

The Enriching Complexity of Complex Tasks:
Revisiting the Mechanisms behind Individual and Regional
Productivity Growth

Short summary of the dissertation

In partial fulfillment of the requirements for the degree doctor rerum
politicarum (Dr. rer. pol.)

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Ingolstadt, July, 2, 2020

Overview of the contributions

In my dissertation, I use a combination of theoretical and empirical methods to analyse the role of a specific kind of human capital—namely, the skill that is used to acquire other types of human capital in the process of lifelong learning. The learning skill is approximated by an individual’s ability to solve complex problems in daily life. It is a type of a cognitive skill and is related to complex problem solving skills studied in cognitive psychology (Fischer, Greiff & Funke, 2012; Funke, 2010; Greiff et al., 2013; Wüstenberg, Greiff & Funke, 2012) although it is not limited to a type of intelligence. Learning and problem solving skills were discussed already by Arrow (1962), although it was not until Herbert Simon that the concept was investigated properly (Anzai & Simon, 1979; Simon, 1975). Experimental evidence on learning and complexity shows that they are interrelated (Argote, Insko, Yovetich & Romero, 1995; Jovanovic & Nyarko, 1995). In relation to other types of learning already considered in economics (formal learning, learning-by-dong, signalling, and learning-by-interaction), learning by problem-solving is a distinct kind that does not reduce to any of them, although it is closest to learning-by-doing. The importance of problem solving skills is highlighted by the fact that they predict earnings (Ederer, Nedelkoska, Patt & Castellazzi, 2015; Patt, 2015) and contribute to understanding innovativeness (Ederer, Patt & Greiff, 2016). To this date, little research has been done to synthesise the role of problem solving skills in relation to economic issues.

More specifically, the research collected in this dissertation contributes to answering three fundamental questions:

- (i) How does complexity at work help us understand lifecycle wage dynamics?
- (ii) How does it help us understand labour supply decisions?
- (iii) How does it explain general equilibrium-level outcomes, such as regional productivity differences?

An answer to the first question explains why we should care about complexity and problem solving skills. If these skills are indeed important, then understanding which economic policies can facilitate their acquisition requires going beyond an analysis of individual-level outcomes, since they are largely determined by occupational structures. This is accomplished by answering the second and the third question, which provide the tools to discuss the supply and demand side of such skills in a general equilibrium framework. Since these questions are broad in nature, I focus on migration as one specific determinant of the supply of skills.

What made possible tackling all these questions are recent advances in data collection, which made available detailed information on daily tasks per-

formed by workers from job content surveys such as the Dictionary of Occupational Titles (DOT) and Occupational Information Network (O*NET) in the US, Employment Surveys (BIBB) in Germany, CONOCER in Mexico, and others. Following the work of Autor and Handel (2013), Autor, Levy and Murnane (2003), Caines, Hoffmann and Kambourov (2017), Ingram and Neumann (2006), Yamaguchi (2012), I use tasks data to create novel measures of skills. Such skill measurement approach captures a broader set of skills compared to cognitive intelligence test scores. Its primary advantage lies in applicability to the entire working adults population with no need for expensive psychometric testing in the field. Combining information on tasks with a learning-by-doing framework allows to infer actual skills that individuals have from their employment history. The new measure of human capital is different from other measures such as demographic background, education, training, and years of work experience. Unlike education, it is informative about individual productivity during the entire career.

Several implications for economic policy-making emerge based on the new results collected in this dissertation. First, since my research shows that occupational skills are an integral part of human capital, economic policy needs to take them into account when evaluating the effect of education expenditures on human capital. As the model presented in the first paper demonstrates, in the long run the nature of occupational tasks becomes more important for shaping individual human capital than education. Second, economic policies during recessions should reevaluate the social cost of unemployment, since it needs to correctly account for the loss of potential human capital due to absence of learning when jobs are destroyed. High levels of youth unemployment as for example observed in Spain, Italy, and Greece following the Great Recession were in particular detrimental for human capital development in those countries. Third, the implication for developing economies is that they need to invest in improving problem solving skills of their population in order to catch up with the frontier. Lowering migration costs and improving inter-industry linkages to increase spillover effects from learning and technology adoption can constitute complementary policies. Finally, understanding the effects of migration calls for improving the measurement and collection of direct data on job tasks, in particular in countries with large cross-border migration flows.

Summary of the contributions

Paper 1—Learning and Lifecycle Wage Dynamics

Authors: Peer Ederer, Ljubica Nedelkoska, Alexander Patt

In the first paper, I introduce a human capital development model and apply it to an analysis of earnings dynamics over lifecycle. The idea of the model is to relate individual learning-by-doing to the level of job complexity and accumulated problem solving skills. As pointed by Arrow (1962), learning-by-doing is primarily driven by learning by problem-solving. In this sense, a job is a collection of daily tasks (“problems”) with varying complexity. Jobs characterised by greater intensity of complex tasks create a better learning environment. Learning on the job causes an increase in skills and earnings over time.

The model has two key implications. First, workers in different jobs accumulate skills at different rates, which gives rise to occupation-specific wage profiles. The differences in the profiles are hard to reconcile with the standard Mincer model which is based on declining formal learning (Ben-Porath, 1967) and does not allow the slope of the earnings profile to vary with occupation. Second, unlike linear skill accumulation models (e.g., Keane and Wolpin, 1997; Yamaguchi, 2012), individual skills converge to an occupation-specific value, which explains why experience-earnings profiles are concave.

The empirical part of the paper tests the human capital model using a novel job complexity measure obtained by the principal component analysis (PCA) of the tasks items in the German BIBB/BAuA work content survey. In order to represent the complexity dimension, the PCA is applied on a subset of survey items which are closely related to problem-solving and dealing with novelty. This allows to create a complexity score for 120 distinct occupations available in the administrative data and impute the level of complexity faced by individuals at work using their job codes.

Most of the empirical literature on individual learning is hindered by a lack of suitable data on skills measured for the same individual over time. The empirical design overcomes this problem by showing that the model can be identified from wage dynamics data when tenure approaches zero. To estimate all model parameters, two complementary approaches are used. First, the estimates of historic returns to schooling, job complexity, and tenure for the period 1980-1995 using German administrative data allow to measure skill elasticities. Second, running wage growth regressions for fresh labour market entrants allows to identify the learning rate. Compared to other research on complexity and learning (e.g., Jovanovic and Nyarko, 1995, 1997), this approach provides a test of the theory for the entire occupational spectrum.

I find that wage growth is positively related to job complexity and negatively related to the starting skill level. The parameter estimates suggest that

workers in highly complex occupations acquire twice as much human capital throughout life compared to workers in simple occupations. Employees receive a positive wage premium to the complexity of their job. The premium can be decomposed into static and dynamic parts. On-the-job learning accounts for about 20–50% of all skills that workers have by retirement, depending on job complexity. The findings are robust to controlling for year, birth cohort, industry, regional, and occupational effects. This suggests that learning-by-doing is a far more important earnings determinant than investment in education and training that have been the focus of the literature.

The results conveyed in the paper have important implications for the evaluation of the effects of structural changes in occupational composition on human capital development and income inequality, such as job polarisation in USA and Europe as documented by Autor, Katz and Kearney (2006), Autor et al. (2003), Goos, Manning and Salomons (2009). However, any immediate policy recommendation needs to take into account several potential limitations of the empirical design. On the theory side, the learning model does not consider other skill dimensions. For example, broad cognitive, interpersonal, and manual skills also play a role in wage determination. On the measurement side, changes in task content over time and during career in the same occupation are not observed and can lead to biases in the estimates. Since the identification relies on using the data on fresh labour market entrants, one needs to take into account employer-employee matching and its effect on early job transitions. Finally, there can be potential endogeneity due to unobservable ability shifts over time. All these limitations will need to be addressed in future research.

Paper 2—Selection on Cognitive and Manual Skills

Authors: Miguel Flores, Alexander Patt, Jens Ruhose, Simon Wiederhold

In the second paper, I take a broader approach to skills and introduce novel measures of cognitive and manual skills to study the movement of labour across countries using the case of Mexican migration to the US. The cognitive measure considered in this paper is closely related to job complexity, however, it is derived from a broader set of items that represent a skill which facilitates performance in any cognitive task.

The theoretical part of the paper is based on the Roy (1951) model, which shows the connection between earnings and occupational choices. The model was first applied to the context of international migration by Borjas (1987) who argued that cross-border movement of labour is driven by differences in the returns to economic factors. Surprisingly little research has been done to date on connecting occupational skills to migration. Using a two-dimensional measure of human capital, the paper presents the first evidence on the role of occupational choices and implied skills for migrant selection.

Since the Roy-Borjas migration model is formulated in terms of unobservable skills, I introduce a refined model that allows to identify migrant selection from the difference in the returns to observable two-dimensional skills and correlation strength between the skills in the population. The model shows that under broad conditions with skill price equalisation across jobs, individuals will maximise the skills-tasks match quality, which makes it possible to infer workers' skills from their tasks. This provides an alternative justification for deriving skill measures from the tasks data compared to the learning-by-doing framework developed in the first paper. To obtain sharp results, the model assumes that skills are exogenous and migration decision is static, thus ignoring possible dynamic implications of return migration (Dustmann, Fadlon & Weiss, 2011).

The empirical part of the paper uses skill measures obtained with the PCA of the data from the US O*NET and Mexican CONOCER surveys. For the first time work content surveys are combined across countries to produce comparable skill measures, which is achieved by creating a mapping between similar items in both surveys and using the same calculation procedure to obtain the scores. Following such an approach ensures that the skills are measured in the same units in both countries, and therefore skill returns comparison is meaningful.

The paper presents three main findings. First, Mexican migrants to the US are positively selected on manual skills and negatively selected on cognitive skills. Second, the direction of selection is related to the difference in returns to these skills. Third, the role of other factors in explaining selection is considerably reduced once variation in the returns to occupational skills is taken into account. These findings also hold within narrowly defined region-industry-

occupation cells and for all education levels. Thus, the research on migrant selection on cognitive and manual skills reaffirms the Roy-Borjas model and reinterprets previous empirical evidence on migration determinants, such as differences in the returns to education and basic worker characteristics.

Paper 3—Regional Productivity Differences

Author: Alexander Patt

In this final paper, I combine the insights on the role of cognitive skills in determining earnings and migration from the first two papers and introduce a general equilibrium model of technological adoption. The model shows how differences in regional problem solving skills lead to variation in per capita income and its growth. I present both theoretical and empirical evidence on the relation between economic growth and tasks-based measures of human capital.

The theoretical part is based on extending the spatial model of Fujita, Krugman and Venables (1999) by allowing for labour heterogeneity and technological growth. The key implication of the model is that migration costs and a positive externality in technology adoption give rise to an empirical relation between average income and problem solving skills in a region. The model generalises the results on migrant selection from the second paper by allowing skill returns to vary in relation to local demand and supply for heterogeneous skills. The results still imply negative selection on cognitive skills for migrants from a relatively unskilled region, thus confirming the observation on the pattern of Mexican migration to the US made in the second paper.

The empirical part uses the measure of problem solving skills obtained from job complexity in the first paper and presents non-causal evidence on the role of job complexity in predicting income growth in 203 regions in Europe during 2000-2017. Due to absence of work content surveys for every country in the sample, I rely on the measures obtained from the German BIBB survey to infer regional skills from occupational distributions. To address this and other data limitations, I also report the results from fixed effects regressions that allow for time invariant regional heterogeneity.

The main finding of the paper is that job complexity is an important determinant of regional differences in economic development. The empirical relation between economic growth and job complexity is robust to controlling for physical capital investment, population growth, education, R&D expenditures, and other tasks-based measures of skills. Therefore, cognitive and problem solving skills are important not only for determining individual earnings and migration but also for regional and country-level economic outcomes.

Abstracts

Paper 1—Learning and Lifecycle Wage Dynamics

Based on Peer Ederer, Ljubica Nedelkoska, and Alexander Patt. Learning by Problem-Solving. Unpublished manuscript.

The standard Mincer model does not account for large differences in earnings across occupations. We present an alternative learning-by-doing model that relates wages and skill development to the level of job complexity of a worker. Using administrative data on German labour market entrants, we find that wage growth is positively related to job complexity and negatively related to the initial level of skill. We calibrate the model and show that workers in highly complex occupations acquire twice as much human capital throughout life compared to workers in simple occupations. The results suggest that learning-by-doing is a far more important earnings determinant than investment in education and training that have been the focus of the literature.

JEL classification: J24, J31, D83.

Keywords: wages, human capital, wage growth, Mincer curve, job complexity, tasks.

Paper 2—Selection on Cognitive and Manual Skills

Based on Alexander Patt, Jens Ruhose, Simon Wiederhold, and Miguel Flores. International Emigrant Selection on Occupational Skills. Forthcoming in the *Journal of the European Economic Association*.

We present the first evidence on the role of occupational choices and acquired skills for migrant selection. Combining novel data from a representative Mexican task survey with rich individual-level worker data, we find that Mexican migrants to the United States have higher manual skills and lower cognitive skills than non-migrants. Results hold within narrowly defined region-industry-occupation cells and for all education levels. Consistent with a Roy/Borjas-type selection model, differential returns to occupational skills between the United States and Mexico explain the selection pattern. Occupational skills are more important to capture the economic motives for migration than previously used worker characteristics.

JEL classification: F22, O15, J61, J24.

Keywords: migration, human capital, tasks, multi-dimensional skills.

Paper 3—Regional Productivity Differences

Based on Alexander Patt. Job Complexity and Economic Growth in European Regions. Unpublished manuscript.

I introduce a measure of regional job complexity to an empirical analysis of economic growth in 203 European regions during 2000–2017. The measure is calculated from the occupational distribution of complex tasks in a region. Job complexity proxies regional human capital acquired by solving complex tasks, which I relate to the rate of adoption of new technologies in a variant of a neoclassical growth model. The new tasks-based measure of human capital is sufficiently different from education, work experience, and socio-demographic characteristics and is highly predictive for income both on individual and aggregate level. The empirical relation between economic growth and job complexity is robust to controlling for differences in investment, population growth, education, R&D expenditures, and alternative measures of tasks. Job complexity turns out to be the strongest single explanatory factor of regional income inequality.

JEL classification: E13, O47, O52

Keywords: complex tasks, new economic geography, growth empirics, migration, technology diffusion.