On-the-Job Training

Wenzhi Wang

August 17, 2023

Contents

1. Review Articles

1.1. A Summary of Becker's Theory

Becker (1964) drew a crucial distinction between *general skills* and *specific skills*. General skills are defined as those which are also useful with other employers. In contrast, specific skills increase the productivity of the worker only in his current job.

He argued that in a competitive labor market where workers receive their marginal product, firms could never recoup their investments in general skills, so they will never pay for general training. However, Becker noted, workers themselves will have the right incentives to improve their general skills because in competitive markets, they are the sole beneficiaries of the improvements in their productivity. Moreover, workers can undertake such investments quite easily by accepting a lower wage than their productivity during the period of training.

Becker also argued that training in specific skills was quite different because workers would not benefit from higher productivity when they changed jobs. Firms therefore could recoup their investments in specific skills and would be willing to share some of the costs of specific training investments.

An important conclusion of this work is that there need not be any market failure in training. As long as workers can pay for training, either out of their pockets or by taking lower wages, the right amount of investment would be undertaken. So *insufficient investment in skills could only arise because workers are severely credit constrained*.

1.2. Acemoglu and Pischke (1999a): the Role of Wage Compression

Paper: Beyond Becker: Training in Imperfect Labour Markets, The Economic Journal

Summary of the Paper:

This paper surveyed some recent research on patterns of training practices and theories in which firms are willing to contribute to the costs of general training investments. The author suggested that labor market imperfections have to be an ingredient of any model attempting to understand why firms pay for general training.

Framework:

A worker is hired at time 0 during which he can be trained, and then he becomes productive at time 1. The productivity of the worker during time 0 is normalized to zero. Denote the output of the worker at time 1 by $f(\tau)$, where τ is his level of training. Training costs are $c(\tau)$. There is no discounting, and all parties are risk-neutral. Denote the wage of a worker with training τ at time 1 by $w(\tau)$. First, note that the efficient amount of investment is given by $\tau^* > 0$ where $c'(\tau^*) = f'(\tau^*)$.

A competitive labor market corresponds to the case where many firms compete for the labor services of the worker at time 1, ensuring that $w(\tau) = f(\tau)$. The significant feature is that the wage of the worker at the initial employer is no different from the wage the worker can obtain at a different firm, because all of his skills are general and there are no mobility costs. This immediately implies that the firm will not pay for the worker's training as it would not be able to recoup its investment costs.

Right now, in a non-competitive labor market, the wage is below the productivity of the worker, $w(\tau) < f(\tau)$ (*rents*). The second and more important feature is that the wage function is increasing in the level of training less steeply than productivity, so the gap between productivity and the wage, $\Delta(\tau) = f(\tau) - w(\tau)$, is higher at greater levels of skills. We refer to this as a *compressed wage structure*, since the return to skills for a worker is less than the one prevailing in a competitive labor market. Also, right now, the firm would choose the level of training by setting the marginal change in the second period profit equal to the marginal cost of training $c'\left(\tau^f\right) = f'\left(\tau^f\right) - w'\left(\tau^f\right)$. Thus, firms may have an incentive to invest in the general skills of their employees, though they may under-invest in the general skills.

1.2.1. How this Review Guides my Literature Review on the Incentives for On-the-Job Training

Given that labor market rents and wage compression are two key elements to understand why firms are willing to pay for general skill training for workers, even though the authors didn't directly model the sources of these two features, they discuss several potential reasons and relevant papers:

- the presence of transaction costs in the labour market, for example matching and search frictions (see Acemoglu (1997));
- the presence of asymmetric information between the current employer of the worker and other firms in the economy (see Katz and Ziderman (1990); Chang and Wang (1996); Acemoglu and Pischke (1998); Autor (2001); Malcomson et al. (2003));
- asymmetric information between the worker and the employer regarding the exact level of effort and diligence exerted by the employee[1] (see Acemoglu and Pischke (1999b));
- the interaction of specific and general skills; and
- labor market institutions which compress the structure of wages directly, such as minimum wages (Acemoglu and Pischke (2003)) that increase the pay of less skilled workers, while leaves the wages of skilled workers largely unaffected, and unions that compress the structure of wages by forcing employers to pay higher wages to less skilled workers.

[1] This implies that the remuneration of the worker has to be a function of his performance and other indicators related to his effort in order to ensure that he chooses the appropriate amount of effort. In other words, wages need to satisfy the worker's incentive compatibility constraint.

1.3. Wolter and Ryan (2011)

Paper: Apprenticeship, Handbook of the Economics of Education

Definitions:

Apprenticeship is defined as programs that comprise both work-based training and formal education, in most countries at upper-secondary level, and lead to a qualification in an intermediate skill, not just to semiskilled labor. Apprenticeship is therefore distinct from three activities for which it is often an alternative: *full-time vocational education*, *standalone on-the-job training*, and *labor market programs*.

Why do Firms Finance Apprenticeship Training:

Section 2 of this review paper analyses the incentives of firms in offering and financing apprenticeship training. The structure of their review is as follows:

- Becker's theory.
- Extensions to the Becker model
  - Information asymmetries: Katz and Ziderman (1990); Dustmann and Schönberg (2012); Acemoglu and Pischke (1998).
  - Compressed wage structures: Acemoglu and Pischke (1998, 1999b,a); Bassanini and Brunello (2008).
  - Industry- or occupation-specific monopsonies: Even if one would assume that all skills are technically general, their specificity to an industry or an occupation makes them de facto specific to firms. See Lazear (2009); Smits (2007).
  - Product market competition: Gersbach and Schmutzler (2012); Bassanini and Brunello (2011)
  - The "make or buy" decision: Differences in hiring and training costs may also affect the firm's supply of training. A firm can obtain skilled workers either by hiring from the external labor market or by training apprentices internally and retaining them after training. See Blatter et al. (2016).
  - Reputation—advantages on the product markets.
- Training subsidies
- Production-oriented training motivation

2. Incentives for On-the-Job Training: Contracts, Information Asymmetries and Selection

2.1. Acemoglu and Pischke (1998)

Paper: Why Do Firms Train? Theory and Evidence, The Quarterly Journal of Economics

Summary of the Model: The exact sequence of events in this economy is summarized as follows.

1. In period 1 firms decide how many workers to hire and how much training τ to offer to each worker (Firms cover the training costs τ). At this point firms do not know the ability of workers. Thus, they cannot offer more training to abler workers.
2. At the end of period 1 the incumbent firm finds out about the ability η of each worker.
3. At the beginning of period 2 the incumbent firm chooses which workers to lay off and offers a uniform wage $w(\tau)$ to all retained workers.
4. Next, workers learn their disutility shock θ, and the workers who are retained choose whether to stay ($\widehat{q} = 0$) or to quit ($\widehat{q} = 1$).
5. At the beginning of period 2 the incumbent firm chooses which workers to lay off and offers a uniform wage $v(\tau)$ to all retained workers. In the second period, each worker produces $y = \alpha(\tau)\eta$, where $\alpha(\tau)$ is the general human capital gained from training and η is the ability of the worker.

Information asymmetries (adverse selection) arises because in the second period, the outside firms don't know workers' abilities in the secondhand market and they cannot tell whether they are laid off (because of low ability) or voluntarily quit the job (because of disutility shock θ).

Adverse selection then implies that there are multiple equilibria in the economy: In one equilibrium quits are endogenously high, and as a result employers have limited monopsony power and provide little training, while in another equilibrium quits are low and training is high.

Test the Model:

The test does not look directly at training but rather investigates the presence of adverse selection among those receiving firm sponsored training. In particular, the authors look at the wages of German apprentices who stay in their firm, who are laid off, or quit their firm voluntarily, and compare them with the wages of apprentices who quite for exogenous reasons; that is, to go into the military. Because the firm has monopsony power over workers who stay, they are paid below their marginal product. In contrast, military quitters, thanks to their exogenous reason of separation, are freed from this monopsony power. While they will be less able than stayers on average, they can have higher wages. In fact, the authors indeed find that their wages are above those of stayers.

2.2. Autor (2001)

Paper: Why Do Temporary Help Firms Provide Free General Skills Training?, The Quarterly Journal of Economics

Research Question: Why Do Temporary Help Firms Provide Free General Skills Training?

Summary of the Model: Training serves two key roles in the model. One is to induce *self-selection*. Firms that offer training are able to differentially attract workers of greater unobserved ability. A second role is to facilitate *worker screening*. By tightly coupling worker training with worker skills testing, temporary help firms use training to privately screen the ability of workers whom they train.

Mechanism of the Model: The key premise of the theoretical model is that training is more productive and therefore more valuable to high ability workers. Workers are assumed to have imperfect prior knowledge of their ability while employers cannot initially perceive ability but observe it through training. Because of the learning advantage possessed by high ability workers, firms are able to offer a package of training and initially lower wages that induces self-selection. Workers of high perceived ability choose firms offering training in expectation of wage gains in permanent employment, while low ability workers are deterred by lower wages and limited expected gains. Firms profit from their training investment ex post via their short-run informational advantage about ability and thereby limited monopsony power.

Test the Model: Data has shown that wages are lower at firms offering training by a modest but statistically significant magnitude; that heightened market competition, as measured by a Herfindahl index, substantially increases firms' propensity to offer free training; and, although training increases with market competition, the wage gap between training and nontraining firms contracts significantly.

Notes: The model is basically the same as that in Acemoglu and Pischke (1998) except that in this paper, there is a "zero" period that workers with different ability levels self-select between firms that provide general training and firms that do not provide general training.

2.3. Dustmann and Schönberg (2012)

Paper: What Makes Firm-based Vocational Training Schemes Successful? The Role of Commitment, American Economic Journal: Applied Economics

Research Question: Why do firm-based vocational training schemes work in some countries but not in others?

Mechanism of the Model:

Since training takes place inside firms, it is not easily verifiable by a third party and may simply be too complex to be specified in a contract in a way that is legally enforceable. Suppose that firms promise workers a certain level of training in exchange for an apprenticeship wage that is well be-

low the wage offered to unskilled workers. Clearly, firms have a strong incentive to renege on this promise, as they can increase profits by employing the trainee on tasks typically performed by unskilled workers (such as preparing coffee and cleaning machines) rather than teaching him new skills. If training contracts are not enforceable, such a breach of contract will go unpunished. In equilibrium, workers anticipate this and are therefore only willing to accept training contracts they consider as credible. The ability of the firm to credibly assure workers that they will not renege on their training promises and deliver the promised training intensity is referred to as *commitment to training provision*. The hypothesis is that apprenticeship training schemes are more successful – as evidenced by higher enrollment rates and lower dropout rates – in countries like Germany than they are in Anglo-Saxon countries like the United Kingdom because commitment to training provision is more widespread.

Comparison with Acemoglu and Pischke (1998, 1999b,a):

Acemoglu and Pischke (1998, 1999b,a) point out that firms will provide general training even if they cannot commit to training provision if wages are compressed. The model in this paper does not exclude this as an explanation why training intensities differ across countries. However, the key point is that two countries with the same degree of wage compression may differ greatly in their training intensities because of differences in firms' ability to commit to training provision.

Abstract:

This paper studies a possible market failure in the firm-based vocational training market: training may be too complex to be specified in a contract so that it is legally enforceable, resulting in the inability of firms to commit to training provision. We present a model of firm provided training and show that training is substantially lower in the no commitment than in the commitment case. Thus, firm-based vocational training schemes are more successful in countries where commitment to training provision is more widespread.

2.4. Bac (2000)

Paper: On-the-Job Specific Training and Efficient Screening, Journal of Labor Economics

Research Question: Why do firms invest suboptimally on their workers? This paper provides insights through the lens of a dynamic contractual model.

Abstract: Employment relationships are governed by short-term incomplete contracts and typically involve on-the-job screening and firm-specific training. This article studies a dynamic employment relationship with these features and identifies a potential conflict between the employer's twin objectives to screen and train the worker: when the training technology is quite productive, the employer may have to sacrifice from worker performance during the screening process. The article thus offers an explanation for why firms may invest suboptimally on training, which complements the standard "inappropriable rents" explanation based on ex post mobility of young employees.

Notes: This paper highlights a new source of inefficiency in investment on employer-specific human capital. In labor relationships governed by incomplete contracts, there is a potential conflict between the employer's objectives to perform efficient on-the-job screening and train the specific skills of the workers. This conflict may lead the employer to induce an equilibrium with inefficient level of specific investment.

2.5. Malcomson et al. (2003)

Paper: General Training by Firms, Apprentice Contracts, and Public Policy, European Economic Review

Abstract: Workers will not pay for general on-the-job training if contracts are not enforceable. Firms may if there are mobility frictions. Private information about worker productivities, however, prevents workers who quit receiving their marginal products elsewhere. Their new employers then receive external benefits from their training. In this paper, training firms increase profits by offering apprenticeships which commit firms to high wages for those trainees retained on completion. At these high wages, only good workers are retained. This signals their productivity and reduces the external benefits if they subsequently quit. Regulation of apprenticeship length (a historically important feature) enhances efficiency. Appropriate subsidies enhance it further.

2.6. Owan (2004)

Paper: Promotion, Turnover, Earnings, and Firm-Sponsored Training, Journal of Labor Economics

Abstract: I develop a model in which different technological conditions lead to distinct equilibria with different patterns in labor mobility, promotion, earning distribution, and provision of firm-sponsored training. Key is the asymmetric learning of workers' characteristics. Because of the information that is conveyed to the market by promotion, firms have incentives to adopt strategic promotion policies, which result in different patterns in the use of internal labor market. The theory explains well the differences between the Japanese and the United States labor markets.

Notes: This model in this paper shares the same key element as in Acemoglu and Pischke (1998). A firm is uncertain about its worker's productivity when he enters the labor force but gradually learns about it during his employment. This learning is asymmetric – potential employers do not directly observe a worker's productivity. But this paper adds one more element compared to Acemoglu and Pischke (1998) – promotion. Here, a promotion serves as a signal of the worker's productivity. And firms can strategically choose between different promotion policies: early promotion policies and late promotion policies.

2.7. Balmaceda (2005)

Paper: Firm-Sponsored General Training, Journal of Labor Economics

Abstract: This article analyzes firm and worker's incentives to invest in general and specific training when these are separable in the production technology and wages are determined by the outside-option principle. It is shown that firms pay for general training, while workers receive the full return on it, and firms and workers share both the costs and benefits of specific training. The case of delayed general training is also studied. When general training is delayed, it is shown that the strategic complementarity between specific and general training increases the worker's incentives to invest in specific training.

Notes: This paper has a totally different style from those papers in this section, such as Acemoglu and Pischke (1998). It takes both the general and specific human capital into the production function and takes very seriously about the bargaining and contracting process.

2.8. Fudenberg and Rayo (2019)

Paper: Training and Effort Dynamics in Apprenticeship, American Economic Review

Abstract: A principal specifies time paths of effort provision, task allocation, and knowledge transfer for a cash-constrained apprentice, who is free to walk away at any time. In the optimal contract the apprentice pays for training by working for low or no wages and by working inefficiently hard. The apprentice can work on both knowledge-complementary and knowledge-independent tasks. We study the optimal time path of effort distortions and their impact on the knowledge transfer, and analyze the effect of regulatory limits on the length of apprenticeships and on how much effort apprentices are allowed to provide.

3. Incentives for On-the-Job Training: Frictional Labor Market

3.1. Acemoglu (1997)

Paper: Training and Innovation in an Imperfect Labour Market, Review of Economic Studies

Summary of the Model:

There are two types of investments which can only be undertaken in period 1 and affect productivity in periods $t \geq 2$. The first is an investment in new technology (or innovation). If the employment relation between the firm and the worker ends, the machine will stay with the firm. The second type of investment is in the general human capital of the worker. The worker can acquire τ units of general human capital, but this reduces the output of the firm in the first period by $c(\tau)$. Whether

the firm or the worker incurs this cost is immaterial since throughout the paper there are no credit constraints or equivalently that utility is transferable.

At the end of every period that worker i and firm j are together, there is probability $s \in (0,1)$, that the pair receives an adverse *match-specific shock* which reduces their output to zero in all future periods. After such a shock, both parties can try to find new partners for production. There is however no guarantee that the firm with the investment in the new technology will be matched with the worker who has more training: thus the matching technology is random. And this imperfection of the labor market is the focus of this paper. The frictional labor market implies that part of the productivity gains from general training will be accepted by future employers.

As a result, investments in general skills will be suboptimally low, and contrary to the standard theory, part of the costs may be borne by the employers. The paper also demonstrates that the interaction between innovation and training leads to an amplification of this inefficiency and to a multiplicity of equilibria. Workers are more willing to invest in their skills by accepting lower wages today if they expect more firms to innovate and pay them higher wages in the future. Similarly, firms are more willing to innovate when they expect the quality of the future workforce to be higher, thus when workers invest more in their skills.

3.2. Acemoglu and Pischke (1999b)

Paper: The Structure of Wages and Investment in General Training, Journal of Political Economy

Summary:

If labor market frictions reduce the wages of skilled workers relative to wages of un-skilled workers (i.e., compress the structure of wages), firms may provide and pay for general training. Credit market problems and the presence of a long-term attachment between the worker and the firm are neither necessary nor sufficient to generate firm-sponsored training. The key is labor market imperfections, which imply that trained workers do not get paid their full marginal product when they change jobs, making technologically general skills de facto specific.

Notes: This is a detailed version of the framework in Acemoglu and Pischke (1999a). The crucial condition of firm-sponsored investment in general training is that $f'(\tau) > w'(\tau)$; that is, outside opportunities for the worker should improve less than his productivity as he acquires more skills. This is exactly the *compressed wage structure* defined in Acemoglu and Pischke (1999a).

3.3. Stevens (2001)

Paper: Should Firms Be Required To Pay For Vocational Training?, The Economic Journal

Research Question: If we consider both the credit market imperfections and labor market imperfections, should policy-makers impose a training levy on firms?

Elements and Implications of the Model:

There are two principal theoretical explanations for failure in the market for vocational training. One is that potential trainees do not invest in training because of capital market problems: they cannot borrow against human capital, or insure against associated risks. The second is that the skilled labour market is not perfectly competitive, so that the wage is not equal to the marginal product of the worker.

This paper constructs a model of the market for vocational training allowing for both labor and capital market imperfections. A policy of requiring firms to increase training expenditure beyond their private choice is a first-best response to under-investment caused by labor market imperfections, and can also be a second-best response to problems originating in the capital market. While this provides a rationale for imposing training costs on firms, a levy scheme does not necessarily have that effect; if the firms's liability to train is assessed as a proportion of wages, the scheme acts instead like a training subsidy financed by a tax on wages. I show that such a policy addresses capital market problems only.

3.4. Moen and Rosén (2004)

Paper: Does Poaching Distort Training?, Review of Economic Studies

Summary of the Paper:

This paper analyses the conditions under which the labour market outcome is efficient in a model with endogenous human capital formation and endogenous turnover in the presence of search frictions. It develops a directed search model in which turnover is necessary to obtain an efficient allocation of workers. More precisely, there exists two types of firms; training firms which have a comparative advantage in providing general training, and poaching firms which have a comparative advantage in utilizing general human capital. Workers with different productivities are assumed to search in different submarkets. Within this setting the authors analyze whether training firms have the right incentives to enter the market and to provide the optimal amount of general training. In contrast to the existing literature, they treat worker's on-the-job search intensity and the number of poaching firms as endogenous variables.

The first main result is that *internal efficiency* is a sufficient condition for an efficient allocation of resources in this economy, both with respect to the allocation of workers to firms and with respect to investment in general training. Internal efficiency refers to the resolution of coordination problems within each firm such that the employer and his employees maximize their joint expected income. Internal efficiency can be obtained if workers and firms are able to write long-term binding contracts, or if they are able to bargain efficiently.

The second main result is that this amount of human capital formation is still constrained efficient. Given the search behaviour of workers and the entry behaviour of poaching firms, the social and the private returns from general training coincide.

Comparison with Acemoglu (1997): Acemoglu (1997) finds that turnover in the presence of search frictions creates positive training externalities for future employers. As a result, there is underinvestment in general training even though firms and workers can write long-term contracts. He attributes the inefficient outcome to the workers' inability to contract with future employers. As we argue in what follows, Acemoglu's result hinges (among other things) on his assumption that workers with different productivities search in the same search market. As a result, low-productivity workers create congestion effects for high-productivity workers, thereby reducing the return from training investments.

3.5. Quercioli (2005)

Paper: Training, Turnover, and Search, International Economic Review

Abstract: This article explores a model of firm-specific training in a job search environment with labor turnover. The main substantive finding is a positive association between training and wages (when dispersed). The article then precisely characterizes how both wage dispersion and firm profitability depend on the flow value $b \geq 0$ of workers' unmatched time. It is shown that: (i) for all high values b, no equilibrium exists; (ii) for intermediate values b, multiple equilibria arise, where firms earn zero profits, and choose from a general wage distribution; (iii) for all lower values b, there is a unique equilibrium, with firms earning positive profits, and choosing from an atomless set of wages.

3.6. Fu (2011)

Paper: Training, Search and Wage Dispersion, Review of Economic Dynamics

Abstract: This paper combines on-the-job search and human capital theory to study the coexistence of firm-funded general training and frequent job turnovers. Although ex ante identical, firms differ in their training decisions. The model generates correlations between various firm characteristics that are consistent with the data. Wage dispersion exists among ex ante identical workers because workers of the same productivity are paid differently across firms, and because workers differ in their productivity ex post. Endogenous training breaks the perfect correlation between work experience and human capital, which yields new insights on wage dispersion and wage dynamics.

3.7. Flinn et al. (2017)

Paper: Search, Matching and Training, Review of Economic Dynamics

Abstract: We estimate a partial and general equilibrium search model in which firms and workers choose how much time to invest in both general and match-specific human capital. To help identify the model parameters, we use NLSY data on worker training and we match moments that relate the incidence and timing of observed training episodes to outcomes such as wage growth and job-to-job

transitions. We use our model to offer a novel interpretation of standard Mincer wage regressions in terms of search frictions and returns to training. Finally, we show how a minimum wage can reduce training opportunities and decrease the amount of human capital in the economy.

4. Empirical Papers: Incentives for On-the-Job Training

4.1. Bassanini and Brunello (2008)

Paper: Is Training more Frequent when the Wage Premium is Smaller? Evidence from the European Community Household Panel, Labour Economics

Findings: The Becker model provides insufficient guidance to understand empirical training patterns. Conversely, they are not inconsistent with theories of training in imperfectly competitive labour markets, in which firms may be willing to finance general training if the wage structure is compressed, that is, if the increase in productivity after training is greater than the increase in pay.

4.2. Dustmann and Schönberg (2009)

Paper: Training and Union Wages, Review of Economics and Statistics

Research Question: Do unions, by imposing wage floors that lead to wage compression, increase on-the-job training in Germany?

Findings: The authors find support for the hypothesis that union recognition, via imposing minimum wages and wage compression, increases training in apprenticeship programs.

A Model of Firm-Financed Training: The crucial feature of the model is the coexistence of unionized and nonunionized sectors. The difference between the two sectors is that firms in the unionized sector have to pay at least the union wage, while firms in the nonunionized sector can pay a lower wage.

Empirical Strategy: To study the effects of unions on training, the authors use a DID specification using the unionization (non-unionization) to non-unionization (unionization) transitions.

4.3. Mohrenweiser and Zwick (2009)

Paper: Why do Firms Train Apprentices? The Net Cost Puzzle Reconsidered, Labour Economics

Research Question: Do German enterprises have to accept short-term disadvantages, that is, to bear net costs when they offer apprenticeships?

Because the authors cannot directly measure the net costs of apprenticeship training during the apprenticeship period, they turn to analyse the arguably more relevant question whether establishments that increase the share of apprentices at the cost of the share of unskilled or semiskilled employees face a reduction in their profits and how establishment productivity is affected.

Findings: Employing apprentices in trade, commercial, craft, and construction occupations instead of unskilled or semi-skilled employees has a positive impact on contemporary establishment performance. In contrast, apprentices in manufacturing occupations have higher relative training costs in comparison to their benefits – contemporary establishment performance declines when their share of employees increases while those of unskilled or semi-skilled employees decreases.

4.4. Muehlemann et al. (2010)

Paper: The Financing of Apprenticeship Training in the Light of Labor Market Regulations, Labour Economics

Findings: The authors observe that German firms are willing to finance apprenticeship training, whereas Swiss firms on average only train if the financial investment is offset by the productive contribution of apprentices. Considering the strong similarities between Germany and Switzerland with respect to their vocational education and training systems, they argue in this paper, that the main reason for the differences in net costs of training can be found in the different labor market regulations of the two countries. A higher degree of employment protection increases the firm's labor adjustment costs. Apprenticeship training can, however, serve as a device to reduce such costs. On the one hand, firms can avoid costs for hiring by employing former apprentices as skilled workers. On the other hand, firms can reduce labor turnover, as former apprentices tend to stay longer in a firm and the match quality between the firm and the worker is better compared to externally hired workers.

4.5. Bassanini and Brunello (2011)

Paper: Barriers to Entry, Deregulation and Workplace Training: A Theoretical Model with Evidence from Europe, European Economic Review

Abstract: We study the impact of regulatory barriers to entry on workplace training. We develop a model of training in imperfectly competitive product and labour markets. The model indicates that there are two contrasting effects of deregulation on training. As stressed in the literature, with a given number of firms, deregulation reduces the size of rents per unit of output that firms can reap by training their employees. Yet, the number of firms increases following deregulation, thereby raising output and profit gains from training and improving investment incentives. The latter effect prevails. In line with the predictions of the theoretical model, we find that the substantial deregulation in the 1990s of heavily regulated European industries (energy, transport and communication) increased training incidence.

4.6. Blatter et al. (2016)

Paper: Hiring costs for Skilled Workers and the Supply of Firm-Provided Training, Oxford Economic Papers

Abstract: This article analyses how the costs of hiring skilled workers from the external labour market affect a firm's supply of training. Using administrative survey data with detailed information on hiring and training costs for Swiss firms, we find evidence for substantial and increasing marginal hiring costs. However, firms can invest in internal training of unskilled workers and thereby avoid costs for external hiring. Controlling for a firm's training investment, we find that a 1 standard deviation increase in average external hiring costs increases the number of internal training positions by more than half of a standard deviation.

4.7. Caicedo et al. (2022)

Paper: Unwilling to Train?—Firm Responses to the Colombian Apprenticeship Regulation, Econometrica

Research Question: How do firms react to an apprenticeship regulation program in Colombia?

Institutional Context: There is a labor market reform in 2003 in Colombia, which included a radical overhaul of the apprenticeship regulation. The relevant reform in apprenticeship regulation has three key components:

- Apprentice Quotas: First, apprentice quotas depending on the number of full-time workers in a firm are established. The quota sets both a maximum and a minimum number of apprentices.
- Apprentices' Minimum Wage: The reform also lowers the minimum wage of apprentices as an additional incentive for firms to train.
- Fee: Finally, firms can pay a fee instead of hiring the minimum required apprentices. This fee is proportional to the difference between the minimum quota and the number actually hired by the firm.

Overall Findings: There is strong heterogeneity in responses across sectors, where firms in sectors with high skill requirements tend to avoid training apprentices, while firms in low-skill sectors seek apprentices. Guided by these reduced-form findings, the authors then structurally estimate firms' training costs. Especially in high-skill sectors, many firms face large training costs, limiting their willingness to train apprentices. Yet, there is substantial overall benefits of expanding apprenticeship training, in particular when the supply of trained workers increases in general equilibrium. Finally, counterfactual policy experiments taking into account heterogeneity across sectors can deliver similar benefits from training while inducing fewer distortions in the firm-size distribution and in the allocation of resources across sectors.

Reduced-Form Findings: The basic identification strategy is bunching, since the apprenticeship

regulation introduces multiple discontinuities based on the number of full-time workers in a firm. The key identification strategy assumption is that the density would have been smooth in the absence of the policy. There are three main reduced-form findings:

- Firms in high-skill sectors bunch below the thresholds; firms in low-skill sectors bunch at the thresholds.
- Firms in high-skill sectors tend to choose the minimum number of apprentices; firms in low-skill sectors tend to choose the maximum.
- Only high-skill sector firms tend to pay the fee.

4.7.1. Summary of the Model

Firms differ in two dimensions, their costs of training apprentices and their managerial ability. Training costs explain the heterogeneous firm responses uncovered by the reduced-form analysis, while managerial ability gives rise to the firm size distribution.

Consider an infinite-period economy composed of $K \geq 1$ sectors with a fixed number of heterogeneous firms in each sector. Firms in sector k are characterized by training costs t_a^k and managerial ability z^k, which follow sector-specific distributions $\mathscr{T}^k$ and $\mathscr{Z}^k$. These firms characteristics are invariant across time. Firms produce y_t^k units of good k in period t using labor, which is supplied either by workers l_t^k or by apprentices $l_{a,t}^k$. Suppose that workers are sector-specific, but apprentices can be trained in any sector. All individuals are endowed with a unit of time, which they supply inelastically.

Apprentices have to be trained using workers' time in order to be able to contribute to production. Let $t_a^k \geq 0$ denote training costs in units of time workers have to spend training the apprentice. Across firms and sectors, apprentices potentially require different amounts of training time. In addition, the opportunity cost of workers who train apprentices can vary. If a firm hares n_t^k workers and trains $n_{a,t}^k$ apprentices, labor supplied by workers is $l_t^k \equiv n_t^k - t_a^k n_{a,t}^k$ and labor supplied by apprentices is $l_{a,t}^k \equiv \zeta_a^k n_{a,t}^k$. $\zeta \in [0,1]$ is apprentices' productivity per unit of time they contribute to production (relative to workers), which may differ across sectors. Finally, firms in different sectors also differ in their production function $f^k\left(l_t^k, l_{a,t}^k; z^k\right)$. Assume that the production function is increasing in labor inputs $\left(l_t^k, l_{a,t}^k\right)$ and in managerial ability.

Firms maximize profits by choosing the number of workers and apprentices in each period. They take as given the price of the good they produce p_t^k, and the wages of the workers and apprentices w_t^k and $w_{a,t}^k$. It solves

$$\max_{\left(n_t^k\right)_t, \left(n_{a,t}^k\right)_t \geq 0} \sum_{t=0}^{\infty} \beta^t \left[p_t^k f^k \left(n_t^k - t_a^k n_{a,t}^k, \zeta_a^k n_{a,t}^k; z^k \right) - w_t^k n_t^k - w_{a,t}^k n_{a,t}^k \right] \quad \text{s.t. } t_a^k n_{a,t}^k \leq n_t^k \forall\, t \tag{4.7.1}$$

The constraints $t_a^k n_{a,t}^k \leq n_t^k$ ensure that the firm must hire enough workers to train the chosen num-

ber of apprentices in every period.

The supply side is simple, where the number of apprentices trained increases the number of workers in a sector in the next period. Let L_t^k and $L_{a,t}$ denote the supply of workers in sector k and the total number of untrained apprentices in period t, respectively. Workers can perform the tasks of apprentices but not vice versa. This implies that in equilibrium, apprentices' wages are smaller or equal to those of workers. In addition, the minimum wage could be binding. Both constraints together imply $w_t^k \geq w_{a,t}^k \geq w_{\min} \geq 0, \forall\, t, k$.

Suppose that the labor market clears separately by sector. The wage constraints imply that some workers could remain unemployed and potential apprentices untrained. Let N_t^k and $N_{a,t}^k$ denote aggregate demand for workers and apprentices, respectively. The market clearing conditions are $N_t^k + U_t^k = L_t^k$, $\sum_k N_{a,t}^k + U_{a,t} = L_{a,t}$, where $U_t^k, U_{a,t} \geq 0$ denote unemployed workers and untrained apprentices. Having separate labor markets by sector allows us to account for wage differences across sectors as observed in the data.

Trained apprentices increase the future supply of workers in their sector of training. This component of the model captures potentially important dynamic benefits of the policy. Therefore,

$$L_{t+1}^k = L_t^k + \chi_a^k N_{a,t}^k, \tag{4.7.2}$$

where χ_a^k denotes the effective units of labor a trained apprentice contributes to next-period labor supply. This parameter reflects how useful or transferable the skills acquired by apprentices are within a sector.

Given the above model without apprenticeship regulation, the authors then directly incorporate the the apprenticeship regulation into the theoretical framework.

Quantitative Exercises Motivated by the Model:

The authors then estimate the key parameters of the model, and then use the model to guide the following exercises:

- First, they quantify the effects of the regulation under three scenarios: (i) in partial equilibrium, (ii) in general equilibrium, where wages and prices adjust and any excess labor supply is absorbed, and (iii) in a dynamic scenario, where trained apprentices increase the future supply of workers.
- Then, they study the distributional effects of apprenticeship regulation.
- Counterfactual simulations in the current policy context: the role of each of the three policy components.
- Counterfactual apprenticeship policies: (i) a pure subsidy on training costs financed by payroll taxes, and (ii) sector-specific minimum wages for apprentices.

5. Empirical Papers: Effects of (Firm-Provided) Training Programs

There are many papers talking about the impacts of job training programs. According to Card et al. (2018), these active labor market programs can be classified into the following five types:

1. classroom or on-the-job training
2. job search assistance, monitoring, or sanctions for failing to search
3. subsidized private sector employment
4. subsidized public sector employment
5. other programs combining two or more of the above types.

Among these categories, only the first one is relevant to our context. Therefore, I try to find as many as possible papers of type 1 and summarize them in this section. Among papers in this section, only Munasinghe and O'Flaherty (2005) is a theory paper.

McKenzie (2017) is also a frequently cited review paper that surveys recent empirical papers investigating the effects of "Active Labor Market Policies (ALMP)". It focuses on developing countries and cares less about on-the-job training, thus making it less relevant to our topic. They divide these policies into three main categories.

- On the supply side, aiming to increase the employability of workers through vocational training.
- On the demand side, through subsidizing the cost of labor to firms with employment subsidies.
- Search and matching assistance programs, aiming to lower frictions that prevent demand from meeting supply in the labor market.

5.1. de Grip and Sauermann (2012)

Paper: The Effects of Training on Own and Co-worker Productivity: Evidence from a Field Experiment, The Economic Journal

RCT Context:

The field experiment was carried out in the call centre of a multi-national telephone company in the Netherlands. The main task of call agents in this department is to answer customer phone calls. The randomly assigned training programme mainly focuses on information in promotional campaigns, communication and information technology skills, as well as on handling more complex calls. In a more general context, work-related training is an important element of the call centre industry. In general, call agents receive hardly any initial vocational training, whereas the heavy use of information technology in in-house centres requires high investments in work-related training.

The agents are organised into 10 teams. Agents were randomly assigned to treatment and control groups. The training was a one-week course to train call agents in conversation techniques designed to decrease the average handling time of calls while maintaining call quality. However, due to capacity constraints, only one group, with a maximum of 10 agents, could be trained at a time. This *time-varying treatment* of the agents in a team allows for the further random assignment of agents into a first and a second training group. This enables us to identify possible externalities from training on untreated peers within a team.

Measuring Productivity:

In this context, the authors can use the key performance indicator used by the call centre to evaluate its call agents, that is, the average time needed to handle inbound customer calls. More specifically, they use the inverse of the average handling time (aht_{it}) multiplied by 100: $y_{it} = (1/aht_{it})100$.

Identification Strategy:

Identification of externalities: There are three groups of agents: those who were trained first (first training group); their teammates who were trained later (second training group); and the agents in the teams in the original control group who will not be trained in the period this paper analyses. The authors exploit the fact that the agents of one team were randomly assigned to training groups to identify within-team externalities.

Findings: Participation in the training programme leads to a 10% increase in performance. Moreover, the experimental evidence for externalities from training shows that an increase of 10 percentage points in the share of treated peers improves a worker's performance by 0.51%.

5.2. Konings and Vanormelingen (2015)

Paper: The Impact of Training on Productivity and Wages: Firm-Level Evidence, Review of Economics and Statistics

Findings: An increase in the share of trained workers by 10 percentage points is associated with 1.7% to 3.2% higher productivity, depending on the specification. However, consistent with the theoretical insights about wage compression and training, this increase in productivity is not entirely offset by a similar increase in wages. The average wage per worker increases only by 1.0% to 1.7% in response to the same increase in training.

Empirical Framework:

The authors use a control function approach to estimate production functions and wage equations at the firm level to infer productivity and wage premiums of training, taking explicitly the endogeneity of training into account.

The output of a firm i in period t is a function of capital and a labor quality aggregate used by the

firm in period t. That is,

$$Y_{it} = \widehat{L}_{it}^{\beta_l} K_{it}^{\beta_k} \exp\left(q_{it}\right) \exp\left(\varepsilon_{it}\right), \tag{5.2.1}$$

where Y_{it} represents value added, $\widehat{L}_{it}$ is aggregate effective labor input, K_{it} is capital, and q_{it} represents technical efficiency shifting the production function.

Suppose for the moment that workers can be distinguished according to their education and training level. If these characteristics enter the effective labor input as in a Mincer (1974) wage equation, the labor aggregate at the firm level can be written as

$$\ln \widehat{L}_{it} = \ln L_{it} + \beta_T \overline{T}_{it} + \beta_S \overline{S}_{it} + Z_{it}.$$

Here, $\overline{T}_{it}$ represents the average training intensity of the workforce employed in firm i during period t. $\overline{S}_{it}$ represents the average schooling level of the workforce, and Z_{it} is unobserved labor quality. The parameters β_T and β_S are the productivity premiums associated with training and schooling, respectively. The production function can subsequently be written as follows:

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_l \beta_T \overline{T}_{it} + \beta_l \beta_S \overline{S}_{it} + \omega_{it} + \varepsilon_{it}. \tag{5.2.2}$$

Unobserved productivity ω_{it} includes both technological progress and unobserved labor quality. The main parameter of interest is β_T, which measures how the labor aggregate varies with training intensity and reflects the impact of training on the marginal product of a worker. If training intensity is defined as a discrete characteristic, the parameter reflects the productivity premium of a trained worker compared to an untrained worker.

Applying a similar derivation as for the labor aggregate in the production function, the logarithm of the average wage, $\overline{w}_{it}$, paid by firm i in period t can be written as

$$\overline{w}_{it} = w_0 + \alpha_T \overline{T}_{it} + \alpha_S \overline{S}_{it} + \alpha_0 Z_{it}, \tag{5.2.3}$$

where again $\overline{T}_{it}$ and $\overline{S}_{it}$ represent the average training intensity and the average schooling level, respectively. Then, the authors add industry and year effects to the estimation equation as well as observed firm characteristics X_{it} such as the capital-labor ratio and an additive i.i.d. error term ε_{it}. The equation that will be estimated is

$$\overline{w}_{it} = w_0 + \alpha_T \overline{T}_{it} + \alpha_S \overline{S}_{it} + X_{it}\beta + \alpha_0 Z_{it} + \varepsilon_{it}. \tag{5.2.4}$$

The parameters α_T and α_S measure how wages change in response to training and schooling, respectively.

Estimation Strategy

The empirical framework is mostly relevant to Hellerstein et al. (1999), and the estimation strategy is proposed by Ackerberg et al. (2006), which effectively uses the insight that optimal input choices hold information about unobserved productivity.

5.3. Crépon and Premand (2019)

Paper: Direct and Indirect Effects of Subsidized Dual Apprenticeships, IZA Discussion Paper Series

Institutional Context:

Characteristics of *traditional apprenticeships*:

- They are private arrangements between youths (or their families) and private sector firms. Arrangements are rarely formalized through a contract.
- They take place in micro and small firms, many of which operate in the informal sector.
- With the help of their family, youths are often placed with master craftsmen identified through connections. A fee (in-kind or in cash) is paid for the placement.
- Youth learn the trade through practical, on-the-job training by working in enterprises under the mentoring of a master craftsman, either an experienced worker or the enterprise owner.
- Over time, youths start being paid.
- Traditional apprenticeships last many years, and often do not lead to certification, though master craftsmen typically need to grant departure to mark the completion of an apprenticeship.
- After completing traditional apprenticeships, youths transition either as an employee in the host firm, as a wage worker in another firm, or in self-employment.

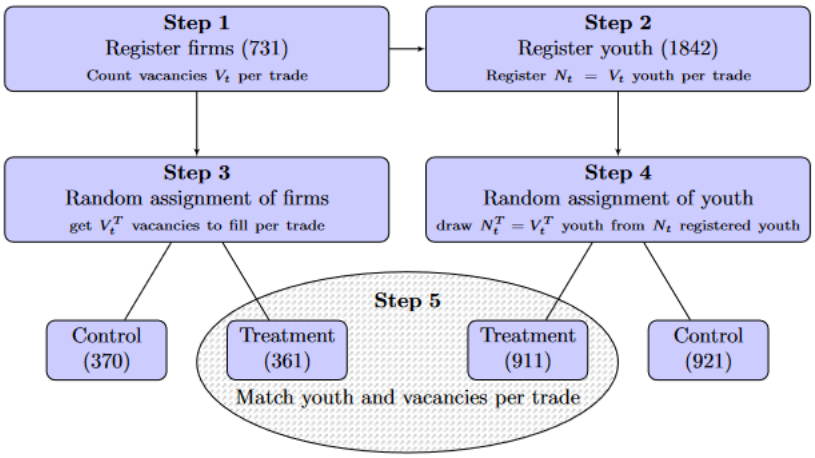
The Côte d'Ivoire Formal Apprenticeship (PEJEDEC) Program:

- The program puts in place a formal apprenticeship scheme lasting 12 or 24 months, depending on occupations.
- Low-skilled youths between 18 and 24 years old are placed in firms, where they receive on-the-job training under the supervision of a master craftsman.
- Youths sign a contract with the implementation agency (AGEFOP) and are paid a monthly *subsidy* of 30,000 FCFA (approximately USD 54, or half the formal minimum wage), which is aimed to cover meals and transport costs. They receive an insurance coverage and work equipment.
- The apprenticeship is *dual*, since on-the-job practical training is complemented by theoretical training (approximately 180 hours per year) tailored to the needs of apprentices and delivered by local training institutions.
- The program ends with an assessment of youths' skills, with a possibility of certification.
- Firms are not compensated for taking on apprentices, though they receive a small toolkit of material to facilitate practical learning.

RCT Design:

To simultaneously measure direct effects among individuals and indirect (substitution) effects in firms, the authors set up a *double-sided experiment*. Specifically, they randomize whether interested youths were assigned to a formal apprenticeship, and whether apprenticeship positions opened by firms were filled with formal apprentices. A simple theoretical framework shows that this design is tailored to estimate direct impacts such as *windfall effects* for youths, as well as indirect impacts such as *substitution effects* in firms hosting apprentices. The RCT design is illustrated in the following figure.

Figure 5.3.1: Experimental Design



Model: The authors develop a simple matching model for apprenticeship positions to describe the interaction between treated and control units among both youths and firms. The objective of the model is to show how the introduction of subsidized dual apprenticeships affects the equilibrium in the market for traditional apprenticeship.

Empirical Strategy:

Intent-to-treat (ITT) program impacts on firms can be estimated by comparing outcomes between firms assigned to treatment (i.e. where formal apprentices were assigned by the program to fill open positions), and firms assigned to control (i.e. where open apprenticeship positions were not filled by the program). It is performed using OLS regressions with the 667 firm-level observations:

$$y_i = a + bT_i + \sum_v \gamma_v 1_v + \sum_s \delta_s 1_s + u_i, \tag{5.3.1}$$

where T is the variable capturing assignment to treatment, v stands for locality and s for sector.

Intent-to-treat program impacts on youths can be estimated by comparing outcomes between youths assigned to treatment (i.e. offered a formal apprenticeship position in a treatment firm), and control. To account for the fact that youths were assigned to treatment and control with probabilities that were specific to each trade in each locality, the authors run an inversely propensity weighted

regression with strata dummies on the 1661 youth observations:

$$y_i = a + bT_i + \sum_{St} \mu_{St} 1_{St} + u_i. \tag{5.3.2}$$

Findings:

The authors document direct effects for youths and indirect effects for firms, such as whether they substitute between traditional and subsidized apprentices. In the short run, youths increase their human capital investments and we observe a net entry of apprentices into firms. Substitution effects are limited: the intervention creates 0.74 to 0.77 new position per subsidized apprentice. The subsidy offsets forgone labor earnings. Four years after the start of the experiment, treated youths perform more complex tasks and their earnings are higher by 15 percent. We conclude that subsidized dual apprenticeships expand access to training, upgrade skills and improve earnings for youths without crowding out traditional apprentices.

5.4. Alfonsi et al. (2020)

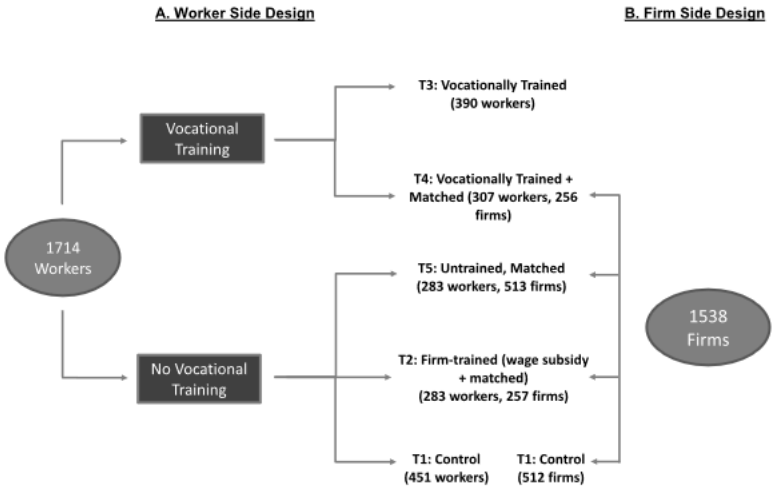
Paper: Tackling Youth Unemployment: Evidence From a Labor Market Experiment in Uganda, Econometrica

Research Question: Which kind of training is more effective in fighting youth unemployment, vocational training (VT) or firm-provided training (FT)?

RCT Design:

It is a double-sided experiment, just like Crépon and Premand (2019). The design is graphically illustrated as follows.

Figure 5.4.1: Experimental Design



Findings:

The first finding is that, two to three years post intervention, workers who have received training have accumulated sector-specific skills (equivalent to a 30% or 0.4sd increase over control workers).

The second finding is that there is substantial divergence in compliance: 68% of workers assigned to VT start this training, but only 24% of workers assigned to FT do. This gap is driven by firm, rather than worker, characteristics.

The third finding is that both treatments improve an index of worker labor market outcomes, that combines employment, total labor supply, and earnings. Due to differences in compliance, the ranking of the two treatments depends on whether we look at ITT or ATE, but in both cases, we fail to reject the null of equality.

However, these similarities mask differences in dynamic treatment effects. FT workers find employment more quickly than VT workers, but over time, their employment rate converges to the control group, while employment rates for VT workers increase over time. This reversal of fortune between FT and VT workers is also found for earnings—FT workers do well initially, but then over time, their earnings fall behind those of VT workers.

After developing and estimating a job ladder model relevant to this context, the authors offer an interpretation to what drives the dynamic treatment effects: vocational trainees pull away from FT workers in their employment rates and earnings because they are more likely to get back onto the job ladder if they fall into unemployment.

Therefore, tackling youth unemployment by skilling youth using vocational training pre-labor market entry appears to be more effective than incentivizing firms through wage subsidies to hire and train young labor market entrants.

Abstract: We design a labor market experiment to compare demand- and supply-side policies to tackle youth unemployment, a key issue in low-income countries. The experiment tracks 1700 workers and 1500 firms over four years to compare the effect of offering workers either vocational training (VT) or firm-provided training (FT) for six months in a common setting where youth unemployment is above 60%. Relative to control workers, we find that, averaged over three post-intervention years, FT and VT workers: (i) enjoy large and similar upticks in sector-specific skills, (ii) significantly improve their employment rates, and (iii) experience marked improvements in an index of labor market outcomes. These averages, however, mask differences in dynamics: FT gains materialize quickly but fade over time, while VT gains emerge slowly but are longlasting, leading VT worker employment and earning profiles to rise above those of FT workers. Estimating a job ladder model of worker search reveals the key reason for this: VT workers receive significantly higher rates of job offers when unemployed, thus hastening their movement back into work. This likely stems from the fact that the skills of VT workers are certified and therefore can be demonstrated to potential employers. Tackling youth unemployment by skilling youth using vocational training pre-labor market entry therefore appears to be more effective than incentivizing firms through wage subsidies to hire and train young labor market entrants.

5.5. Sandvik et al. (2021)

Paper: Should Workplace Programs be Voluntary or Mandatory? Evidence from a Field Experiment on Mentorship, NBER Working Paper Series

Research Question: First, do workplace mentorship programs improve productivity and retention? Second, does a program's efficacy depend on whether it is mandatory or voluntary? Third, are the workers that opt out stronger or weaker?

RCT Context:

The context for this paper is a mentorship program in a U.S.-based inbound sales call center. The workers at this firm answer incoming calls to sell digital products, like television and internet subscriptions. They are strongly incentivized to increase their individual sales, as commissions make up over a third of the median employee's compensation.

The novelty of the experimental design is the ability to estimate treatment effects and compare them when the identical program is either voluntary or mandatory. This design entailed two levels of randomization: the first is at the new hire training batch/cohort level, and the second is at the agent level within a cohort.

The authors first randomized new hire cohorts into one of two groups, labeled the *Mandatory-Condition* and the *Voluntary-Condition*. For cohorts in the Mandatory-Condition, the lower level treatment involved randomly assigning sales agents to have a mentor or not. The Mandatory-Condition label does not imply universal participation or compliance after a mentor was assigned. They refer to agents who were assigned a mentor as "mentored," even though some did not interact with their mentor. For cohorts in the Voluntary-Condition, on the first day of training, the firm's staff asked each new hire to write a private message indicating whether they wanted to participate in a mentorship program that would begin after their two-week training. For those who opted in, the lower level treatment involved randomly assigning agents to have a mentor or not. Agents who opted out of participation were not assigned a mentor. All mentors were randomly drawn from a pool of established, non-supervisory sales agents. Matched mentor-protege pairs were asked to meet for 30 minutes every week for four weeks and to follow a protocol.

Findings:

First, the intention-to-treat estimates show that agents randomized into receiving mentorship in the Mandatory-Condition generate 17% more daily revenue than non-mentored agents during their first two months on the job. Mentorship also improves retention. Treated agents are significantly more likely to remain with the firm through the first 30 days on the job (where attrition rates are traditionally highest). Treatment effects on long-term retention are insignificant.

Second, the authors test whether the treatment effects of mentorship differ for workers who opt into the program in the Voluntary-Condition. And they find that the productivity gains from mentorship are substantially smaller when the program is voluntary, although treatment effects on retention are similar across conditions.

Third, they test whether the workers who opt-in are stronger or weaker. Given that they find that workers who opt-in have a larger treatment effect of mentorship, this also tests whether mentorship is a complement or substitute for skills. And they find that those who opt-in are about 30% more productive than agents who opt into the program at baseline.

5.6. Card et al. (2018)

Paper: What Works? A Meta Analysis of Recent Active Labor Market Program Evaluations, Journal of the European Economic Association

Abstract: We summarize the estimates from over 200 recent studies of active labor market programs. We classify the estimates by type of program and participant group, and distinguish between three different post-program time horizons. Using regression models for the estimated program effect (for studies that model the probability of employment) and for the sign and significance of the estimated effect (for all the studies in our sample) we conclude that: (1) average impacts are close to zero in the short run, but become more positive 2-3 years after completion of the program; (2) the time profile of impacts varies by type of program, with larger average gains for programs that emphasize human capital accumulation; (3) there is systematic heterogeneity across participant groups, with larger impacts for females and participants who enter from long term unemployment; (4) active labor market programs are more likely to show positive impacts in a recession.

5.7. McKenzie (2017)

Paper: How Effective Are Active Labor Market Policies in Developing Countries? A Critical Review of Recent Evidence, The World Bank Research Observer

Abstract: Jobs are the primary policy concern of policymakers in many countries. The 2007-2008 global financial crisis, rising demographic pressures, high unemployment rates, and concerns over automation all make it seem imperative that policymakers employ increasingly more active labor market policies. This paper critically examines recent evaluations of labor market policies that have provided vocational training, wage subsidies, job search assistance, and assistance moving to argue that many active labor market policies are much less effective than policymakers typically assume. Many of these evaluations find no significant impacts on either employment or earnings. One reason is that urban labor markets appear to work reasonably well in many cases, with fewer market failures than is often thought. As a result, there is less of a role for many traditional active labor market policies than is common practice. The review discusses examples of job-creation policies that do seem to offer promise, and concludes with lessons for impact evaluation and policy is this area.

5.8. Munasinghe and O'Flaherty (2005)

Paper: Specific Training Sometimes Cuts Wages and Always Cuts Turnover, Journal of Labor Economics

Abstract: Turnover falls with tenure, but wages do not always rise (and sometimes fall) with tenure. We reconcile these findings by revisiting an old issue: how gains from firm-specific training are split between workers and firms. The division is determined by a stationary distribution of outside offers. The lower the wage a firm pays to a specifically trained worker, the more profit it makes but the more likely the employee is to leave. The optimal time paths of wages and turnover show that, if marginal product is increasing, wages need not be increasing but it always implies a falling turnover rate.

5.9. Kuruscu (2006)

Paper: Training and Lifetime Income, American Economic Review

Summary of the Paper: In this paper, the author develops a nonparametric methodology to estimate the net gains in lifetime income from on-the-job investments using wage data. The intensity of on-the-job training is Ben-Porath (1967) style and is endogenously chosen by individuals. The key assumption is that there is no wage growth after 20 years of experience.

Overall, this paper is not so relevant to our topic.

5.10. Blundell et al. (2021)

Paper: Wages, Experience, and Training of Women over the Life Cycle, Journal of Labor Economics

Abstract: We investigate the role of training in reducing the gender wage gap using the British Household Panel Survey. On the basis of a lifecycle model and using tax and welfare benefit reforms as a source of exogenous variation, we evaluate the role of formal training and experience in defining the evolution of wages and employment careers, conditional on education. Training is potentially important in compensating for the effects of children, especially for women who left education after completing high school, but does not fundamentally change the wage gap resulting from labor market interruptions following child birth.

Notes: A life-cycle model, not so relevant to our topic.

6. Papers Related to Our Topic

This section tries to review the papers that talk about how firms are responding to new tasks and jobs due to automation and other forms of technological advances. The most relevant empirical paper is Bartel et al. (2007) and some macro papers (Jaimovich et al., 2021; Fornino and Manera, 2022) are also relevant. In general, the following paragraph is how I think about firms' adjustments to new technology.

A lot of evidence documents that the development of technology greatly increases demand for certain skills, tasks, and jobs. They are often described as non-routine, abstract, and intellectually complex. However, few papers provide firm-level investigation on how firms adjust for these new demands when they introduce new technology. In general, there are two ways for adjustments: a typical *"make or buy" choice*. First, they can fire current workers and hire new workers. Some macro paper, such as Fornino and Manera (2022) focuses on this channel and discusses the importance of labor mobility and flexibility. Other papers (Acemoglu et al., 2022; Atalay et al., 2018) which directly study firms' job posts also corroborate this channel of adjustments. Second, firms can also retain their current employees and re-train them to achieve skill-upgrade. Relevant to this channel, Jaimovich et al. (2021) consider the general equilibrium effects of possible retraining programs targeted at workers who are adversely affected by automation. The most relevant paper is Bartel et al. (2007), which collects plant-level data in one industry and shows that the introduction of IT leads to increasing demand for technical and problem-solving skills, and incentivizes the adoption of new human resource practices (including training in technical skills, meetings for information sharing, and teams) to support these skills. However, few papers talk about the effectiveness of these firm-provided re-training programs, and this may be the most significant contribution of our paper.

6.1. Bartel et al. (2007)

Paper: How Does Information Technology Affect Productivity? Plant-Level Comparisons of Product Innovation, Process Improvement, and Worker Skills, The Quarterly Journal of Economics

Research Question: How does now information technology affect firm-level productivity? What are the possible mechanisms?

Findings:

There are three main findings in this paper:

- First, valve manufacturers that adopt new IT-enhanced equipment also shift their business strategies and begin producing more customized valve products.
- Second, new IT investments improve the efficiency of all stages of the production process by reducing setup times, run times, and inspection times. [2]

[2] The reductions in setup times are theoretically important because they make it less costly to switch production from

- Third, adoption of new computer-based IT coincides with increases in the skill requirements of machine operators, notably technical and problem-solving skills, and with the adoption of new human resource practices.

And their third finding is extremely relevant to our topic. The authors demonstrate that plants that introduce new IT also report an increased demand for programming and computer skills, engineering knowledge, and problem-solving skills. Then, they consider three forms of HRM practices: teams, shop floor meetings for information sharing, and training in technical skills. They draw a conclusion that when a plant makes a new investment in more technologically advanced versions of the central CNC production technology, it is also more likely to institute technical training programs, problem solving teams, and shop floor meetings.

Abstract: We analyse how job training requirements interact with engineering complexity in shaping firms' automation decisions. A model that distinguishes between a task's engineering complexity and its training requirements predicts that when two tasks are equally complex, firms automate the task that requires more training. Under plausible conditions this leads to job polarisation, and in particular to polarisation of employment by initial training requirements. US data provide empirical support for the model's implications. Training requirements and a measure of engineering complexity account for much of US job polarisation from 1980 to 2008.

6.2. Dauth et al. (2021)

Paper: The Adjustment of Labor Markets to Robots, Journal of the European Economic Association

Research Question: How do local labor markets adjust to industrial robots in Germany?

Findings:

1. Robot exposure, as predicted by a shift-share variable, is associated with displacement effects in manufacturing, but those are fully offset by new jobs in services.
2. The incidence mostly falls on young workers just entering the labor force.
3. Automation is related to more stable employment within firms for incumbents, and this is driven by workers taking over new tasks in their original plants. Several measures indicate that those new jobs are of higher quality than the previous ones.
4. Young workers also adapt their educational choices, and substitute away from vocational training towards colleges and universities.
5. Industrial robots have benefited workers in occupations with complementary tasks, such as managers or technical scientists.

Their third finding confirms a mechanism of adjustments for robots that is relevant to our topic: the

one product to another and support the change in business strategy to more customized production.

reassignment of workers to new tasks and the upgrading of skills. But their identification variation comes form different levels of robot exposure in different local labor markets, so they cannot study firm-level adjustments or explain how these reassignments and upgrading take place.

6.3. Fornino and Manera (2022)

Paper: Automation and the Future of Work: Assessing the Role of Labor Flexibility, Review of Economic Dynamics

Abstract: We study the economic incentives for automation when labor and machines are perfect substitutes. Labor may still be employed in production, even when it is a costlier input than robots on a productivity-adjusted basis. This occurs if firms face idiosyncratic risk, adjusting the stock of machines is costly, and workers can be hired and fired quickly enough. Even though labor survives, jobs become less stable, as workers are hired in short-lived bursts to cope with shocks. We calibrate a general equilibrium, multi-industry version of our model to match data on robot adoption in US manufacturing sectors, and use it to compute the employment and labor share consequences of progress in automation technology. A fall in the relative price of robots leads to relatively few jobs losses, while reductions in adjustment costs, or improvements in relative robot productivity, can be far more disruptive. The model-implied semi-elasticity of aggregate employment to robot penetration (number of robots per thousand employees) ranges between 0.01% and 0.12%, depending on the underlying source of increased robot adoption, consistent with findings in the empirical literature. In an extension, we show that reduced-form hiring and firing costs unambiguously depress long-run employment.

6.4. Jaimovich et al. (2021)

Paper: The Macroeconomics of Automation: Data, Theory, and Policy Analysis, Journal of Monetary Economics

Abstract: The decline in middle-wage occupations and rise in automation over the last decades are at the center of policy discussions. We develop an empirically relevant general equilibrium model that features endogenous labor force participation, occupational choice, and automation capital. We use the model to consider two types of policies: the retraining of workers who were adversely affected by automation, and redistribution policies that transfer resources to these workers. Our framework emphasizes general equilibrium effects such as displacement effects of retraining programs, complementarities between the factors of production, and the effects of distortionary taxation that is required to fund these programs.

References

Acemoglu, Daron (1997) "Training and Innovation in an Imperfect Labour Market," *Review of Economic Studies*, 64 (3), 445, 10.2307/2971723.

Acemoglu, Daron, David Autor, Jonathon Hazell, and Pascual Restrepo (2022) "Artificial Intelligence and Jobs: Evidence from Online Vacancies," *Journal of Labor Economics*, 40 (S1), S293–S340, 10.1086/718327.

Acemoglu, Daron and Jörn-Steffen Pischke (1998) "Why Do Firms Train? Theory and Evidence," *The Quarterly Journal of Economics*, 113 (1), 79–119, https://www.jstor.org/stable/2586986.

——— (1999a) "Beyond Becker: Training in Imperfect Labour Markets," *The Economic Journal*, 109 (453), 112–142, 10.1111/1468-0297.00405.

——— (1999b) "The Structure of Wages and Investment in General Training," *Journal of Political Economy*, 107 (3), 539–572, 10.1086/250071.

——— (2003) "Minimum Wages and On-the-Job Training," *Research in Labor Economics*, 22, 159–202, 10.1016/S0147-9121(03)22005-7.

Ackerberg, Daniel A., Kevin Caves, and Garth Frazer (2006) "Structural Identification of Production Functions," *Working Paper*, 1–43.

Alfonsi, Livia, Oriana Bandiera, Vittorio Bassi, Robin Burgess, Imran Rasul, Munshi Sulaiman, and Anna Vitali (2020) "Tackling Youth Unemployment: Evidence From a Labor Market Experiment in Uganda," *Econometrica*, 88 (6), 2369–2414, 10.3982/ECTA15959.

Atalay, Enghin, Phai Phongthiengtham, Sebastian Sotelo, and Daniel Tannenbaum (2018) "New Technologies and the Labor Market," *Journal of Monetary Economics*, 97, 48–67, 10.1016/j.jmoneco.2018.05.008.

Autor, D. H. (2001) "Why Do Temporary Help Firms Provide Free General Skills Training?" *The Quarterly Journal of Economics*, 116 (4), 1409–1448, 10.1162/003355301753265615.

Bac, Mehmet (2000) "On-the-Job Specific Training and Efficient Screening," *Journal of Labor Economics*, 18 (4), 681–701, 10.1086/209973.

Balmaceda, Felipe (2005) "Firm-Sponsored General Training," *Journal of Labor Economics*, 23 (1), 115–133, 10.1086/425435.

Bartel, Ann, Casey Ichniowski, and Kathryn Shaw (2007) "How Does Information Technology Affect Productivity? Plant-Level Comparisons of Product Innovation, Process Improvement, and Worker Skills," *The Quarterly Journal of Economics*, 122 (4), 1721–1758, 10.1162/qjec.2007.122.4.1721.

Bassanini, Andrea and Giorgio Brunello (2008) "Is Training More Frequent When the Wage Premium Is Smaller? Evidence from the European Community Household Panel," *Labour Economics*, 15 (2), 272–290, 10.1016/j.labeco.2007.01.002.

——— (2011) "Barriers to Entry, Deregulation and Workplace Training: A Theoretical Model with Evidence from Europe," *European Economic Review*, 55 (8), 1152–1176, 10.1016/j.euroecorev.2011.05.004.

Ben-Porath, Yoram (1967) "The Production of Human Capital and the Life Cycle of Earnings," *Journal of Political Economy*, 75 (4, Part 1), 352–365, 10.1086/259291.

Blatter, Marc, Samuel Muehlemann, Samuel Schenker, and Stefan C. Wolter (2016) "Hiring Costs for Skilled Workers and the Supply of Firm-Provided Training," *Oxford Economic Papers*, 68 (1), 238–257, 10.1093/oep/gpv050.

Blundell, Richard, Monica Costa-Dias, David Goll, and Costas Meghir (2021) "Wages, Experience, and Training of Women over the Life Cycle," *Journal of Labor Economics*, 39 (S1), S275–S315, 10.1086/711400.

Caicedo, Santiago, Miguel Espinosa, and Arthur Seibold (2022) "Unwilling to Train?—Firm Responses to the Colombian Apprenticeship Regulation," *Econometrica*, 90 (2), 507–550, 10.3982/ECTA18911.

Card, David, Jochen Kluve, and Andrea Weber (2018) "What Works? A Meta Analysis of Recent Active Labor Market Program Evaluations," *Journal of the European Economic Association*, 16 (3), 894–931, 10.1093/jeea/jvx028.

Chang, Chun and Yijiang Wang (1996) "Human Capital Investment under Asymmetric Information: The Pigovian Conjecture Revisited," *Journal of Labor Economics*, 14 (3), 505–519, 10.1086/209820.

Crépon, Bruno and Patrick Premand (2019) "Direct and Indirect Effects of Subsidized Dual Apprenticeships," *IZA Discussion Paper Series*, 12793, 1–94, 10.2139/ssrn.3495770.

Dauth, Wolfgang, Sebastian Findeisen, Jens Suedekum, and Nicole Woessner (2021) "The Adjustment of Labor Markets to Robots," *Journal of the European Economic Association*, 19 (6), 3104–3153, 10.1093/jeea/jvab012.

Dustmann, Christian and Uta Schönberg (2009) "Training and Union Wages," *Review of Economics and Statistics*, 91 (2), 363–376, 10.1162/rest.91.2.363.

——— (2012) "What Makes Firm-based Vocational Training Schemes Successful? The Role of Commitment," *American Economic Journal: Applied Economics*, 4 (2), 36–61, 10.1257/app.4.2.36.

Flinn, Christopher, Ahu Gemici, and Steven Laufer (2017) "Search, Matching and Training," *Review of Economic Dynamics*, 25, 260–297, 10.1016/j.red.2017.02.003.

Fornino, Michele and Andrea Manera (2022) "Automation and the Future of Work: Assessing the Role of Labor Flexibility," *Review of Economic Dynamics*, 45, 282–321, 10.1016/j.red.2021.07.002.

Fu, Chao (2011) "Training, Search and Wage Dispersion," *Review of Economic Dynamics*, 14 (4), 650–666, 10.1016/j.red.2010.11.003.

Fudenberg, Drew and Luis Rayo (2019) "Training and Effort Dynamics in Apprenticeship," *American Economic Review*, 109 (11), 3780–3812, 10.1257/aer.20171939.

Gersbach, Hans and Armin Schmutzler (2012) "Product Markets and Industry-Specific Training," *The RAND Journal of Economics*, 43 (3), 475–491, 10.1111/j.1756-2171.2012.00182.x.

de Grip, Andries and Jan Sauermann (2012) "The Effects of Training on Own and Co-worker Productivity: Evidence from a Field Experiment," *The Economic Journal*, 122 (560), 376–399, 10.1111/j.1468-0297.2012.02500.x.

Hellerstein, Judith K., David Neumark, and Kenneth R. Troske (1999) "Wages, Productivity, and Worker Characteristics: Evidence from Plant-Level Production Functions and Wage Equations," *Journal of Labor Economics*, 17 (3), 409–446, 10.1086/209926.

Jaimovich, Nir, Itay Saporta-Eksten, Henry Siu, and Yaniv Yedid-Levi (2021) "The Macroeconomics of Automation: Data, Theory, and Policy Analysis," *Journal of Monetary Economics*, 122, 1–16, 10.1016/j.jmoneco.2021.06.004.

Katz, Eliakim and Adrian Ziderman (1990) "Investment in General Training: The Role of Information and Labour Mobility," *The Economic Journal*, 100 (403), 1147, 10.2307/2233964.

Konings, Jozef and Stijn Vanormelingen (2015) "The Impact of Training on Productivity and Wages: Firm-Level Evidence," *Review of Economics and Statistics*, 97 (2), 485–497, 10.1162/REST_a_00460.

Kuruscu, Burhanettin (2006) "Training and Lifetime Income," *American Economic Review*, 96 (3), 832–846, 10.1257/aer.96.3.832.

Lazear, Edward P (2009) "Firm-Specific Human Capital: A Skill-Weights Approach," *Journal of Political Economy*, 117 (5), 914–940, 10.1086/648671.

Malcomson, James M., James W. Maw, and Barry McCormick (2003) "General Training by Firms, Apprentice Contracts, and Public Policy," *European Economic Review*, 47 (2), 197–227, 10.1016/S0014-2921(02)00207-6.

McKenzie, David (2017) "How Effective Are Active Labor Market Policies in Developing Countries? A Critical Review of Recent Evidence," *The World Bank Research Observer*, 32 (2), 127–154, 10.1093/wbro/lkx001.

Moen, Espen R. and Åsa Rosén (2004) "Does Poaching Distort Training?" *Review of Economic Studies*, 71 (4), 1143–1162, 10.1111/0034-6527.00317.

Mohrenweiser, Jens and Thomas Zwick (2009) "Why Do Firms Train Apprentices? The Net Cost Puzzle Reconsidered," *Labour Economics*, 16 (6), 631–637, 10.1016/j.labeco.2009.08.004.

Muehlemann, Samuel, Harald Pfeifer, Günter Walden, Felix Wenzelmann, and Stefan C. Wolter (2010) "The Financing of Apprenticeship Training in the Light of Labor Market Regulations," *Labour Economics*, 17 (5), 799–809, 10.1016/j.labeco.2010.04.006.

Munasinghe, Lalith and Brendan O'Flaherty (2005) "Specific Training Sometimes Cuts Wages and Always Cuts Turnover," *Journal of Labor Economics*, 23 (2), 213–233, 10.1086/428022.

Owan, Hideo (2004) "Promotion, Turnover, Earnings, and Firm-Sponsored Training," *Journal of Labor Economics*, 22 (4), 955–978, 10.1086/423160.

Quercioli, Elena (2005) "Training, Turnover, and Search," *International Economic Review*, 46 (1), 133–143, 10.1111/j.0020-6598.2005.00312.x.

Sandvik, Jason, Richard Saouma, Nathan Seegert, and Christopher Stanton (2021) "Should Workplace Programs Be Voluntary or Mandatory? Evidence from a Field Experiment on Mentorship," *NBER Working Paper Series*, w29148, 1–71.

Smits, W. (2007) "Industry-Specific or Generic Skills? Conflicting Interests of Firms and Workers," *Labour Economics*, 14 (3), 653–663, 10.1016/j.labeco.2006.09.002.

Stevens, Margaret (2001) "Should Firms Be Required To Pay For Vocational Training?" *The Economic Journal*, 111 (473), 485–505, 10.1111/1468-0297.00647.

Wolter, Stefan C. and Paul Ryan (2011) "Apprenticeship," *Handbook of the Economics of Education*, 3, 521–576, 10.1016/B978-0-444-53429-3.00011-9.