

The causes and consequences of general-purpose technological progress: Evidence from the adoption of steam engines in 19th-century France

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Extended abstract

Inspired by contemporary fears that *robotics* will make workers redundant, we test the well-known hypothesis that early industrial technologies (in this case steam engines) were introduced because they were labour-*cheapening*. The common understanding is that mechanisation historically allowed firms to replace skilled with unskilled male workers – that is, new technology was *deskilling* – and moreover involved that male workers could be substituted with less-expensive female and child labourers. To test these ideas, we use propensity score matching on two all-inclusive, industry-level censuses from 19th-century France to determine the labour-market conditions that led to the adopting of steam engines, as well as the subsequent effects of adopting them on the demand for male, female and child labour as well as their wage rates. We find that the present worries that *automation* will be labour- and skill-saving are not supported by the historical evidence. General-purpose technological progress during early stages of industrialisation, captured by the introduction of steam technology in historical France, was ultimately both labour-*augmenting* and skill-*demanding*, thus contrasting the labour-*cheapening* hypothesis.

More specifically, we use the earliest-recorded industrial census in France, from the 1840s, to identify locations with industries that did not employ steam engines at this point in time. Then, we move forward to the second industrial census, recorded in the 1860s, to compare the labour-market conditions in the sampled locations that *had* and *had not* adopted steam technology twenty years hence, using several observable covariates to match locations on the probability of receiving *treatment* (that is, implementing steam engines). Consistent with the idea that steam technology emerged for labour-*cheapening* purposes, our (preliminary) analyses show that the likelihood of receiving treatment was significantly higher in districts (*arrondissements*), where (i) industrial labour productivity was relatively low, so that capital-deepening could serve to improve output per worker; (ii) the gender pay gap was relatively large, making it profitable to substitute high-cost males for low-cost females; (iii) the share of male employees was relatively high, so the potential for cutting labour-costs by shifting towards women and children was relatively large; and where (iv) steam engines had already been installed in other local industries, thus lowering the costs of adopting new technology.

Using a diff-in-diff approach in combination with propensity score matching, we also observe, however, that the adoption of steam technology was neither labour-saving nor skill-saving *following* treatment. Treated (steam-powered) industries did use higher shares of (cheaper) female

and child labourers than non-steam-powered industries. But because the treated locations also employed *more* workers in total (that is, steam technology was labour-*augmenting*), steam-run industries actually ended up using also more *male* workers on average, and not just more women and children. We also find that steam-powered industries paid significantly higher wages on average, both to male and female workers (although not to children). We interpret this as steam technology being skill-*demanding* averagely, contradicting the traditional narrative that early industrial technologies were *deskilling*. Lastly, the average wage rate paid per worker went up in the treated industries, contesting the argument that steam technology was ultimately labour-cheapening. Our findings thus highlight the multisided effects of general-purpose technological progress. On the positive side, steam technology meant higher male and female wages, and a growing demand for both male and female workers. On the negative side, steam-powered industries relied more heavily on child labour, and technological progress moreover intensified gender-wage inequality.

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