| Physicians' assistants                   | Non-Automatable        | Polarized Automatable    |
| Subject instructors, college             | Non-Automatable        | Non- Automatable         |
| Kindergarten and earlier school teachers | Non-Automatable        | Non- Automatable         |
| Primary school teachers                  | Non-Automatable        | Non- Automatable         |
| Secondary school teachers                | Non-Automatable        | Non- Automatable         |
| Special education teachers               | Non-Automatable        | Non- Automatable         |
| Teachers, n.e.c.                         | Non-Automatable        | Non- Automatable         |

| <b>Occupation</b>                                    | <b>Author and Dorn</b> | <b>Lordan and Josten</b> |
|--|------------------------|--------------------------|
| Vocational and educational counselors                | Non-Automatable        | Non- Automatable         |
| Librarians   | Non-Automatable        | Polarized Automatable    |
| Archivists and curators                              | Non-Automatable        | Non- Automatable         |
| Economists, market and survey researchers            | Non-Automatable        | Non- Automatable         |
| Psychologists  | Non-Automatable        | Non- Automatable         |
| Social scientists and sociologists, n.e.c.           | Non-Automatable        | Non- Automatable         |
| Urban and regional planners                          | Automatable            | Non- Automatable         |
| Social workers                                       | Non-Automatable        | Non- Automatable         |
| Clergy and religious workers                         | Non-Automatable        | Non- Automatable         |
| Welfare service workers                              | Non-Automatable        | Non- Automatable         |
| Lawyers and judges                                   | Automatable            | Polarized Automatable    |
| Writers and authors                                  | Automatable            | Non- Automatable         |
| Technical writers                                    | Non-Automatable        | Non- Automatable         |
| Designers  | Non-Automatable        | Non- Automatable         |
| Musicians and composers                              | Non-Automatable        | Non- Automatable         |
| Actors, directors, and producers                     | Non-Automatable        | Non- Automatable         |
| Painters, sculptors, craft-artists, and print-makers | Automatable            | Fully Automatable        |
| Photographers  | Automatable            | Fully Automatable        |
| Dancers  | Non-Automatable        | Non- Automatable         |
| Art/entertainment performers and related occs        | Non-Automatable        | Non- Automatable         |
| Editors and reporters                                | Automatable            | Non- Automatable         |
| Announcers   | Automatable            | Non- Automatable         |

| <b>Occupation</b>                                   | <b>Author and Dorn</b> | <b>Lordan and Josten</b> |
|---|------------------------|--------------------------|
| Athletes, sports instructors, and officials         | Non-Automatable        | Polarized Automatable    |
| Clinical laboratory technologies and technicians    | Non-Automatable        | Fully Automatable        |
| Dental hygienists                                   | Automatable            | Fully Automatable        |
| Health record technologists and technicians         | Automatable            | Fully Automatable        |
| Radiologic technologists and technicians            | Non-Automatable        | Fully Automatable        |
| Licensed practical nurses                           | Non-Automatable        | Non- Automatable         |
| Health technologists and technicians, n.e.c.        | Non-Automatable        | Polarized Automatable    |
| Engineering technicians                             | Non-Automatable        | Non- Automatable         |
| Drafters  | Automatable            | Fully Automatable        |
| Surveyors, cartographers, mapping scientists/techs  | Non-Automatable        | Polarized Automatable    |
| Biological technicians                              | Non-Automatable        | Polarized Automatable    |
| Chemical technicians                                | Non-Automatable        | Polarized Automatable    |
| Other science technicians                           | Non-Automatable        | Polarized Automatable    |
| Airplane pilots and navigators                      | Non-Automatable        | Polarized Automatable    |
| Air traffic controllers                             | Automatable            | Fully Automatable        |
| Broadcast equipment operators                       | Non-Automatable        | Polarized Automatable    |
| Computer software developers                        | Non-Automatable        | Non- Automatable         |
| Programmers of numerically controlled machine tools | Non-Automatable        | Non- Automatable         |
| Legal assistants and paralegals                     | Automatable            | Fully Automatable        |
| Technicians, n.e.c.                                 | Non-Automatable        | Polarized Automatable    |
| Sales supervisors and proprietors                   | Non-Automatable        | Non- Automatable         |
| Insurance sales occupations                         | Automatable            | Fully Automatable        |

| <b>Occupation</b>                                    | <b>Autor and Dorn</b> | <b>Lordan and Josten</b> |
|--|-----------------------|--------------------------|
| Real estate sales occupations                        | Automatable           | Fully Automatable        |
| Financial service sales occupations                  | Automatable           | Fully Automatable        |
| Advertising and related sales jobs                   | Automatable           | Fully Automatable        |
| Sales engineers                                      | Non-Automatable       | Non- Automatable         |
| Salespersons, n.e.c.                                 | Non-Automatable       | Non- Automatable         |
| Retail salespersons and sales clerks                 | Non-Automatable       | Non- Automatable         |
| Cashiers   | Automatable           | Fully Automatable        |
| Door-to-door sales, street sales, and news vendors   | Non-Automatable       | Non- Automatable         |
| Sales demonstrators, promoters, and models           | Non-Automatable       | Polarized Automatable    |
| Office supervisors                                   | Automatable           | Fully Automatable        |
| Computer and peripheral equipment operators          | Non-Automatable       | Non- Automatable         |
| Secretaries and stenographers                        | Automatable           | Fully Automatable        |
| Typists  | Automatable           | Fully Automatable        |
| Interviewers, enumerators, and surveyors             | Automatable           | Non- Automatable         |
| Hotel clerks   | Automatable           | Fully Automatable        |
| Transportation ticket and reservation agents         | Automatable           | Fully Automatable        |
| Receptionists and other information clerks           | Automatable           | Fully Automatable        |
| Correspondence and order clerks                      | Automatable           | Fully Automatable        |
| Human resources clerks, excl payroll and timekeeping | Automatable           | Fully Automatable        |
| Library assistants                                   | Non-Automatable       | Polarized Automatable    |
| File clerks  | Automatable           | Fully Automatable        |
| Records clerks                                       | Automatable           | Fully Automatable        |



| <b>Occupation</b>  | <b>Author and Dorn</b> | <b>Lordan and Josten</b> |
|--|------------------------|--------------------------|
| Bookkeepers and accounting and auditing clerks           | Automatable            | Fully Automatable        |
| Payroll and timekeeping clerks                           | Automatable            | Fully Automatable        |
| Billing clerks and related financial records processing  | Automatable            | Fully Automatable        |
| Mail and paper handlers                                  | Automatable            | Fully Automatable        |
| Office machine operators, n.e.c.                         | Automatable            | Fully Automatable        |
| Telephone operators                                      | Automatable            | Fully Automatable        |
| Other telecom operators                                  | Automatable            | Fully Automatable        |
| Postal clerks, excluding mail carriers                   | Automatable            | Fully Automatable        |
| Mail carriers for postal service                         | Non-Automatable        | Fully Automatable        |
| Mail clerks, outside of post office                      | Automatable            | Fully Automatable        |
| Messengers   | Automatable            | Fully Automatable        |
| Dispatchers  | Automatable            | Fully Automatable        |
| Shipping and receiving clerks                            | Automatable            | Fully Automatable        |
| Stock and inventory clerks                               | Automatable            | Fully Automatable        |
| Meter readers  | Automatable            | Fully Automatable        |
| Weighers, measurers, and checkers                        | Automatable            | Fully Automatable        |
| Material recording, sched., prod., plan., expediting cl. | Automatable            | Fully Automatable        |
| Insurance adjusters, examiners, and investigators        | Automatable            | Fully Automatable        |
| Customer service reps, invest., adjusters, excl. insur.  | Automatable            | Fully Automatable        |
| Eligibility clerks for government prog., social welfare  | Automatable            | Fully Automatable        |
| Bill and account collectors                              | Automatable            | Fully Automatable        |
| General office clerks                                    | Automatable            | Fully Automatable        |

| <b>Occupation</b>  | <b>Author and Dorn</b> | <b>Lordan and Josten</b> |
|--|------------------------|--------------------------|
| Bank tellers   | Automatable            | Fully Automatable        |
| Proofreaders   | Automatable            | Fully Automatable        |
| Data entry keyers  | Automatable            | Fully Automatable        |
| Statistical clerks                                       | Automatable            | Fully Automatable        |
| Teacher's aides  | Non-Automatable        | Polarized Automatable    |
| Administrative support jobs, n.e.c.                      | Automatable            | Fully Automatable        |
| Housekeepers, maids, butlers, and cleaners               | Non-Automatable        | Polarized Automatable    |
| Laundry and dry cleaning workers                         | Automatable            | Fully Automatable        |
| Supervisors of guards                                    | Non-Automatable        | Non- Automatable         |
| Fire fighting, fire prevention, and fire inspection occs | Non-Automatable        | Polarized Automatable    |
| Police and detectives, public service                    | Non-Automatable        | Non- Automatable         |
| Sheriffs, bailiffs, correctional institution officers    | Non-Automatable        | Non- Automatable         |
| Crossing guards  | Non-Automatable        | Non- Automatable         |
| Guards and police, except public service                 | Automatable            | Fully Automatable        |
| Protective service, n.e.c.                               | Non-Automatable        | Polarized Automatable    |
| Supervisors of food preparation and service              | Non-Automatable        | Non- Automatable         |
| Bartenders   | Automatable            | Polarized Automatable    |
| Waiters and waitresses                                   | Non-Automatable        | Polarized Automatable    |
| Cooks  | Automatable            | Fully Automatable        |
| Food preparation workers                                 | Non-Automatable        | Polarized Automatable    |
| Miscellaneous food preparation and service workers       | Non-Automatable        | Polarized Automatable    |
| Dental Assistants  | Automatable            | Fully Automatable        |

| <b>Occupation</b>                                    | <b>Author and Dorn</b> | <b>Lordan and Josten</b> |
|--|------------------------|--------------------------|
| Health and nursing aides                             | Non-Automatable        | Non- Automatable         |
| Supervisors of cleaning and building service         | Non-Automatable        | Non- Automatable         |
| Superv. of landscaping, lawn service, groundskeeping | Non-Automatable        | Polarized Automatable    |
| Gardeners and groundskeepers                         | Non-Automatable        | Polarized Automatable    |
| Janitors   | Non-Automatable        | Polarized Automatable    |
| Pest control occupations                             | Non-Automatable        | Fully Automatable        |
| Barbers  | Automatable            | Non- Automatable         |
| Hairdressers and cosmetologists                      | Automatable            | Non- Automatable         |
| Recreation facility attendants                       | Non-Automatable        | Polarized Automatable    |
| Guides   | Non-Automatable        | Polarized Automatable    |
| Ushers   | Non-Automatable        | Polarized Automatable    |
| Baggage porters, bellhops and concierges             | Non-Automatable        | Polarized Automatable    |
| Recreation and fitness workers                       | Non-Automatable        | Polarized Automatable    |
| Motion picture projectionists                        | Automatable            | Fully Automatable        |
| Child care workers                                   | Non-Automatable        | Non- Automatable         |
| Personal service occupations, n.e.c                  | Non-Automatable        | Polarized Automatable    |
| Supervisors of personal service jobs, n.e.c          | Non-Automatable        | Polarized Automatable    |
| Public transportation attendants and inspectors      | Non-Automatable        | Polarized Automatable    |
| Animal caretakers, except farm                       | Non-Automatable        | Non- Automatable         |
| Farmers (owners and tenants)                         | <i>Automatable</i>     | Fully Automatable        |
| Farm managers  | <i>Automatable</i>     | Fully Automatable        |
| Farm workers, incl. nursery farming                  | <i>Automatable</i>     | Fully Automatable        |

| <b>Occupation</b>                                      | <b>Author and Dorn</b> | <b>Lordan and Josten</b> |
|--|------------------------|--------------------------|
| Graders and sorters of agricultural products           | <i>Automatable</i>     | Fully Automatable        |
| Inspectors of agricultural products                    | <i>Automatable</i>     | Fully Automatable        |
| Timber, logging, and forestry workers                  | <i>Automatable</i>     | Fully Automatable        |
| Fishers, marine life cultivators, hunters, and kindred | <i>Automatable</i>     | Fully Automatable        |
| Supervisors of mechanics and repairers                 | Non-Automatable        | Non- Automatable         |
| Automobile mechanics and repairers                     | Non-Automatable        | Non- Automatable         |
| Bus, truck, and stationary engine mechanics            | Non-Automatable        | Non- Automatable         |
| Aircraft mechanics                                     | Non-Automatable        | Non- Automatable         |
| Small engine repairers                                 | Non-Automatable        | Non- Automatable         |
| Auto body repairers                                    | Automatable            | Fully Automatable        |
| Heavy equipment and farm equipment mechanics           | Non-Automatable        | Non- Automatable         |
| Industrial machinery repairers                         | Non-Automatable        | Non- Automatable         |
| Machinery maintenance occupations                      | Automatable            | Fully Automatable        |
| Repairers of industrial electrical equipment           | Automatable            | Fully Automatable        |
| Repairers of data processing equipment                 | Automatable            | Fully Automatable        |
| Repairers of household appliances and power tools      | Non-Automatable        | Non- Automatable         |
| Telecom and line installers and repairers              | Non-Automatable        | Non- Automatable         |
| Repairers of electrical equipment, n.e.c.              | Non-Automatable        | Non- Automatable         |
| Heating, air conditioning, and refrigeration mechanics | Non-Automatable        | Non- Automatable         |
| Precision makers, repairers, and smiths                | Automatable            | Fully Automatable        |
| Locksmiths and safe repairers                          | Non-Automatable        | Polarized Automatable    |
| Repairers of mechanical controls and valves            | Non-Automatable        | Non- Automatable         |

| <b>Occupation</b>                                  | <b>Author and Dorn</b> | <b>Lordan and Josten</b> |
|--|------------------------|--------------------------|
| Elevator installers and repairers                  | Non-Automatable        | Non- Automatable         |
| Millwrights  | Non-Automatable        | Non- Automatable         |
| Mechanics and repairers, n.e.c.                    | Non-Automatable        | Non- Automatable         |
| Supervisors of construction work                   | Non-Automatable        | Non- Automatable         |
| Masons, tilers, and carpet installers              | Non-Automatable        | Polarized Automatable    |
| Carpenters   | Non-Automatable        | Non- Automatable         |
| Drywall installers                                 | Non-Automatable        | Non- Automatable         |
| Electricians                                       | Non-Automatable        | Non- Automatable         |
| Electric power installers and repairers            | Non-Automatable        | Non- Automatable         |
| Painters, construction and maintenance             | Non-Automatable        | Polarized Automatable    |
| Paperhangers                                       | Non-Automatable        | Polarized Automatable    |
| Plasterers   | Non-Automatable        | Polarized Automatable    |
| Plumbers, pipe fitters, and steamfitters           | Non-Automatable        | Non- Automatable         |
| Concrete and cement workers                        | Non-Automatable        | Polarized Automatable    |
| Glaziers   | Non-Automatable        | Non- Automatable         |
| Insulation workers                                 | Non-Automatable        | Non- Automatable         |
| Paving, surfacing, and tamping equipment operators | Non-Automatable        | Non- Automatable         |
| Roofers and slaters                                | Non-Automatable        | Non- Automatable         |
| Structural metal workers                           | Non-Automatable        | Non- Automatable         |
| Drillers of earth                                  | Non-Automatable        | Fully Automatable        |
| Misc. construction and related occupations         | Non-Automatable        | Polarized Automatable    |
| Drillers of oil wells                              | Non-Automatable        | Fully Automatable        |

| <b>Occupation</b>                                   | <b>Author and Dorn</b> | <b>Lordan and Josten</b> |
|---|------------------------|--------------------------|
| Explosives workers                                  | Non-Automatable        | Polarized Automatable    |
| Miners  | Non-Automatable        | Polarized Automatable    |
| Other mining occupations                            | Non-Automatable        | Polarized Automatable    |
| Production supervisors or foremen                   | Non-Automatable        | Polarized Automatable    |
| Tool and die makers and die setters                 | Automatable            | Fully Automatable        |
| Machinists  | Automatable            | Fully Automatable        |
| Boilermakers  | Automatable            | Fully Automatable        |
| Precision grinders and fitters                      | Automatable            | Fully Automatable        |
| Patternmakers and model makers                      | Automatable            | Fully Automatable        |
| Engravers   | Automatable            | Fully Automatable        |
| Other metal and plastic workers                     | Non-Automatable        | Polarized Automatable    |
| Cabinetmakers and bench carpeters                   | Non-Automatable        | Non- Automatable         |
| Furniture/wood finishers, other prec. wood workers  | Automatable            | Fully Automatable        |
| Dressmakers, seamstresses, and tailors              | Non-Automatable        | Polarized Automatable    |
| Upholsterers  | Automatable            | Fully Automatable        |
| Shoemakers, other prec. apparel and fabric workers  | Non-Automatable        | Fully Automatable        |
| Hand molders and shapers, except jewelers           | Automatable            | Fully Automatable        |
| Optical goods workers                               | Automatable            | Fully Automatable        |
| Dental laboratory and medical appliance technicians | Non-Automatable        | Polarized Automatable    |
| Bookbinders   | Non-Automatable        | Fully Automatable        |
| Other precision and craft workers                   | Automatable            | Fully Automatable        |
| Butchers and meat cutters                           | Automatable            | Fully Automatable        |

| <b>Occupation</b>                                   | <b>Author and Dorn</b> | <b>Lordan and Josten</b> |
|---|------------------------|--------------------------|
| Bakers  | Automatable            | Fully Automatable        |
| Batch food makers                                   | Automatable            | Fully Automatable        |
| Water and sewage treatment plant operators          | Non-Automatable        | Polarized Automatable    |
| Power plant operators                               | Non-Automatable        | Fully Automatable        |
| Plant and system operators, stationary engineers    | Non-Automatable        | Polarized Automatable    |
| Other plant and system operators                    | Non-Automatable        | Polarized Automatable    |
| Lathe, milling, and turning machine operatives      | Automatable            | Fully Automatable        |
| Punching and stamping press operatives              | Non-Automatable        | Fully Automatable        |
| Rollers, roll hands, and finishers of metal         | Non-Automatable        | Non- Automatable         |
| Drilling and boring machine operators               | Automatable            | Fully Automatable        |
| Grinding, abrading, buffing, and polishing workers  | Automatable            | Fully Automatable        |
| Forge and hammer operators                          | Non-Automatable        | Polarized Automatable    |
| Molders and casting machine operators               | Automatable            | Fully Automatable        |
| Metal platers                                       | Automatable            | Fully Automatable        |
| Heat treating equipment operators                   | Non-Automatable        | Polarized Automatable    |
| Sawing machine operators and sawyers                | Non-Automatable        | Fully Automatable        |
| Nail, tacking, shaping and joining mach ops (wood)  | Automatable            | Fully Automatable        |
| Other woodworking machine operators                 | Automatable            | Fully Automatable        |
| Printing machine operators, n.e.c.                  | Automatable            | Fully Automatable        |
| Typesetters and compositors                         | Automatable            | Fully Automatable        |
| Winding and twisting textile and apparel operatives | Automatable            | Fully Automatable        |
| Knitters, loopers, and toppers textile operatives   | Automatable            | Fully Automatable        |

| <b>Occupation</b>  | <b>Author and Dorn</b> | <b>Lordan and Josten</b> |
|--|------------------------|--------------------------|
| Textile cutting and dyeing machine operators               | Automatable            | Fully Automatable        |
| Textile sewing machine operators                           | Non-Automatable        | Fully Automatable        |
| Shoemaking machine operators                               | Non-Automatable        | Fully Automatable        |
| Clothing pressing machine operators                        | Non-Automatable        | Polarized Automatable    |
| Miscellaneous textile machine operators                    | Automatable            | Fully Automatable        |
| Cementing and gluing machine operators                     | Automatable            | Fully Automatable        |
| Packers, fillers, and wrappers                             | Non-Automatable        | Fully Automatable        |
| Extruding and forming machine operators                    | Automatable            | Fully Automatable        |
| Mixing and blending machine operators                      | Automatable            | Fully Automatable        |
| Separating, filtering, and clarifying machine operators    | Non-Automatable        | Non- Automatable         |
| Food roasting and baking machine operators                 | Automatable            | Fully Automatable        |
| Washing, cleaning, and pickling machine operators          | Automatable            | Fully Automatable        |
| Paper folding machine operators                            | Automatable            | Fully Automatable        |
| Furnance, kiln, and oven operators, apart from food        | Non-Automatable        | Polarized Automatable    |
| Slicing, cutting, crushing and grinding machine            | Automatable            | Fully Automatable        |
| Photographic process workers                               | Automatable            | Automatable              |
| Machine operators, n.e.c.                                  | Non-Automatable        | Polarized Automatable    |
| Welders, solderers, and metal cutters                      | Non-Automatable        | Polarized Automatable    |
| Assemblers of electrical equipment                         | Automatable            | Fully Automatable        |
| Painting and decoration occupations                        | Non-Automatable        | Polarized Automatable    |
| Production checkers, graders, and sorters in manufacturing | Automatable            | Fully Automatable        |
| Supervisors of motor vehicle transportation                | Non-Automatable        | Non- Automatable         |



| <b>Occupation</b>                                 | <b>Author and Dorn</b> | <b>Lordan and Josten</b> |
|---|------------------------|--------------------------|
| Truck, delivery, and tractor drivers              | Non-Automatable        | Fully Automatable        |
| Bus drivers                                       | Non-Automatable        | Fully Automatable        |
| Taxi cab drivers and chauffeurs                   | Non-Automatable        | Fully Automatable        |
| Parking lot attendants                            | Non-Automatable        | Polarized Automatable    |
| Railroad conductors and yardmasters               | Non-Automatable        | Non- Automatable         |
| Locomotive operators: engineers and firemen       | Non-Automatable        | Polarized Automatable    |
| Railroad brake, coupler, and switch operators     | Non-Automatable        | Polarized Automatable    |
| Ship crews and marine engineers                   | Non-Automatable        | Non- Automatable         |
| Miscellaneous transportation occupations          | Non-Automatable        | Polarized Automatable    |
| Operating engineers of construction equipment     | Non-Automatable        | Non- Automatable         |
| Crane, derrick, winch, hoist, longshore operators | Non-Automatable        | Non- Automatable         |
| Excavating and loading machine operators          | Non-Automatable        | Polarized Automatable    |
| Stevedores and misc. material moving occupations  | Non-Automatable        | Polarized Automatable    |
| Helpers, constructions                            | Non-Automatable        | Polarized Automatable    |
| Helpers, surveyors                                | Non-Automatable        | Polarized Automatable    |
| Construction laborers                             | Non-Automatable        | Fully Automatable        |
| Production helpers                                | Automatable            | Fully Automatable        |
| Garbage and recyclable material collectors        | Non-Automatable        | Fully Automatable        |
| Machine feeders and offbearers                    | Non-Automatable        | Polarized Automatable    |
| Garage and service station related occupations    | Automatable            | Fully Automatable        |
| Vehicle washers and equipment cleaners            | Automatable            | Fully Automatable        |
| Packers and packagers by hand                     | Automatable            | Fully Automatable        |

**Occupation**

Laborers, freight, stock, and material handlers, n.e.c.

**Author and Dorn**

Non-Automatable

**Lordan and Josten**

Polarized Automatable

Table 2: Shares of Automatable Employment

|                | (1)         | (2)               | (3)                   | (4)                    |
|----------------|-------------|-------------------|-----------------------|------------------------|
|                | Automatable | Fully Automatable | Polarized Automatable | Author and Dorn (2013) |
| E.U.           | 0.474       | 0.352             | 0.123                 | 0.268                  |
| Austria        | 0.516       | 0.379             | 0.137                 | 0.312                  |
| Belgium        | 0.443       | 0.306             | 0.137                 | 0.248                  |
| Croatia        | 0.565       | 0.470             | 0.095                 | 0.280                  |
| Cyprus         | 0.512       | 0.357             | 0.155                 | 0.282                  |
| Czech Republic | 0.516       | 0.379             | 0.138                 | 0.313                  |
| Denmark        | 0.370       | 0.252             | 0.118                 | 0.205                  |
| Estonia        | 0.458       | 0.345             | 0.113                 | 0.248                  |
| Finland        | 0.207       | 0.148             | 0.059                 | 0.112                  |
| France         | 0.478       | 0.311             | 0.168                 | 0.239                  |
| Germany        | 0.474       | 0.359             | 0.115                 | 0.301                  |
| Greece         | 0.574       | 0.484             | 0.089                 | 0.285                  |
| Hungary        | 0.544       | 0.414             | 0.130                 | 0.282                  |
| Iceland        | 0.374       | 0.271             | 0.103                 | 0.228                  |
| Ireland        | 0.481       | 0.381             | 0.100                 | 0.282                  |
| Italy          | 0.508       | 0.134             | 0.374                 | 0.302                  |
| Latvia         | 0.525       | 0.398             | 0.127                 | 0.281                  |
| Lithuania      | 0.527       | 0.411             | 0.116                 | 0.267                  |
| Luxembourg     | 0.442       | 0.339             | 0.103                 | 0.286                  |
| Netherlands    | 0.374       | 0.276             | 0.098                 | 0.227                  |
| Norway         | 0.363       | 0.224             | 0.119                 | 0.192                  |
| Portugal       | 0.485       | 0.363             | 0.122                 | 0.283                  |
| Spain          | 0.474       | 0.474             | 0.131                 | 0.252                  |
| Sweden         | 0.378       | 0.271             | 0.107                 | 0.217                  |
| Slovakia       | 0.513       | 0.382             | 0.131                 | 0.296                  |
| UK             | 0.405       | 0.303             | 0.101                 | 0.249                  |

**Table 3: ‘People’ “Brains’ and ‘Brawn’ Estimates**

| Variable        | Marginal Effect   |
|-----------------|-------------------|
| People          | 0.009<br>(0.000)  |
| Brains          | -0.070<br>(0.000) |
| Brawn           | 0.032<br>(0.000)  |
| People * Brains | -0.002<br>(0.000) |
| People* Brawn   | 0.003<br>(0.000)  |
| Brains* Brawn   | 0.000<br>(0.000)  |
| N               | 2,698,151         |
| R squared       | 42%               |