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Capital-Skill Complementarity Beyond Firm Boundaries

Based on BFI Working Paper No. 2026-132, "Capital-Skill Complementarity Beyond Firm Boundaries," by Gert Bijnens, National Bank of Belgium; Anders Humlum, University of Chicago; and Stijn Vanormelingen, KU Leuven

New machinery raises demand for workers with STEM degrees, though not at the firms purchasing the machinery, but instead at the outside suppliers that install, integrate, and service the machines.

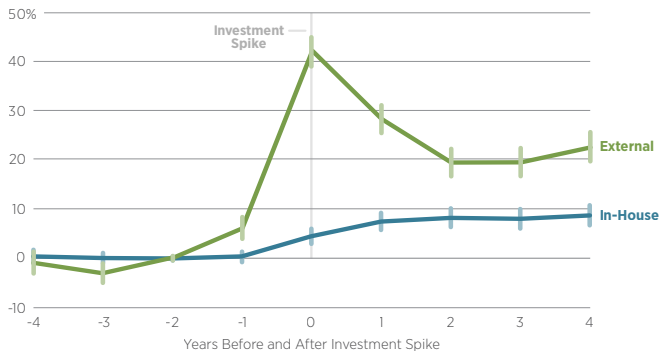
For more than half a century, economists have argued that new machines complement skilled workers. This idea, known as **capital–skill complementarity**, dates to Zvi Griliches in 1969 and helps explain why the wage premium for skilled workers has risen alongside technological advancement.

Yet a growing body of research on how firms adjust their workforces after investing in new machinery has failed to find evidence of the capital-skill complementarity. Studies drawing on newly available firm data from France, Finland, and the United States document that firms investing in new machinery expand their employment but leave their skill mix unchanged, leading some researchers to question the capital-skill complementarity altogether.

In this paper, the authors argue that capital–skill complementarity operates beyond firm boundaries, with companies contracting skilled workers from external firms to operate their new machinery, rather than hiring them in-house.

The authors use administrative business records from Belgium to test this theory. The data cover capital investments, buyer–supplier transactions, and worker skills, and allow the authors to measure how firms adjust both in-house employment and external labor services after major capital investments.

Figure 1 · Employment of High-STEM around Machinery Investment Spikes: In-House vs External



Note: This figure shows the effect of the investment spike on employment of high-STEM in terms of their pre-spike employment. Whiskers represent 95% confidence intervals.

The authors compare 3,863 firms that undergo an investment spike with similar firms in the same industry, tracking in-house and external employment four years before and after the spike. Importantly, since the capital-skill complementarity theory proposes that machinery raises demand for *skilled* workers (**skill bias**),

capital–skill complementarity: the idea that new equipment and machinery make skilled workers more productive than less-skilled workers, so investment in capital raises demand for skilled labor relative to other labor. First proposed by economist Zvi Griliches in 1969, it helps explain why the wage premium for skilled workers has grown as technology has advanced.

skill bias: when a change in the economy, such as a new technology or a wave of investment, raises demand for skilled workers more than for less-skilled workers. In this paper, it means that new machinery raises demand for high-STEM workers relative to other workers.

the authors focus on how these investments affect high-STEM workers, defined as those with a college degree in a STEM field. They find the following:

- Machinery investments sharply raise the demand for high-STEM labor, and the skill bias comes entirely from outside the firm. Total high-STEM employment (in-house plus external) rises by 50% in the spike year, against 11–20% for other skill groups, and remains 33% above baseline four years later. In-house employment grows evenly across skill groups, raising total employment by only 3–5% at the spike and 9–13% after four years, consistent with firm-level studies that observe only in-house payrolls.
- The external skill bias unfolds in two stages that match the two channels of capital–skill complementarity: integration followed by production. Machine suppliers and integrators first drive an initial burst, raising total high-STEM demand by about 15% in the spike year, as prior research on integrating new machinery predicts. The bias then persists but shifts toward skill-intensive services complementary to more capital-intensive production, such as software, as prior research on operating more capital-intensive production predicts.
- The external skill bias varies systematically across investing firms and capital types. It is stronger for smaller firms and for services firms, which employ fewer high-STEM workers to begin with. It is absent for intangible investments, which follow smoother investment profiles and rely far less on external suppliers. And it is specific to new machinery: building spikes generate a weaker bias that fades over time, while machinery from suppliers new to the firm, which is more likely to embody new technologies, generates the strongest bias of all.

Building on these results, the authors develop a framework that combines prior research on how capital drives demand for skills with research on why firms outsource work rather than hire in-house. They use the framework to explain why firms buy these skills externally. They then build an economy-wide model based on the framework to measure how much the growing use of machinery in Belgium between 2003 and 2021, when machinery per worker nearly tripled, shifted demand toward high-STEM workers. They find the following:

- Firms outsource these skills because their individual demand is typically too small and too sporadic to sustain an in-house team. In the spike year, the median spiking firm sources only 0.05 full-time-equivalent high-STEM workers through its suppliers, and the 90th percentile just 0.77, both well below the single full-time worker a dedicated in-house integration role would require. Machine suppliers, in turn, absorb firms' demand by spreading their workforce across many clients. Saving on wages does not appear to be the motive: machine suppliers pay about 3.6% more than the firms they serve for comparable workers, and lower-wage firms outsource more, not less.
- The growing use of machinery raised the wage premium for high-STEM workers, with integration playing an outsized role. In the authors' model, the rise in machinery between 2003 and 2021 increased relative demand for high-STEM workers by roughly 9%, raised their wage premium by about 3%, and raised their relative employment by about 5%, all compared with workers who have neither a college degree nor STEM training. Integrating new machinery accounts for 36% of the rise in relative demand, even though integration employs only 4.3% of high-STEM workers.
- Measured using payroll data alone, machinery would appear to *lower* the skill premium. Counting only the workers on investing firms' own payrolls, the same analysis implies that the growing use of machinery lowered the wage premium for high-STEM workers rather than raising it.

These findings revive the capital–skill complementarity hypothesis with an important qualification: new machinery is skill-biased, but the bias arises at the outside suppliers of investing firms. They also highlight the role of outside suppliers in technology adoption. By pooling many firms' small and sporadic needs for specialized workers, suppliers lower the cost of adopting new technology, so the availability of these services may shape which firms adopt new machinery and how quickly.

READ THE WORKING PAPER

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