Returns to routine and non-routine job tasks: Evidence from Germany

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==== **Comments Very Welcome** ====

Abstract

In the last ten years the task-based approach has received a great deal of attention in the economic literature. This approach (Autor et al. 2003) offers a novel framework for studying the impact of computerization on the demand for routine versus non-routine labour. In this framework computers act as substitutes for routine and complements for non-routine labour, resulting in different demand for different types of job tasks.

This analysis builds on the task-based literature by studying the relationship between the type of tasks which workers do on the job and their wages. Using representative German data, the paper finds that routine tasks are negatively and significantly associated with wages. The negative effect is present in both OLS and 2SLS estimations. To account for possible endogeneity of job tasks, we employ an instrumental variable approach. Routine task-intensity (RTI) of individual jobs is instrumented with *(i)* RTI of father's occupation at the time when workers were 15 years old, and *(ii)* lagged values of own occupation's RTI including 6, 14, 21, 27 and 33 years lags. The paper provides an extensive discussion of the validity of our instruments.

JEL Classification: J01, J24, J30

Keywords: occupation, wages, routine tasks, instrumental variables, Germany

1 Introduction

In the last ten years the task-based approach has received a great deal of attention in the economic literature. This approach (Autor et al. 2003) offers a novel framework for studying the impact of computerization on the demand for routine versus non-routine labour. In this framework computers act as substitutes for routine and complements for non-routine labour, resulting in different demand for different types of job tasks. The task approach has proved to be a valuable tool for analyzing changing demand for skills (Spitz-Oener, 2006), job polarization (Goos et al., 2014; Goos and Manning, 2007) and wage inequality (Firpo et al., 2011; Dustmann et al., 2009; Antonczyk et al., 2009).

The current analysis contributes to the existing literature by mixing the routine task-based approach with the wage determination literature (Mincer, 1974). Aim of the paper is to study the relationship between routine tasks and wages, and find out whether routine and non-routine tasks are rewarded differently in the labor market. Assuming that routine tasks receive competition from computers, one would expect lower returns to these tasks.

To this end, the paper estimates a standard Mincer wage equation in which individual wages are regressed on an index measuring routine task-intensity of individual jobs (RTI). To account for possible endogeneity of occupations, and hence of the routine task-intensity variable, we apply an instrumental variable approach. A unique feature of our data is that it provides information about parental occupation. We use routine task-intensity of father's occupation at the time when workers were 15 years old as an instrument for individual RTIs. Additionally, individual RTIs are instrumented with lagged values of own occupation's RTI. The lagged values go back to 1979.

The rest of the paper is organized as follows. Chapter 2 discusses the related literature. Chapter 3 describes the data used in the empirical analyses. Chapter 4 provides a discussion of the empirical methods. It describes the way our endogenous and instrumental variables are constructed as well as the validity of our instruments. Chapter 5 presents some preliminary results. Preliminary sensitivity results are reported in Chapter 6.

2 Related literature

=== TO BE ADDED ===

3 Data

The empirical analysis utilizes data from the German Employment Survey 2012 (Rohrbach-Schmidt and Hall, 2013). It is a representative survey targeting employed individuals who are in paid employment for at least ten hours a week in Germany, and aged 15 years or older. The 2012 wave of the survey covers two thematic areas: "work and occupation in transition" and "acquisition and utilization of vocational qualifications". The survey provides a wealth of information on occupational activity, working hours, place of work, type of work and professional requirements, employment status, school education, vocational education and training, employment history, as well as personal information. A distinctive feature of the survey is the collected data on work activities which individuals do on the job. Respondents are asked about the frequency of performing 17 work activities (Table A1 in the appendix). Activities range from manufacturing of goods to training and teaching, and from advertising and marketing to cleaning and removing waste. Survey respondents can indicate on a 3-point scale whether they perform each activity often, sometimes or never.

Of special interest for this analysis is the collected data on parental occupation. Survey respondents are asked about the occupational activity pursued by their father when they were 15 years old. Furthermore, the survey provides limited information about mother's occupation. Occupation of the mother is known only for those individuals who indicate that they did not "live together with [their] father all the time between birth and age 15".

Table A2 in the appendix presents selected descriptive statistics for the sample used in this analysis.

The analysis excludes individuals with current military occupations (71 individuals).

3 Empirical methods

Following the previous empirical literature we estimate a standard Mincer (1974) wage equation. Log hourly wages are regressed on a detailed set of observed individual, job, firm and industry characteristics:

$$(1) \quad WAGE_i = RTI_i + DEM_i + EDU_i + EMPL_i + JOB_i + D_i + u_i$$

The outcome variable stands for individual log hourly wages. *RTI* is an index measuring the intensity of performing routine job tasks by respondent *i*. *DEM* contains standard socio-demographic controls such as marital status, children, geographic region, immigration status. *EDU* adds controls for general education and a set of dummy variables for overall score of the last completed vocational education or training (training duration of at least 12 months). *EMPL* stands for employment history and includes measures as experience, tenure, first occupation, number of employers since first job, interruption of occupational activity since first job, previous unemployment, as well as duration of unemployment. *JOB* controls for workplace characteristics such as job complexity, intensity of using computers at work, dummy variables for irregular working hours, stand-by-duty and working in the weekend, as well as a dummy for having a supervisory position. *FIRM* adds controls for firm size and financial situation of the company (assessed by respondents). *D* includes a set of location, sector and occupational dummy variables - 17 dummies for firm location, 21 dummies for sector of employment, 10 dummies for first and 43 dummies for current occupation.

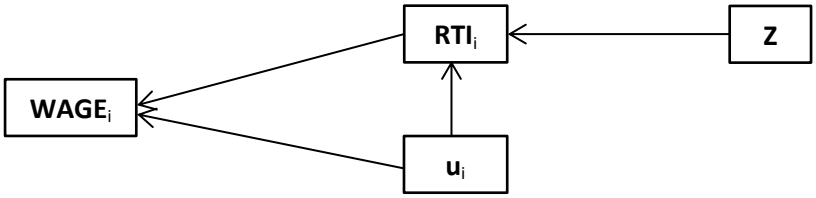
At this point the analysis is restricted to male workers only. The reason for not including females is technical. Routine task-intensity of father's occupation is used as an instrumental variable for own job's routine task-intensity. While for male workers there is a strong association between father's and son's RTIs, this is not the case for females. Father's occupation does not correlate sufficiently with the occupation of female workers, providing a weak instrument[1].

One concern with the estimation of equation (1) is that RTI may not be exogenous. The share of routine tasks in occupations is likely to be affected by technology. Spitz-Oener (2006) shows that between 1979 and 1999 in Germany there has been a pronounced shift in occupations away from routine towards non-routine activities. This change has been intensified by technology and computers at the workplace, which, according to Spitz-Oener, act as a substitute for routine and complement for non-routine tasks. A second source of endogeneity may arise if RTI is correlated with some unobservable factors, e.g. ability, which affect both individual wages and RTI.

To account for possible endogeneity of RTI, equation (1) is estimated with OLS and Instrumental variables approach (IV)[2]. Routine task-intensity of individual jobs (in 2012) is instrumented with the routine task-intensity of father's occupation at the time when worker was 15 years old, as well as lagged RTI values of worker's own occupation.

To provide consistent estimates, an instrumental variable (Z) is required to be relevant and valid. Concerning the relevance – father's occupation is likely to be a good predictor of children' occupations, because fathers can affect occupational preferences and choice of their children. More complicated is the issue of validity, which requires that the share of routine tasks in father's occupation is not directly related to children' earnings or correlated with the error term. The use of family background variables as instruments has been criticized in the literature (citation).

[1] As mentioned, the survey provides limited information about mothers' occupations. Mothers' occupations are reported only for those workers who indicate they did live together with father when they were 15 years old.
[2] For the IV estimation we applied the user-written "ivreg2" code (Baum et al., 2010). See Baum et al. (2007, 2003) for a discussion of the features of "ivreg2" and a comparison with "ivregress".



In the following chapter we provide an extensive discussion and formal "testing" of the validity of our instruments based on father's occupation. Additionally, we use lagged values of routine task-intensity of own occupation which go back to 1979. Hence, routine task-intensity of individual jobs in 2012 is instrumented with (i) routine task-intensity of father's occupation at the time when individuals were 15 years old, and (ii) lagged values of own occupation's routine task-intensity in the years 1979, 1985, 1991, 1998, 2006.

3.1 Constructing routine task-intensity (RTI) measures

To construct routine task-intensity measures, we utilize information provided by survey respondents on the frequency of performing seventeen work activities. Activities range from manufacturing and producing of goods to training and teaching (full list of activities in Table A1). Survey respondents are asked to indicate how often they performs each of these work activities. Frequency is coded on a three-point scale – often, sometimes and never.

Routine task-intensity measures are calculated at the individual level in few steps. Firstly, following Spitz-Oener (2006) all seventeen work activities in Table A1 are classified into five broad categories – non-routine analytic, non-routine interactive, routine cognitive, routine manual and non-routine manual. Second, raw task answers are standardized and composite task measures are created by summing up the standardized task data. Then the composite task measures are standardized again[3].

(2) $\mathbf{T_{ij} = \Sigma \text{ work activity }_j}$

whereas *i* stands for survey respondent and *j* indicates non-routine analytic (NRA), non-routine interactive (NRI), routine cognitive (RC), routine manual (RM) and non-routine manual (NRM).

Figure 1 presents the five standardized indexes for low, middle and highly educated individuals. As the graph shows, highly educated workers perform relatively more non-routine analytic and non-routine interactive tasks, while low and middle educated do more routine and non-routine manual tasks.

[3] In order to compare indexes, we follow the same calculation procedure as Acemoglu and Autor (2011). Hence, we first standardize the raw data and then the calculated indexes.

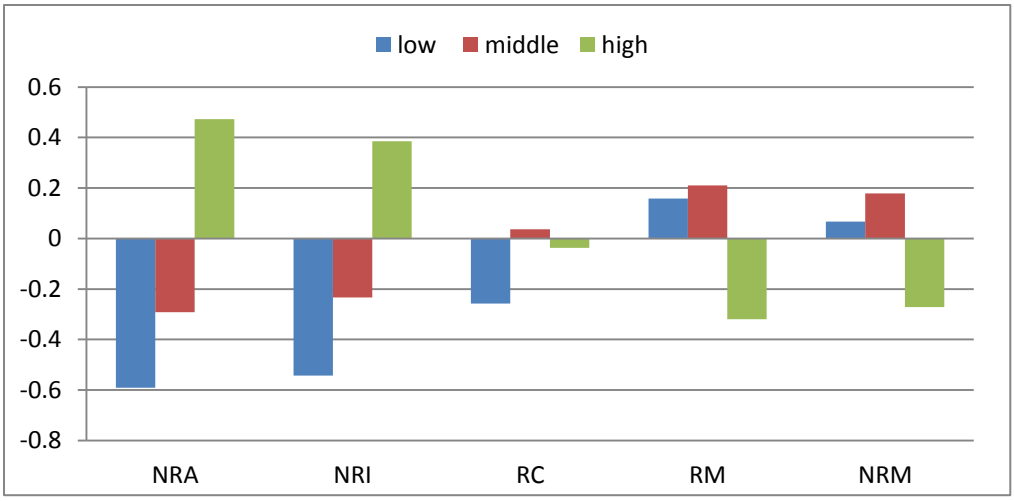


Figure 1. Education level and standardized task indexes

When the five indexes are aggregated into abstract (non-routine analytic and interactive), routine (routine cognitive and manual) and non-routine manual tasks, it seems that routine tasks are primarily done by workers with middle level of education.

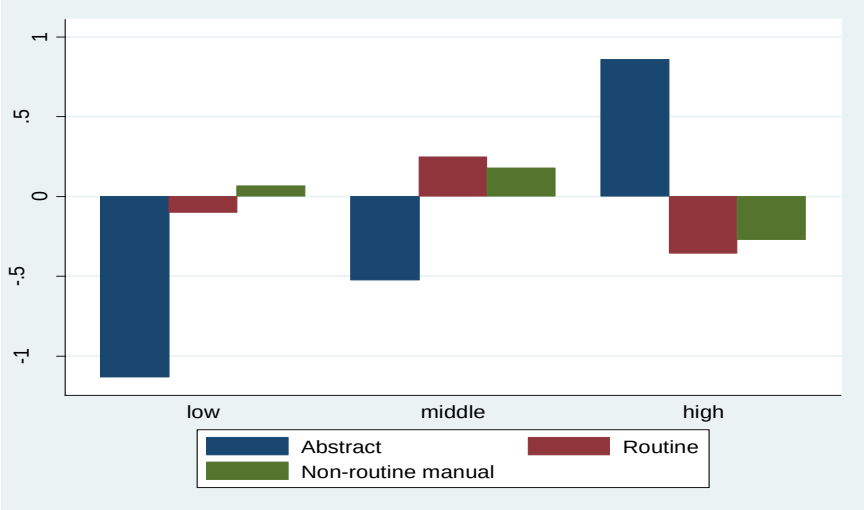


Figure 2. Educational level and routinization

To reduce dimensionality, following Autor and Dorn (2013), the five indicators are combined into a single composite measure of routine task-intensity (RTI).

(3) RTI = RC + RM - NRM – NRA - NRI

RTI is the variable of main interest for this analysis. Table 1 reports the routine task-intensity of nine major ISCO-08 occupations. Routinization is highest for Elementary occupations, Plant, machine operators and assemblers and Craft and related trades workers and lowest for Managers, Professionals and Technicians and associate professionals. There is a substantial variation *within* groups. This results from the fact that RTI is calculated at individual level and varies *within* and *between* occupations, but also the fact that the nine major occupations include sub-occupations with different degree of routinization.

Table 1. Routine task-intensity index by major occupations

Major occupations	RTI	SD
Managers	-1.39	1.71
Professionals	-1.31	1.70
Technicians and associate professionals	-.573	1.90
Clerical support workers	-.286	2.00
Services and sales workers	-.656	1.76
Skilled agric., forestry, fishery workers	-.327	1.75
Craft and related trades workers	1.53	2.02
Plant, machine operators and assemblers	1.85	1.95
Elementary occupations	2.11	1.91

Table 2 lists some examples of sub-occupations with different degree of routinization. Take for example the group of Elementary occupations. Labourers in mining, construction, manufacturing and transport have an RTI that is as twice as high as the routinization index of Cleaners and helpers. Numerical and material recording clerks have an index that is three times higher than Customer services clerks. These examples show furthermore that routinization is not one-to-one related to education or ability (see Table A2 in the appendix for a full list of two-digit occupations).

Table 2. Routine task-intensity by some sub-major occupations

Sub-major occupations	RTI	SD	Correlation RTI – years schooling
Professionals			-0.07
Health professionals	-2.53	1.59	0.38
ICT professionals	-1.06	1.52	-0.10
Clerical support workers			-0.16
Customer services clerks	-1.24	1.56	0.05
Numerical and material recording clerks	.281	2.20	-0.11
Plant, machine operators and assemblers			0.07
Stationary plant and machine operators	2.57	1.88	0.08
Drivers and mobile plant operators	1.41	1.86	0.05
Elementary occupations			-0.03
Cleaners and helpers	1.01	1.93	0.02
Labourers in mining, construction, manufacturing and transport	2.35	1.85	-0.13

Figure 2 shows the relationship between log hourly wages and routine task-intensity of individual jobs. The downward slope of the fitted line indicates a negative correlation between wages and routine tasks, correlation coefficient = -0.25.

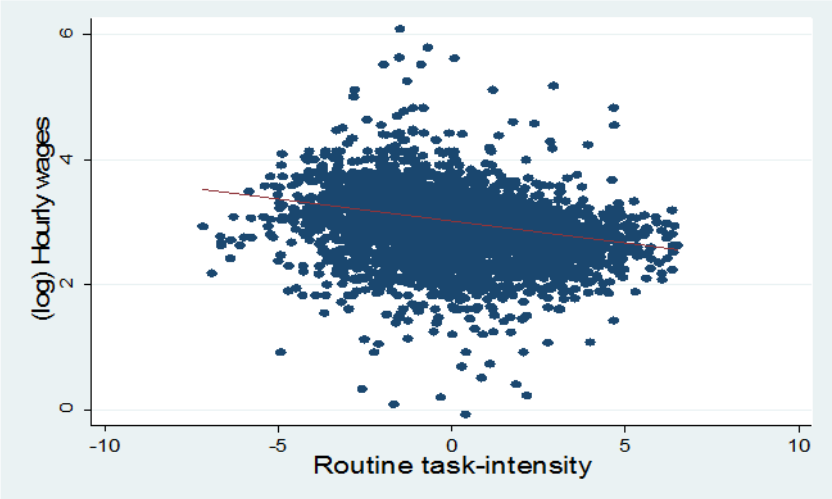


Figure 2. Correlation routine task-intensity of jobs and individual wages

3.2 Constructing instrumental variables

As mentioned, routine task-intensity of individual jobs is instrumented with routine task-intensity of father's occupation. From the survey we know what the occupation of the father was at the time when respondent was 15 years old. However, no information is provided about the tasks which fathers used to perform in these occupations. To calculate routine indexes for fathers we proceed in two steps. First, we aggregate individual RTIs to the two-digit occupational level (ISCO-08 occupational classification). This results in 43 unique routinization measures. Second, we append these measures to the occupations of the fathers.

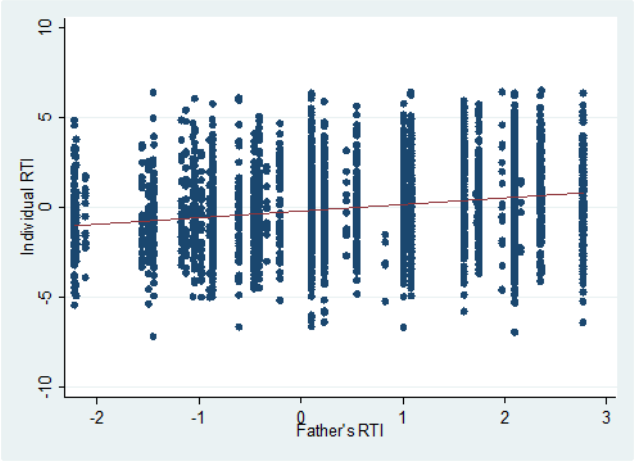


Figure 3. Correlation father's – worker's routine task-intensity

Figure 3 illustrates the relation between individual RTIs and father's RTIs (correlation=0.21). As the graph shows, fathers' routinization is occupation-specific and varies only *between* the 43 two-digit occupations. Oppositely, individual RTIs are worker-specific. By aggregating fathers' indexes at occupational level, we are able to average out the influence of any personal characteristics on these indexes.

Alternative definition instrument

As a sensitivity check, we construct a second instrument measuring routine task-intensity of father's occupation. We utilize an external online occupational database - O*NET, version 18.1. O*NET provides detailed information about hundreds of occupations and the work activities, skills, knowledge, abilities etc. associated with these occupations.

Following Autor's (2013) recommendation that researchers repeatedly use "off-the-shelf" routinization measures, we create the same task indexes as Acemoglu and Autor (2011) and Autor and Handel (2013). These are non-routine cognitive analytic, non-routine cognitive interactive, routine cognitive, routine manual, non-routine manual physical, non-routine manual personal. The Stata code used to create the six measures is borrowed from Acemoglu and Autor (2011).

As before, the six task measures are combined into a single routine task-intensity index:

(4) **RTI-ONET = RC + RM – NRA – NRI – NRM-physical – NRM-personal**

RTI-ONET is aggregated to two-digit occupational level (ISCO-08 classification) and appended to fathers' occupations.

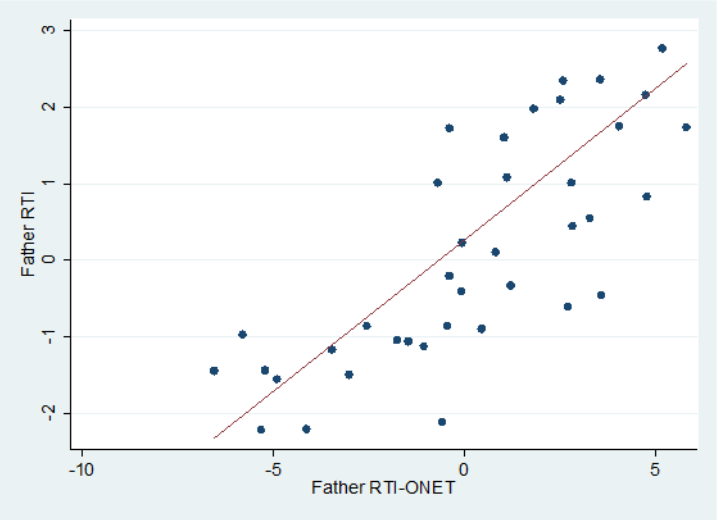


Figure 4. Correlation both instruments

As Figure 4 shows, there is a high positive correlation (corr. coefficient = 0.79) between both instruments. In the following the paper presents results from both instruments, as well as from other instruments based on lagged RTI values of own occupation.

Validity instruments

Instrumental validity is a central issue in each IV estimation. To be valid, instruments are required to satisfy three conditions. They need to be relevant – sufficiently correlated with the endogenous variable, excludable – being non-significant predictors of the dependent variable in the second-stage, and exogenous - being uncorrelated with the error term in the second-stage.

IV relevance can be tested straightforward, more complicated is the issue of exogeneity. Fathers' RTIs will not be valid if there are unobserved factors (such as common genes, ability, preferences) which affect both instruments and individual wages. Furthermore, fathers' RTIs might have a direct effect on individual wages. While we "test" both conditions in the following empirical analyses, here we provide some discussion of why we think our instruments are valid.

As evident from Table 1 and 2, individual RTI scores have a high variation within occupational groups. This suggests that seemingly similar individuals – i.e. those with same occupation or educational level –

perform different types of tasks. Stationary plant and machine operators do twice as much routine work as Drivers and mobile plant operators. Both occupation belong to the same major occupation and are likely to be very similar in terms of educational requirements or ability. This suggests that routinization is not one-to-one related to ability or education.

Since our instruments are hypothetical and constructed at 2-digit occupational level, they are practically unrelated to individual father-specific effects[4]. This makes us think that father RTI is uncorrelated with unobserved individual characteristics in the second-stage equation. Also the direct influence of the instruments on individual wages will be limited, once we control for own occupation (including up to 43 occupation dummies) and a very detailed set of observables. Both – exogeneity and excludability – conditions will be thoroughly examined in the empirical section.

5 Preliminary results[5]

Table 3 presents some selected regression results - the estimated effect of RTI on individual hourly wages. For a complete overview of results, including all control variables, the interested reader is referred to Table A4 in the appendix.

Table 3. Estimation results log(hourly wages)

	(1) OLS	(2) OLS	(3) IV-2SLS	(4) IV-2SLS	(5) IV-2SLS	(6) IV-2SLS
First-stage results						
Father RTI	-	-	.369***	.108***	.082***	.082***
			(12.77)	(4.17)	(3.31)	(3.32)
F-test excl. instr.	-	-	163.14	17.36	10.99	11.04
Hausman endogeneity	-	-	35.218***	9.423**	5.713*	3.842*
			[0.0000]	[0.0021]	[0.0168]	[0.0500]
Second-stage results						
RTI	-.061***	-.012***	-0.173***	-0.178**	-0.172*	-0.145+
	(-16.11)	(-3.27)	(-8.34)	(-2.77)	(-2.09)	(-1.88)
Controls	No	Yes	No	Yes	Yes	Yes
10 dummies *first* occupation	No	Yes	No	Yes	Yes	Yes
10 dummies *current* occup.	No	-	No	No	Yes	-
43 dummies current occup.	No	Yes	No	No	-	Yes
N	**3,212**	**3,212**	**3,212**	**3,212**	**3,212**	**3,212**

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, + p<0.1. *t* statistics in parentheses, p values in [ ].
Controls include demographic characteristics, education, detailed employment history and unemployment duration, job and work-place characteristics (job complexity, supervisory position, irregular working hours, stand-up duty, working with computers etc.), 17 dummies for firm location, 21 dummies for firm sector, dummies for firm size and economic situation.

[4] Remember that we have no information about the tasks which fathers performed on their job. Our instruments represent a hypothetical measure of what father's RTI would have been based on his occupation.

[5] All Stata DO-files will be made available online after the paper is completed. Raw data is available from GESIS.

Table 3 reports first and second-stage results for RTI. The sample includes full-time working males. We consider as full-time working all individuals who work at least 30 hours per week. By selecting full-time workers only, the paper aims to reduce unobserved heterogeneity. Additional analyses show that the results are not sensitive to different definition of full-time (e.g. working time ≥ 20 or ≥ 40 hours per week).

Looking at the first-stage results, fathers' RTIs seem to be sufficiently correlated with individual RTIs. F-statistic of excluded instruments is above 10 in all estimated models (F-statistic > 10 is a rule-of-thumb for rejecting the null-hypothesis of weak instruments, see Staiger and Stock, 1997)[6].

Model (1) and (2) report results from OLS estimation. Results from IV estimation are presented in models (3) – (6). Turning to the second-stage results, the empirical analysis finds a negative and significant relationship between log hourly wages and routine task-intensity of individual jobs. The estimated effect is consistently significant across various specifications in which we gradually include additional covariates. Also, the size of the estimated coefficient remains relatively stable in all IV-2SLS models. The RTI coefficient drops somewhat in size and significance in model (6). However, it is worth noting that in this specification we include 43 occupational dummies. This is a very demanding specification, because RTI is highly correlated with occupations. Table A4 in the appendix presents full estimation results from second-stage.

=== MORE EXTENSIVE DISCUSSION OF RESULTS TO BE ADDED ===

Unobserved individual ability

One concern with the estimation of wage equations with cross-sectional data is that of unobserved individual heterogeneity. Individual-specific characteristics such as motivation, ability, personal appearance and others may not be fully observed in cross-sectional data. To reduce unobserved heterogeneity, we re-estimate model (6) in Table 3 adding a set of dummy variables controlling for overall score of the last completed training (training lasting for at least 12 months). The score can be seen as an approximation of individual ability/motivation. The overall score is coded on a 4-point scale in the data – very good, good, satisfactory and sufficient.

Table 4 presents results for middle and highly educated workers. Low educated individuals (schooling ≤ 10 years) are excluded from the analysis. The reason for this is the small number of low educated individuals who report score of the last completed training. Table 4 shows that the estimated effect of RTI on log hourly wages in very similar to the results in Table 3.

Table 4. Estimation results log(hourly wages), middle and high educated (schooling >10 years)

	(6) **IV-2SLS**
First-stage results	
Father RTI	.084*** (3.32)
F-test excl. instr.	10.99
Second-stage results	
RTI	-.145^{+} (-1.88)
N	3.016

Robust t statistics in parentheses, * p < 0.05, ** p < 0.01, *** p < 0.001, $^{+}$ p < 0.1.
Model (6) is the same as model (6) in Table 3 including additionally dummy variables for overall score of the last completed training

[6] Cited in Baum et al. (2007).

Alternative definition father's occupation RTI

This section examines the robustness of the estimated results to alternative definitions of father's RTI. As mentioned, a second measure of routine task-intensity is constructed that utilizes information provided by O*NET. Sensitivity results are reported in column (1) – (4) in Table 5. *Father RTI-ONET* stands for the second instrument and *Father RTI* for the first instrument. Column (5) and (6) show estimated from both instruments used simultaneously. The estimated effects in Table 5 are very similar to the results in Table 3. The Sargan-Hansen test of overidentifying restrictions fails to reject the joint null hypothesis that both instruments are uncorrelated with the error term. As Nichols (2007) points out, failing to reject the null hypothesis is not a prove of instrument validity. However, it gives some confidence.

In the following sections we are going to further scrutinize the validity of both instruments by including each of them as a right hand side variable in the second-stage equation, while using the other variable as instrument.

Table 5. Estimation results log(hourly wages), O*NET instrumental variable

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	IV-2SLS	**IV-2SLS**	**IV-2SLS**	**IV-2SLS**	**IV-2SLS**	**IV-2SLS**
First-stage results						
Father RTI	-	-	-	-	.444***	.083+
					(9.31)	(1.95)
Father RTI - ONET	.129***	.047***	.042***	.042***	-.046*	.016
	(9.06)	(3.81)	(3.55)	(3.58)	(-2.00)	(0.78)
F-test excl. instr.	82.02	14.53	12.58	12.84	82.92	9.13
Hausman endogeneity	15.320***	9.221**	7.463**	6.164*	37.404***	10.205**
	[0.0001]	[0.0024]	[0.0063]	[0.0130]	[0.0000]	[0.0014]
Hansen J. statistic	-	-	-	-	0.019	0.151
					[0.8908]	[0.6975]
LM redundancy – father RTI	-	-	-	-	79.677***	3.861*
					[0.0000]	[0.0494]
LM redundan. – father RTI-ONET	-	-	-	-	3.985*	0.626
					[0.0459]	[0.4288]
Second-stage results						
RTI	-0.171***	-0.196**	-0.187*	-0.173*	-0.174***	-0.183**
	(-5.80)	(-2.64)	(-2.32)	(-2.24)	(-8.47)	(-2.87)
Controls	No	Yes	Yes	Yes	No	Yes
10 dummies *first* occupation	No	Yes	Yes	Yes	No	Yes
10 dummies *current* occ.	No	No	Yes	-	No	No
43 dummies *current* occ.	No	No	-	Yes	No	No
N	**3,212**	**3,212**	**3,212**	**3,212**	**3,212**	**3,212**

Robust t statistics in parentheses, * p < 0.05, ** p < 0.01, *** p < 0.001, + p<0.1.
Controls include demographic characteristics, education, detailed employment history and unemployment duration, job and work-place characteristics (job complexity, supervisory position, irregular working hours, stand-up duty, working with computers etc.), 17 dummies for firm location, 21 dummies for firm sector, dummies for firm size and economic situation.

6 Sensitivity analyses

This section examines the sensitivity of estimated results with respect to using alternative definitions of the endogenous variable - RTI - as well as additional instrumental variables – lagged values of worker's own occupation RTI.

Alternative definition endogenous variable

So far we presented results from RTI – our endogenous variable – which is constructed at individual level. The main advantage of an individual RTI index is that it can vary between and within occupations. As we saw in Table 1 and 2, the variation of RTI is substantial even within detailed occupations.

In this section we create a second routinization measure from O*NET data. This index is occupation-specific and varies only between occupations. we attach this new index to the occupation of each respondent (3-digit level). Thus, our new index is occupation-specific at the 3-digit level.

Figure 3 compares both measures. RTI stands for the first individual-specific index and RTI-ONET for the new occupation-specific index. Overall, both indexes show similar trend in routine task-intensity across major occupations. One pronounced exception is Clerical support workers.

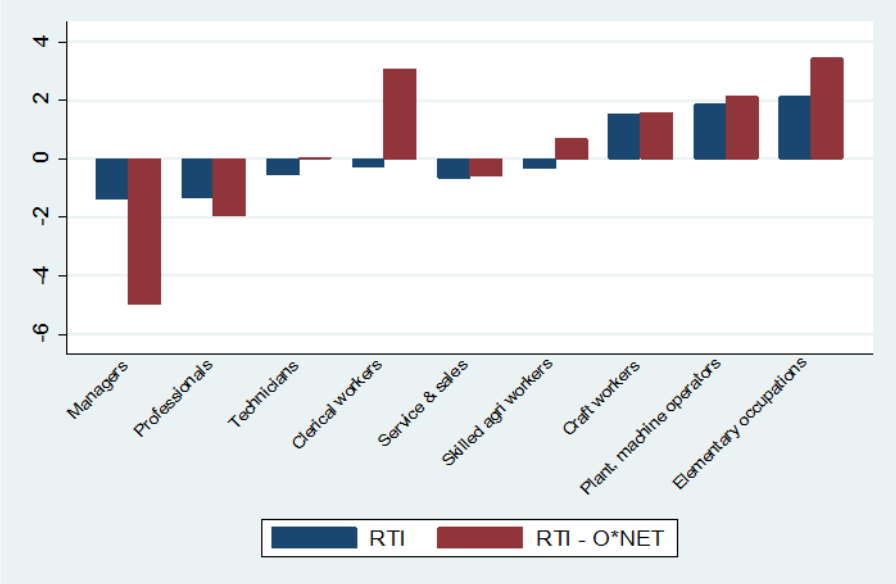


Figure 3. Routine task-intensity per major occupation

RTI and RTI-ONET are depicted in Figure 4. The correlation coefficient is 0.41.

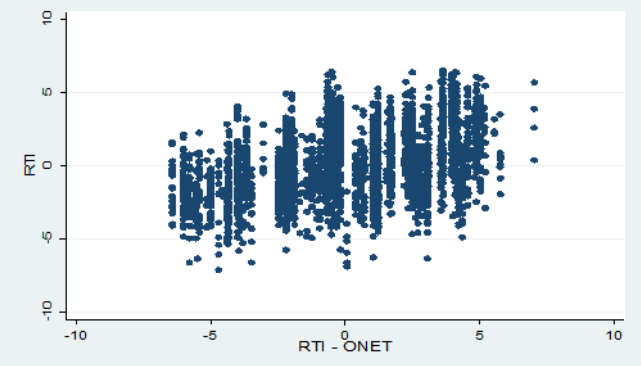


Figure 4. Individual and occupation-specific routnization measures

=== further explanation follows ===

Table 6 presents some preliminary results with RTI-ONET. Colum (1) shows results with no covariates included and Colum (2) with all covariates included. RTI-ONET is occupation-specific and therefore we do not include dummies for current occupation. These results are very similar to our baseline estimates.

Table 6. Estimation results log(hourly wages), RTI-ONET

	(1) IV-2SLS	(2) IV-2SLS
First-stage results		
Father RTI	.388***	.106**
	(10.12)	(3.00)
F-test excl. instr.	102.49	8.98
Hausman endog.	41.904***	8.678**
	[0.0000]	[0.0032]
Second-stage results		
RTI-ONET	-0.165***	-0.182*
	(-7.75)	(-2.42)
Controls	No	Yes
10 dummies *first* occupation	No	Yes
10 dummies *current* occupation	No	No
43 dummies *current* occupation	No	No
N	**3212**	**3212**

Robust t statistics in parentheses, * p < 0.05, ** p < 0.01, *** p < 0.001.
Controls include demographic characteristics, education, detailed employment history and unemployment duration, job and work-place characteristics (job complexity, supervisory position, irregular working hours, stand-up duty, working with computers etc.), 17 dummies for firm location, 21 dummies for firm sector, dummies for firm size and economic situation.

Second alternative definition endogenous variable

So far I utilized information on work activities – such as manufacturing of goods, training, teaching, guarding etc. – to create task routinization measures. The survey, however, provides also a wealth of information about work context and work demands. Using some of this information I create a third measure of routine task-intensity (ROUTINE). ROUTINE is created from the answers of survey respondents and is thus individual-specific.

In particular, I use the answers to four questions to construct the new index. In the survey, respondents are asked about the frequency that they (i) are given highly specific regulations on how to perform their work, (ii) have to repeat the same step in every detail, (iii) are facing new tasks which you have to think through and get familiar with, and (iv) improve existing procedures or try something new.

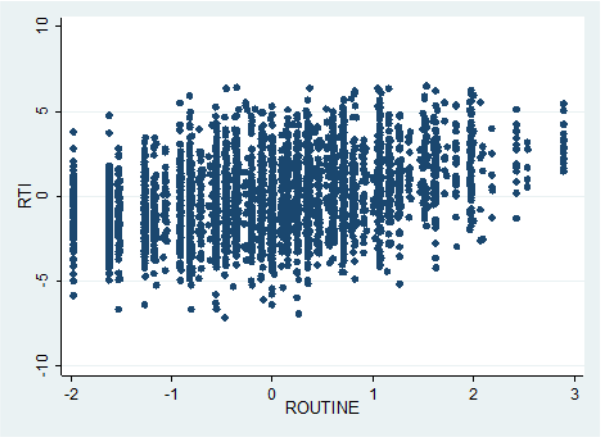


Figure 5. Correlation RTI – ROUTINE

=== estimation results follow ===

Instrumental variables based on lagged RTI values

In addition to routine task-intensity of father's occupation, we use lagged RTI values of worker's own occupation.

=== results follow ===

7 Preliminary conclusion

This paper is work-in-progress in early stage and there are no conclusions yet.

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Appendix A

Table A1: Work activities

Code	Classification	Work activity
F303	RM	Manufacturing, producing goods and commodities
F304	RC	Measuring, testing, quality control
F305	RM	Monitoring, control of machines, plants, technical processes
F306	NRM	Repairing, refurbishing
F307	NRI	Purchasing, procuring, selling
F308	RM	Transporting, storing, shipping
F309	NRI	Advertising, marketing, public relations
F310	NRI	Organising, planning and preparing work processes
F311	NRA	Developing, researching, constructing
F312	NRI	Training, instructing, teaching, educating
F313	NRA	Gathering information, investigating, documenting
F314	NRI	Providing advice and information
F315	NRM	Entertaining, accommodating, preparing food
F316	NRM	Nursing, caring, healing
F317	NRM	Protecting, guarding, patrolling, directing traffic
F320	NRM	Cleaning, removing waste, recycling

Classification is based on Spitz-Oener (2006) and Antonczyk et al. (2009). NRA = non-routine analytic, NRI = non-routine interactive, RC = routine cognitive, RM = routine manual, NRM = non-routine manual

Table A2. Descriptive statistics

	Mean	SD
Dependent variable		
log (hourly wage)	2.90	.563
Demographic variables		
years of schooling	14.43	2.26
low education	.032	.176
middle education	.573	.494
high education	.393	.488
immigrant	.092	.289
married/cohabiting	.559	.496
children	.631	.482
male	1	0
Employment history		
experience	25.71	10.92
tenure	13.84	10.99
# employers since 1st job	3.86	3.27
interrupted work activity since 1st job	.453	.497
ever been unemployed	.332	.471
duration unemployment	.484	1.22

first occupation (ISCO-08 major groups)		
- managers	.009	.098
- professionals	.128	.334
- technicians & associate professionals	.097	.296
- clerical support workers	.095	.294
- services & sales workers	.073	.260
- Skilled agricultural workers	.018	.133
- craft & related trades	.453	.497
- plant & machine operators	.055	.229
- elementary occupations	.050	.219
Workplace variables		
working hours (per week)	44.17	10.30
regular working hours (7am-7pm)	.784	.411
stand-by-duty	.198	.399
work in weekend (regularly or occasionally)	.757	.428
working with computer (% of work-time)	40.71	33.29
supervisory position	.412	.492
current occupation (ISCO-08 major groups)		
- managers	.085	.279
- professionals	.199	.399
- technicians & associate professionals	.214	.410
- clerical support workers	.076	.265
- services & sales workers	.066	.249
- skilled agricultural workers	.013	.116
- craft & related trades	.220	.414
- plant & machine operators	.089	.286
- elementary occupations	.033	.179
Observations	3,348	

Table A3. Routine task-intensity by some sub-major occupations

Sub-major occupations	**RTI**	**SD**	**Years schooling**	**Correlation RTI – years schooling**
Managers				
Chief Executives, Senior Officials and Legislators	-1.47	1.52	15.81	-0.25
Administrative and Commercial Managers	-1.59	1.58	15.95	-0.22
Production and Specialized Services Managers	-1.03	1.77	15.50	-0.26
Hospitality, Retail and Other Services Managers	-1.91	1.90	14.15	-0.33
Professionals				
Science and Engineering Professionals	-1.07	1.55	17.45	-0.05
Health Professionals	-2.53	1.59	17.30	0.38
Teaching Professionals	-2.45	2.32	15.77	0.19
Business and Administration Professionals	-1.24	1.78	16.04	-0.24
Information and Communications Technology	-1.06	1.52	16.10	-0.10

Professionals				
Legal, Social and Cultural Professionals	-1.41	1.48	17.06	-0.08
Technicians and Associate Professionals				
Science and Engineering Associate Professionals	-.15	1.84	14.44	-0.17
Health Associate Professionals	-.77	1.87	13.48	-0.01
Business and Administration Associate Professionals	-1.07	1.70	14.91	0.03
Legal, Social, Cultural and Related Associate Professionals	-2.23	2.31	14.29	-0.11
Information and Communications Technicians	-1.13	1.84	14.7	-0.13
Clerical Support Workers				
General and Keyboard Clerks	-.80	1.39	13.72	-0.36
Customer Services Clerks	-1.24	1.56	13.86	0.05
Numerical and Material Recording Clerks	.281	2.20	13.38	-0.11
Other Clerical Support Workers	-.04	2.05	13.5	-0.12
Service and Sale Workers				
Personal Services Workers	-.38	1.53	13.54	-0.12
Sales Workers	-.52	1.77	13.81	-0.14
Personal Care Workers	-2.56	1.85	13.81	0.01
Protective Services Workers	-1.27	1.69	13.33	-0.30
Skilled Agricultural, Forestry and Fishery Workers				
Market-oriented Skilled Agricultural Workers	-.31	1.77	14.66	-0.25
Market-oriented Skilled Forestry, Fishery and Hunting Workers	-.84	.	13	.
Craft and Related Trade Workers				
Building and Related Trades Workers (excluding Electricians)	1.05	1.84	13.22	-0.05
Metal, Machinery and Related Trades Workers	1.85	2.15	13.16	-0.06
Handicraft and Printing Workers	1.97	1.83	13.62	-0.48
Electrical and Electronic Trades Workers	1.07	1.89	13.40	-0.10
Food Processing, Woodworking, Garment and Other Craft and Related Trades Workers	1.79	1.92	13.31	-0.28
Plant, Machine Operators and Assemblers				
Stationary Plant and Machine Operators	2.57	1.88	12.96	0.08
Assemblers	1.02	1.84	12.53	-0.24
Drivers and Mobile Plant Operators	1.41	1.86	12.78	0.05
Elementary occupations				
Cleaners and Helpers	1.01	1.93	13.64	0.02
Agricultural, Forestry and Fishery Labourers	2.47	1.10	13.8	0.05
Labourers in Mining, Construction, Manufacturing and Transport	2.35	1.85	12.75	-0.13
Food Preparation Assistants	2.57	.53	13.66	0.87

Refuse Workers and Other Elementary Workers	-.16	2.43	11.5	0.87

Table A4. Full estimation results log(hourly wages)

	(1) OLS	(2) OLS	(3) IV-2SLS	(4) IV-2SLS	(5) IV-2SLS	(6) IV-2SLS
Second-stage results						
RTI	-0.0617***	-0.0127**	-0.173***	-0.178**	-0.172*	-0.145
	(-16.11)	(-3.27)	(-8.34)	(-2.77)	(-2.09)	(-1.88)
Low education (ref.)	-	-	-	-	-	-
Middle education	-	0.113*	-	0.126*	0.109*	0.110*
		(2.53)		(2.27)	(2.02)	(2.22)
High education	-	0.206***	-	0.166*	0.157*	0.162**
		(4.30)		(2.31)	(2.56)	(2.79)
Married	-	0.0627***	-	0.0624**	0.0637**	0.0669***
		(3.73)		(2.90)	(3.07)	(3.43)
Children	-	0.0277	-	0.0127	0.0113	0.0104
		(1.60)		(0.54)	(0.48)	(0.47)
Migration	-	0.0162	-	0.0173	0.0138	0.00125
		(0.58)		(0.51)	(0.41)	(0.04)
Health	-	0.0497***	-	0.0487***	0.0485***	0.0490***
		(5.78)		(4.33)	(4.48)	(4.95)
Employment history						
Experience	-	0.0180***	-	0.0161***	0.0158***	0.0171***
		(6.06)		(4.27)	(4.34)	(5.12)
Experience^2	-	-0.00029***	-	-0.00025***	-0.00023**	-0.00026***
		(-4.91)		(-3.37)	(-3.26)	(-3.90)
Tenure	-	0.00623***	-	0.00535***	0.00529***	0.00527***
		(7.02)		(4.67)	(4.47)	(4.63)
# employers	-	-0.00474	-	-0.00717*	-0.00678*	-0.00631*
		(-1.78)		(-2.29)	(-2.19)	(-2.19)
Ever unemployed	-	-0.0406	-	-0.0569*	-0.0618*	-0.0559*
		(-1.86)		(-2.14)	(-2.21)	(-2.21)
Duration unemployed	-	-0.0312*	-	-0.0289*	-0.0251	-0.0238
		(-2.49)		(-2.02)	(-1.66)	(-1.78)
Job-related						
Immediate supervisor	-	0.0775***	-	0.00905	0.00538	0.000346
		(5.12)		(0.20)	(0.11)	(0.01)
Job complexity	-	0.119***	-	0.0596	0.0606	0.0660

		(5.52)		(1.40)	(1.42)	(1.66)
% working with PC	-	0.000402 (1.35)	-	-0.00113 (-1.22)	-0.000733 (-1.05)	-0.000712 (-0.97)
Working hours	-	-0.00779*** (-7.14)	-	-0.00978*** (-4.84)	-0.00995*** (-4.91)	-0.00997*** (-5.50)
Working hours 7-7pm	-	0.0207 (1.08)	-	-0.0782 (-1.40)	-0.0699 (-1.30)	-0.0484 (-1.02)
Stand-by-duty	-	-0.0130 (-0.74)	-	-0.0513 (-1.86)	-0.0509 (-1.89)	-0.0376 (-1.57)
Work weekend	-	0.0149 (0.90)	-	0.00695 (0.32)	-0.000568 (-0.02)	-0.00374 (-0.17)
Firm variables Firm size <10 (Ref.)						
Firm size 1--49	-	0.0826** (3.24)	-	0.156*** (3.46)	0.147** (3.05)	0.144** (3.20)
Firm size 50-99	-	0.100*** (3.64)	-	0.166*** (3.38)	0.154** (2.96)	0.163*** (3.45)
Firm size 100-249	-	0.123*** (4.49)	-	0.197*** (4.24)	0.175*** (3.60)	0.183*** (4.00)
Firm size 250-499	-	0.134*** (4.62)	-	0.199*** (4.25)	0.193*** (3.67)	0.200*** (4.11)
Firm size >500	-	0.214*** (8.47)	-	0.275*** (7.15)	0.265*** (5.89)	0.272*** (6.32)
Econ. situation firm	-	0.0765*** (7.34)	-	0.0629*** (4.30)	0.0663*** (4.60)	0.0664*** (4.87)
Occupation, region, sector dummies						
21 firm sector dummies	-	Yes	-	Yes	Yes	Yes
17 firm location dummy	-	Yes	-	Yes	Yes	Yes
10 dummies *first* occ.	-	Yes	-	Yes	Yes	Yes
10 dummies *current* occ.	-	-	-	-	Yes	-
43 dummies *current* occ.	-	Yes	-	-	-	Yes
Constant	2.917*** (316.87)	1.756*** (12.86)	2.917*** (285.26)	2.166*** (7.95)	2.416*** (10.99)	2.070*** (8.59)
F – tests						
Sector dummies	-	[0.0000]	-	[0.0000]	[0.0000]	[0.0000]
Location dummies	-	[0.0000]	-	[0.0000]	[0.0000]	[0.0000]
Dummies first occupation	-	[0.0000]	-	[0.0000]	[0.0000]	[0.0000]
10 dummies current occ.	-	-	-	-	[0.0000]	-
43 dummies current occ.	-	[0.0000]	-	-	-	[0.0000]
N	3212	3212	3212	3212	3212	3212
adj. R^2	0.067	0.501	-0.153	0.159	0.206	0.322