The Local Labor Market Effects of Modern Manufacturing Capital: Evidence from France

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Many public policies affect the costs of investments in modern manufacturing capital, e.g., in automation technologies such as numerically controlled machine tools, automatic conveyor systems, industrial robots, etc. To date, the employment effects of these investments remain highly debated.

There are growing concerns about technological unemployment that may be brought about by modern technologies like robots (e.g., Brynjolfsson and McAfee (2014), Acemoglu and Restrepo (2018)). However, others have pointed out that robots are a small fraction of total investment (Benmelech and Zator (2022)). Furthermore, there are paradigmatic cases of technologies substituting for workers that in fact raise labor demand. For example, Bessen (2015) documents that automated teller machines (ATM) led to an increase in the demand for bank tellers, because the ATM allowed banks to operate branch offices at lower cost and thus to open many more branches.

Going beyond case studies of specific technologies, we present new evidence estimating the impact of typical modern manufacturing capital investments on labor demand. To do so, in Aghion et al. (2022) we develop two research designs – event studies and a shift-share methodology – which we apply to comprehensive French micro data on the population of firms in the manufacturing sector. While our initial study focused on firm-level and industry-level estimates, in this companion paper we use the same data and an event study methodology to present additional evidence on the *local labor market effects* of modern manufacturing capital. We find that increased modern manufacturing capital leads to positive employment effects at the *local labor market* level.

In what follows, we first present a simple conceptual framework motivating our analysis, using canonical economic models. The

following sections present in turn the data, the event study research design, and the results. The final section concludes.

I. Conceptual Framework

Economic theory shows that the effects of investments in modern manufacturing capital on employment are ambiguous.

Let us first consider the canonical model of factor-augmenting technological change. If modern manufacturing capital is modeled as capital-augmenting technological change with standard production function elasticities, then it should lead to an increase in both labor demand (and wages) and the labor share.

However, in the task model (Acemoglu and Restrepo 2018), automation may reduce the demand for labor and wages, because it assigns to capital tasks that used to be performed by labor; this would lead to a decline in the labor share. Several counteracting forces could nonetheless lead to an increase in labor demand, e.g., a productivity effect of automation at the intensive margin (sometimes called "automation deepening").

Thus, both from a modeling and a policy perspective, it is important to assess whether the effects of typical investments in modern manufacturing capital are consistent with the predictions of the canonical model of factor-augmenting technological change, or rather with those of the task model. While Aghion et al. (2022) addresses this question by analyzing firm-level and industry-level labor demand, in this companion paper we provide complementary evidence at the local labor market.

II. Data

Following Aghion et al. (2022), we analyze comprehensive micro data on the population of firms in the French manufacturing sector between 2003 and 2016. We obtain detailed information on workers and firms from French administrative datasets, the linked employer-employee (DADS)[1] and the balance sheet (BIC-RN)[2] databases. We then build two measures of modern manufacturing capital.

Our first measure is the balance sheet value of industrial machines, which we observe at the firm level in administrative data and subsequently aggregate to the level of commuting zones (CZ). This measure encompasses all machines used for extraction, processing, shaping, and packages of materials of supplies. We can thus isolate changes in the

[1] DADS refers to the "All employees databases - job position data" dataset provided by the National Institute of Statistics and Economic Studies (Insee) (https://doi.org/10.34724/CASD.21.3038.V2).

[2] BIC-RN refers to the "Industrial and commercial profits - normal scheme" dataset provided by the French Ministry of Finance (DGFiP) (https://doi.org/10.34724/CASD.259.2469.V1).

stock of industrial machines from changes in other components of capital (e.g., land, buildings, IT, office equipment, etc.). While this measure has the benefit of being available for all manufacturing firms, a limitation is that there is no explicit list describing all machines that are accounted for.

As a complement to the first measure, we use the automation measure of Acemoglu and Restrepo (2022), defined as "the range of technologies that relate to industrial automation." This measure is based on imported intermediate goods, defined as products with a 6-digit HS code in the following list: industrial robots, dedicated machinery, numerically controlled machines, automatic machine tools, automatic welding machines, weaving and knitting machines, other dedicated textile machinery, automatic conveyors, and regulating and control instruments. This measure is only available for importing firms, which we observe in the French customs data.

While our measures of investment in modern manufacturing capital and industrial automation are initially observed at the firm level, we allocate them across CZ based on the initial distribution of firm employment across CZs.

III. Event Study Research Design

Our event study methodology is identical to Aghion et al. (2022), although we now implement it at the commuting zone level, rather than at the firm and industry levels.

Specifically, we analyze large investment events in modern manufacturing capital across CZs. We build two investment events, using either of our two measures of modern manufacturing capital.

An investment event for a CZ is defined as a yearly change in the balance sheet value of industrial equipment or in imports of automation machines above a pre-specified threshold, in the distribution of all possible changes across CZs. We take the median as the relevant threshold for our analysis below. The results are similar when using the 75^{th} and 90^{th} percentiles as thresholds, although these results are not reported due to space constraints. When a CZ experiences a change in investment past the threshold more than once during our sample period, we take the largest change as our unique investment event. Thus, each CZ is treated at most once.

The spatial distribution of the investment events is shown below for modern manufacturing capital (Figure 1) and industrial automation (Figure 2). The distributions differ: investments in industrial equipment are more common in the southwest of the country, while

industrial automation is more frequent in the northeast.

[Insert Figure 1 Here]

[Insert Figure 2 Here]

Indexing commuting zones by *i* and years by *t*, our event study specification is

(1) $\Delta \log(Y_{it}) = \sum_{k=-5}^{5} \delta_k E_{i,t-k} + \mu_i + \lambda_{st} + \epsilon_{it}$,

where $\Delta \log(Y_{it})$ denotes the change in CZ-level employment, $E_{i,t-k}$ the investment event-indicator, μ_i commuting zone fixed effects, and λ_{st} "region by year" fixed effects.

This event study specification allows for an analysis of pre-trends. A lack of pre-trends is reassuring and restricts the potential set of confounders to contemporaneous demand or supply shocks.

In Aghion et al. (2022), we validate the event study methodology at the firm level and industry level with a complementary research design, a shift-share instrument variable (SSIV) approach. This approach leverages pre-determined supply linkages and productivity shocks across foreign suppliers of manufacturing capital. The firm-level and industry-level SSIV estimates are similar in magnitudes to the event study estimates, rejecting the hypothesis that the results are driven by contemporaneous shocks. These results motivate our assumption that there are also no contemporaneous shocks confounding the CZ-level event studies.

IV. Results

Using the CZ-level event study approach, we consistently find that investments in modern manufacturing capital lead to an increase in labor demand.

Figure 3 reports the patterns with our first measure, investment in industrial equipment. There are no signs of pre-trends, and employment increases after the investment event. The figure shows that both manufacturing employment and total employment increase, but the effect is much stronger for manufacturing employment, with a semi-elasticity of about 0.05 after five years.

[Insert Figure 3 Here]

Next, we repeat the analysis using our second measure, imports of machines relating to industrial automation as in Acemoglu and Restrepo (2022). Figure 4 shows that the patterns are very similar to our first measure: there are no pre-trends, and we observe an increase in CZ employment after the investment event, which is driven by manufacturing employment, with a semi-elasticity of 0.04 after 5 years.

[Insert Figure 4 Here]

To understand the channel at play, we analyze the response of manufacturing sales. Figure 5 shows a strong increase in manufacturing sales right after the investment event. The semi-elasticity is 0.1 from the first year after the event and remains stable thereafter. This finding is consistent with a productivity channel of modern manufacturing capital: firms invest to reduce their production costs; then can then reduce consumer prices, expand their sales, and thus have higher labor demand.

[Insert Figure 5 Here]

Finally, Figure 6 documents an increase in CZ wages after the investment event, with a semi-elasticity of 0.1 after 5 years. Thus, the CZ-level increase in labor demand brought about by modern manufacturing capital results in both higher employment and higher wages, which is consistent with the fact that labor mobility across CZs is limited. In contrast, at the firm level Aghion et al. (2022) finds that the increase in labor demand from modern manufacturing capital goes entirely through changes in employment, with no change in wages. Indeed, worker mobility is much higher across firms than across CZs.

[Insert Figure 6 Here]

V. Conclusion

In Aghion et al. (2022) we find that investments in modern manufacturing capital – including automation technologies in the sense of Acemoglu and Restrepo (2022) – lead to an increase in employment at the firm and industry levels. In this paper, we showed that the same conclusion carries over to the local labor market level. Aghion et al. (2022) also documents a fall in the labor share at the firm level, which is consistent with the task-based framework since the canonical framework cannot rationalize the observed fall in the labor share.

Overall, our finding of a positive employment response at all levels of analysis implies that the relevant model is a task-based framework where the productivity effect dominates the displacement effect.

Our results are consistent with a growing literature using event studies to estimate the firm-level employment effects of automation and robotization. Indeed, most studies document a positive employment response (e.g., Acemoglu et al. (2020), Dixon et al. (2019), Domini et al. (2021), Humlum (2021), Koch et al. (2021)), with a few studies estimating a negative effect (Bessen et al. (2020), Bonfiglioli et al. (2020)).

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FIGURES

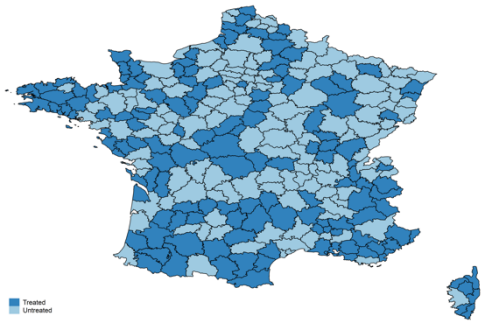

FIGURE 1. CZ-LEVEL INVESTMENT EVENTS FOR INDUSTRIAL EQUIPMENT

Note: This figure shows the distribution of CZ-level investments in industrial equipment. Treated CZs experience a change in the balance sheet value of industrial equipment above median at least once between 2003 and 2016.

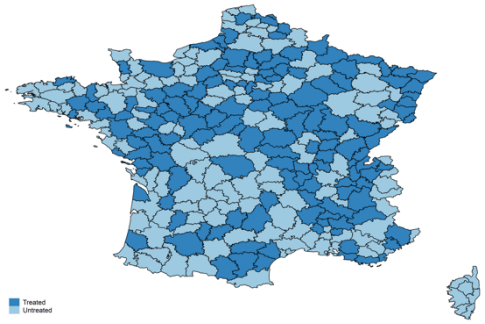

FIGURE 2. CZ-LEVEL INVESTMENT EVENTS FOR INDUSTRIAL AUTOMATION

Note: This figure shows the distribution of CZ-level investments in industrial equipment. Treated CZs experience a change in the balance sheet value of industrial equipment above median at least once between 2003 and 2016.

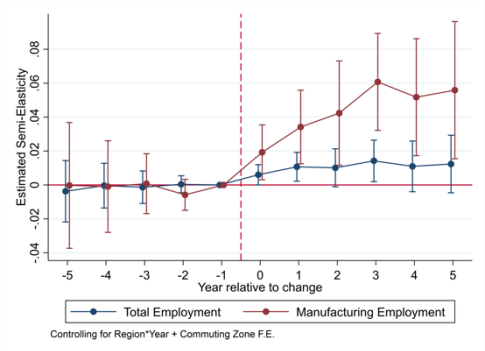

FIGURE 3. THE RESPONSE OF CZ EMPLOYMENT TO INVESTMENT IN INDUSTRIAL EQUIPMENT

Note: This figure documents the response of CZ-level total and manufacturing employment to investments in industrial equipment, using specification (1). Standard errors are clustered by commuting zones.

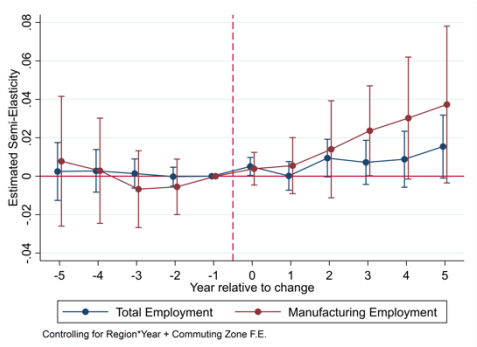

FIGURE 4. THE RESPONSE OF CZ EMPLOYMENT TO INVESTMENT IN INDUSTRIAL AUTOMATION

Note: This figure documents the response of CZ-level total and manufacturing employment to imports of automation technologies in the sense of Acemoglu-Restrepo (2022), using specification (1). Standard errors are clustered by commuting zones.

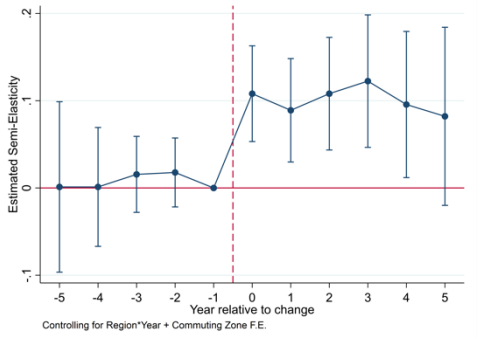

FIGURE 5. THE RESPONSE OF CZ MANUFACTURING SALES TO INVESTMENT IN INDUSTRIAL EQUIPMENT

Note: This figure documents the response of CZ-level manufacturing sales to investments in industrial equipment, using specification (1). Standard errors are clustered by commuting zones.

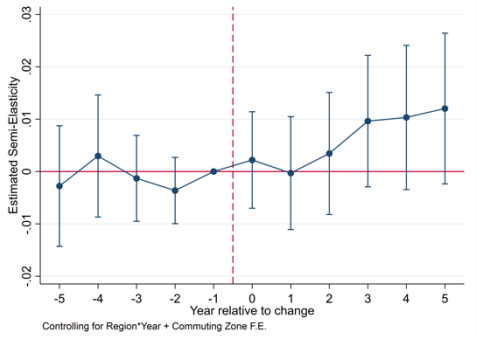

FIGURE 6. THE RESPONSE OF CZ WAGES TO INVESTMENT IN INDUSTRIAL EQUIPMENT

Note: This figure documents the response of CZ-level wages to investment in industrial equipment, using specification (1). Standard errors are clustered by commuting zones.