Final report on NKFIH 125101 „Alacsony képzettségűek foglalkoztatása Magyarországon”

The main output of this research project is our draft working paper “Firm-level Technological Change and Skill Demand” (Attila Lindner, Balázs Muraközy, Ragnhild Schreiner, Balázs Reizer) – growing up from **Project 2**. Early on, we have found that this paper is likely to have the strongest potential, and therefore focused heavily on it (more than 110 pages at this stage) by building a new model with skill-biased technological change and imperfect labour markets, designing a new identification strategy, running regressions in two countries (Hungary and Norway) and quantifying the macro contribution of skill-biased technological change. This is reinforced by the feedback we received on the numerous seminars and conferences we have presented it. Most importantly, we presented it on this year’s NBER Summer Institute – labour. We have already started submitting the paper, and we consider that there is a good chance that we will be able to publish it in a top 5 or other top Economics journal.

In the paper, we propose a novel approach to quantify the contribution of firm-level technological change to skill demand and aggregate inequality. The basic idea behind our approach is that firms' wage and employment decisions reveal information about the nature of technological change when there is imperfect competition in the labor market. Skill-biased technological change increases both the firm-level skill ratio and the skill premium. In contrast, other shocks, including firm-specific output demand shocks or labor supply shocks, have opposite effects on the skill ratio and the skill premium, and so they cannot explain an increase in both outcomes. We apply this idea by exploiting administrative data from Hungary and Norway linked to the Community Innovation Surveys (CIS), which uniquely provide a direct measure for a broad class of technological changes at the firm-level. We show that---even conditional on workers' observable and unobservable skills---firms increase both their college wage premium and college--non-college ratio following technological change. Our estimates imply that technological change taking place over a 10-year period increased the aggregate college premium by 6.1% in Norway and by 13.8% in Hungary. In line with the two countries' different distance from the technological frontier, this was mainly driven by R&D-based and high novelty innovation in Norway and mostly by technology adoption in Hungary. These results highlight that technological change is still a key driver of aggregate trends in inequality, even if the college premium has been falling recently.

To better understand the contribution of technological change to these aggregate trends, we examine first the relationship between firm-level technological change and skill demand. Motivated by our empirical finding that firm-level innovation leads to an increase in the skill premium, we deviate from the canonical models in the literature of technological change, and introduce imperfect competition in the labor markets. We follow Card et al (2018) and Manning (2013) and assume that firms do not take wages as exogenously given, but rather they need to set higher wages in order to expand.

The main insight from our model is that in the absence of skill-biased technological change, a negative relationship emerges between the skill ratio and the skill premium at the firm level. Intuitively, the ``law of demand'' implies that when the relative price of an input goes up, relative demand for that input falls. This logic holds even if both the skill premium and skill ratio are endogenously determined in the model. Then we show that skill-biased

technological change can increase both the skill premium and skill ratio. In contrast, other type of (confounding) shocks that potentially coincide with firm-level innovation (e.g. firm-specific output demand shocks, labor supply shocks) either increase the college ratio and decrease the college premium or vice versa, but they cannot explain an increase in both outcomes.

It is worth emphasizing that the identification assumptions required to assess the extent to which technological change is skill-biased are weaker than what is needed to identify the impact of innovation on firm-level productivity. A key concern for identifying the latter is that innovative firms might foresee, and start innovating in response to, some positive demand shocks, and this can contaminate estimates of innovation on overall productivity. However, such a firm-level shock will not interfere with our proposed test for skill-biased technological change. This is because only relative input demands, and not the level of output, matter for assessing the skill-bias. Identification, in fact, mainly relies on two standard assumptions often made in the literature. First, we assume that there is a constant elasticity of substitution between high skilled and low skilled workers (standard CES production function), and so simply changing the level of production does not alter the marginal rate of transformation, the skill ratio and the skill premium. Second, we assume that firms optimize both before and after innovation such that the first order conditions from the firm's problem hold in each period. In that sense, identifying the extent to which technological change is skill-biased is less challenging than assessing the impact on firm-level productivity, which could be biased by these shocks.

Guided by our model, we investigate empirically whether innovation activities lead to an increase in the skill premium and the skill ratio at the firm level. We use exceptionally rich micro data from two countries, Norway and Hungary, that are at very different distances from the technological frontier. In Norway, R\&D based, high novelty innovation dominates while in Hungary relatively few firms innovate and if so, they often adopt technologies developed elsewhere. This allows us to compare two very different innovation systems. In both countries, we have access to the rich information available from the European Community Innovation Survey (CIS), which allows us to identify firm-level technological changes in a comprehensive way.

We find that innovation is associated with a 2-4 percent increase in the wage premium in Norway, and a 5-6 percent increase in Hungary. This increase in skill premium is permanent and present even 5 years after innovation, is not driven by higher bonus payments, and arise for both new entrants and incumbent workers. We also find that the increase in the skill premium emerges after innovation and is not driven by pre-innovation wage premium differences. Finally, to ensure that the increase in college premium is not driven by simply the compositional change of the workforce, we also control for unobserved workers skills by exploiting our particularly rich data from Norway, where we can follow workers across firms.

Our estimates of the skill premium are robust to including a variety of controls for market-specific shocks, that could potentially be correlated with firm-level innovation. In particular, we include local labor market-specific time trends, industry-skill-group-specific time trends and occupation-specific time trends in our robustness tests. Further, the estimates are not sensitive to alternative timing assumptions, and also robust to allowing for unobserved heterogeneity in firm-specific college premiums.

To assess the impact of firm-level innovation on the skill ratio, we implement a similar difference-in-differences identification strategy. In particular, we estimate how innovation is related to subsequent long (six-year) changes in the skill ratio at the firm level. Estimating a long difference is suitable for capturing the long-term effects of innovation, while at the same time adjusting for unobserved (time invariant) firm heterogeneity.

These findings highlight that technological change tends to be skill-biased both in Norway and Hungary. Using our estimates in the change in skill demand, we also quantify the contribution of technological progress to the change in the aggregate college premium. Firm-level innovation activities contribute to aggregate inequality through two channels. First, reallocation of skilled workers to innovative firms, which pay higher wages. Second, our estimates of the wage premium suggest that firms pay higher premium to workers following innovation. Using our estimates of the change in college ratio and the college premium following innovation, we calculate that skill-biased innovation contributes by 6.1 percentage points to the increase in the aggregate skill premium in Norway and by 13.8 percentage points in Hungary over ten years.

Finally, we assess whether there is heterogeneity in the contribution of different types of innovation to inequality. A common pattern in both countries is that both innovation with technical aspects (product or process innovation) and organizational changes are skill biased. Nevertheless, the bulk of the contribution to aggregate inequality comes from firms combining technical with organizational changes. At the same time, we find a difference between Norway and Hungary with respect to R&D and high-novelty innovation. In Norway, firms conducting R&D-based and high-novelty innovations are responsible for the majority of the changes in skill demand. In contrast, non-R&D and low-novelty innovations, which are associated with technology adoption, play a key role in Hungary. This latter finding underscores that technological change is skill-biased even in countries farther away from the technology frontier.

We have also completed our plans in **Project 4**. Using the funding from NKFIH we implemented a welfare analysis of the minimum wage. First we implemented a proper incidence analysis of the minimum wage where we explored what fraction of the wage increase is paid by firm-owners and what fraction paid by consumers. We found that 75% is paid by consumers. Then we implemented MaCurdy (2015) procedure to examine which households buy goods produced by minimum wage workers. We found that rich and poor households devote very similar fraction of their consumption to goods produced by minimum wage workers. We added these results to an already existing working paper, titled "Who Pays for the Minimum Wage" (Attila Lindner) which was published in the American Economic Review.

We have worked extensively on Project 5 (welfare effects of public work), but we did not find convincing results that can be published. First, we thoroughly cleaned administrative data on unemployment and public work participation on the individual level. We aggregated the data on the municipality level and merged them to the T-STAR database. Second, we compared the administrative data on double bookkeeping firms with the aggregate firm level data to better understand the spatial distribution of different firm types. We confirmed that the participation of public sector work programs increased the most at locations where the

unemployment level were traditionally high and the “Bartik” type shift-share instrument is valid. Our first results show that public work programs are the most prevalent at locations where (1) small firms, (2) agricultural firms and (3) firms without legal entity are the most prevalent. However, we did not find a convincing results about the effects of the policy, with the estimates being too noisy to be useful. We did not publish these results.

Regarding the two trade related **projects 1 and 3**, we were not able to document interesting findings to date. These projects were very much hindered by issues with data access during the COVID pandemic, when we were not able to work much in the dedicated data room. We plan to work further on these projects now that the situation improves. Note that this also led to using less of the funding than planned.

To sum up, we think that we have produced relevant results publishable in top journals in projects 2 and 4, and we mainly focused on this to maximize the quality of our publications. The other projects led to less convincing results to date, partly because pandemic-related issues with data access.