Cash Constraints and Labor Adjustments: Evidence from a Retirement Policy

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Abstract

In this paper I study how cash constraints affect firm responses to labor market policies. I use administrative data from the Netherlands to assess firm adjustments to labor and capital in the context of a change in the effective retirement age for individuals born in 1950 or after. Exploiting this sharp cohort boundary, I find that - for each retained older worker - firms on average employ 0.6 fewer younger workers and reduce investments in machines and equipment by 6,000 EUR annually. All of the labor and investment adjustments are concentrated in cash constrained firms, and only these firms experience declines in revenue and profitability. For every 1 EUR increase in wage costs for older workers, constrained firms reduce their younger workforce by 0.7 EUR in terms of payroll and investments by 0.2 EUR. As a potential policy avenue to alleviate cash constraints, I show that more time to anticipate a policy may help firms smooth adjustments and reduce negative profit effects. Altogether, the results imply that firm response is driven by direct cash flow effects from retaining more older workers rather than the substitutability between older and younger workers. Failing to account for these constraints leads to estimates of the substitutability between different production inputs that are biased by an order of magnitude.

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1 Introduction

Many policy reforms – including changes in tax policy, labor market policies and other regulation – require adjustments by firms. A large literature shows that firms’ ability to respond to shocks is determined by their financial position.\(^1\) Accounting for financial frictions may therefore be important in understanding the market consequences of policy reforms. When financially constrained such policies may force firms to adjust their workforce and investments, or make other changes to the production process. In theory financial frictions could generate large firm response to policies that may be unintended, and change what we learn about the economic drivers of such responses (Bond and Van Reenen, 2007).

In this paper I study this financial channel and its role in labor and capital adjustments in the context of a change in the effective retirement age in the Netherlands. Increasing the retirement age may cause firms to retain costly older workers and squeeze a firm’s internal funds. In the presence of financial frictions, firms may be forced to cut back on other inputs, including their hiring of younger workers or new investments. I find that cash constrained firms make substantial adjustments to labor and capital in response to the policy, whereas cash unconstrained firms do not. These findings highlight the importance of cash constraints as a driver of firm response to the policy. In this context, estimates of the substitutability between older and younger workers or capital would be biased by an order of magnitude when failing to take into account such constraints.

I begin the paper by outlining a basic model of firm production to understand how firms adjust their younger workforce and capital in response to retaining more older workers due to the policy, depending on whether firms are cash constrained or not. First, when firms are not cash constrained their response depends on the degree of substitutability between older and younger workers or capital. When younger and older workers are substitutes, retaining more older workers decreases the demand for younger workers, whereas if they are complements the demand for younger workers increases. Second, when firms are cash constrained their response additionally depends on how the increased wage costs for older workers restricts how many younger workers and how much capital a firm can finance. Intuitively, the differential policy response between cash constrained and unconstrained firms identifies the direct cash flow effect. Lastly, cash constrained firms face a trade off between adjusting their younger workforce and investment. Intuitively, reductions in investments relieve some of the cash constraints imposed on labor.

To examine these effects empirically, I use detailed administrative worker and firm data to analyze the effect of a policy change in the Netherlands that severely limited early retirement options for individuals born in 1950 or after but not those born before. Rather than starting retirement as early as 60, affected workers were more likely to work until the legal retirement age of 65, shifting the average retirement age by approximately two years. I use quasi-random variation in the birth year of workers at a firm level, comparing firms that had more treated workers born in 1950 or 1951 to firms that had more untreated workers born in 1948 or 1949. The analysis relies on the assumption that close enough to the 1950 cohort boundary

\(^1\)See e.g. Giroud and Mueller (2016) and Schoefer (2015) who study the role of firm leverage and financial frictions in firm response to the great recession. In addition, there is a large literature showing a positive correlation between investment and firm cash flow in Fazzari, Hubbard, and Petersen (1988, 2000), Kaplan and Zingales (1997, 2000) and between labor demand and firm cash flow in Benmelech et al. (2015).
the number of workers with a given birth year is as good as random. Using linked employment records and firm balance sheets for 2001-2018 made available through Statistics Netherlands, I examine firm worker composition and investment over time and assess how these adjustments translated into changes in firm revenue and profits. Furthermore, the data allow me to obtain a firm-level measure of free cash flow prior to the policy, which I use as a proxy for firm cash constraints.

The analysis consists of three main parts. First, I examine the overall firm response to the policy change and show that firms with treated workers make substantial labor and investment adjustments in the years that the policy change had an effect. Second, following the theoretical framework, I identify the role of cash constraints in firm adjustments by examining the differential response to the policy depending on firm-level free cash flow prior to the policy. Third, I examine how time to anticipate the policy change can help alleviate cash constraints faced by firms.

First, the results show that on average the policy had a substantial effect on firm worker composition and investments. Each additional treated worker caused firms to retain 0.25 more older workers in the main years that the policy had an effect. For each older worker retained, firms employed approximately 0.6 fewer younger workers. These adjustments are driven by reductions in hiring, rather than increases in firing or voluntary exits. I do not find adjustments in the number of middle-aged workers, nor intensive margin adjustments in hours worked or hourly wages among either young or middle-aged co-workers. Taken together, each additional treated worker raises a firm’s wage bill by approximately 6,000 EUR annually. Additionally, firms made significant adjustments to their investments in response to the policy. For each additional treated worker, firms on average reduced investments in equipment and machines by approximately 1,500 EUR annually, a reduction of 3 percent of total investment, or about 25% of the increase in the wage bill.

Second, I demonstrate the key role of cash constraints in the observed firm response to the policy. I rely on the model to separately identify adjustments due to cash constraints from adjustments arising from substitution effects between older and younger workers or capital. First, I use adjustments among financially less constrained firms, with above median free cash flow prior to the policy, to estimate the substitution channel. Such firms make virtually no adjustments to their younger workforce or investments, suggesting substitution effects between different inputs are small in this setting. Assuming similar substitution effects for more cash constrained firms, adjustments among such firms identify the direct cash channel. I find that more constrained firms, with below median free cash flow before the policy, make large adjustments in response to the policy. These firms consistently offset the additional older worker wage costs by reducing their younger workforce and investments, causing total costs to be unchanged over time. On average, for every 1 EUR increase in the wage bill of older workers due to the policy, such firms reduce their younger workforce by about 0.7 EUR in payroll terms, and investments by about 0.2 EUR. Consistent with the theory, I find that cash constrained firms trade off adjustments to labor and investment, depending on the adjustment costs faced. Adjustments to the younger workforce are concentrated in firms that were growing prior to the policy, and can adjust by reducing hiring. Shrinking firms, which can only make arguably costlier adjustments to labor through firing, do not reduce their younger workforce and instead adjust investments.

I further show that cash constraints are costly in terms of firm production and profits. Firms with treated workers that are more cash constrained experience declines in profits and revenue per worker, whereas less
constrained firms do not. The negative effects on firm profitability are especially concentrated in firms affected by both cash constraints and high labor adjustment costs - i.e. shrinking low free cash flow firms. The median firm in this group experiences about a 3 percentage point increase in the probability of reporting a loss, which is a 20 percent increase relative to baseline.

The results demonstrate the importance of taking cash constraints into account when estimating the substitutability between different factors of production. In this setting, the implied elasticity of substitution between older and younger workers is biased by at least a factor of seven when failing to take into account the direct cash flow effect from retaining older workers. On average for every retained older worker firms reduce their younger workforce by 0.6 workers, whereas cash unconstrained firms - whose response is driven by substitutability alone - only reduce their younger workforce by 0.08 workers.

The validity of these results depends on whether alternative mechanisms can account for the findings. A concern is that cash constrained firms respond more strongly to the policy not because they are cash constrained, but because of other reasons correlated with cash constraints. I evaluate several specific alternative explanations: (1) cash constrained firms were more heavily impacted by the policy, (2) cash constrained firms were less productive before the policy, (3) cash constrained firms grew too much prior to the policy. I find no evidence in support of these alternative explanations.

Lastly, if cash constraints substantially affect firm response to labor market policies, what can be done to minimize such effects? In the third part of the analysis I suggest that more time to anticipate policies might be a potential avenue to alleviate cash constraints. I rely on differences in the exact birth year of workers as a source of variation in the time to anticipate the policy. Intuitively, absent the policy change workers born in 1951 would have started early retirement one year later than workers born in 1950.

Each consecutive birth year therefore shifts the treatment window - the years in which workers would have retired early absent the policy but now continue to work - by one year. I use this variation to show that with three additional years to anticipate the policy, firm younger workforce adjustments are cut approximately in half. In addition, I find that each additional year of anticipation reduces the negative effect on the probability of reporting a positive profit by 1 percentage point, a reduction of about 20 percent. In the model firms could achieve such smoothing by building up cash reserves in advance. I find suggestive evidence in the data consistent with this channel, showing that firms with more time to anticipate appear to have higher free cash flow the years before the policy took effect.

This paper speaks to three main literatures. First, it contributes to the literature on aging and retirement policies. While there is a rich set of papers studying the effects of retirement policies on individual retirement decisions (e.g. Staubli and Zweimuller, 2013; Vestad, 2013), we know much less about how firms respond. One notable exception is a recent paper by Bovini and Paradisi (2019) which studies firm adjustments in terms of younger workers employed and wages in the context of a public pension reform in Italy. I add to these results, first, by examining additional outcomes including capital adjustments and effects on firm performance. Second, I shed light on mechanisms underlying the responses and highlight the importance of taking cash constraints into account.

\[ \text{In either case workers start early retirement beginning at 60 years old, which occurs in 2010 for workers born in 1950 but in 2011 for workers born in 1951.} \]

\[ \text{Note that the model does not include dynamics, but having more cash holdings when the policy hits could prevent cash constraints from binding.} \]
of direct cash flow effects associated with the retention of older workers. I demonstrate the importance of dynamics, through anticipation, in a firm’s ability to respond to retirement policies.

Second, it adds to a literature highlighting that changing factors of production is costly and takes time (Hamermesh and Pfann, 1996, and Bond and Van Reenen, 2007), and more narrowly to a literature on financial frictions and firm outcomes. Most of the empirical studies in this literature have focused on investment as an outcome (e.g. Fazzari et al. (1988, 2000), Kaplan and Zingales (1997, 2000), Chaney et al. (2012)), not labor adjustment. Notable exceptions are recent papers by Schoefer (2015) and Giroud and Mueller (2016), demonstrating the importance of financial frictions in firm employment response to recessions, and Chodorow-Reich (2013) who examines the role of bank lending frictions in labor demand. Furthermore, few papers have examined how financial frictions affect firm response to labor market policies, with the exception of Johnston (2018) who finds that cash constraints drive a large part of firm hiring response to a UI tax. I highlight the importance of cash constraints in my setting, and show how cash constraints affect firm adjustments along different margins. I demonstrate the quantitative importance of financial frictions in terms of effects on firm production and profitability. Furthermore, I highlight the role of dynamics by showing that the time to anticipate a shock appears important for a firm’s ability to make adjustments.

Third, it contributes to a literature on firm production and the substitutability of production inputs. There is a rich theoretical literature on firm production and the substitutability different types of labor and capital (see e.g. Acemoglu, Autor, 2011; Autor et al., 2003; Acemoglu and Restrepo, 2018). Empirical work on this topic notably includes Jaeger and Heining (2019) who examine changes in co-worker wages following unexpected worker death in Germany, amongst others to examine substitutability between co-workers of different occupations. I provide empirical evidence on the relative substitutability of different cohorts of workers, and suggest that in this setting those effects are zero, or at most very small. In doing so I highlight the importance of taking constraints into account when estimating elasticities of substitution. Financial channels might similarly affect firm response to other labor market policies and change how we interpret those adjustments in terms of elasticities of demand or substitution.

The remainder of this paper is organized as follows. Section 2 outlines a basic theoretical framework of firm production to show how firms might adjust labor in response to retaining more older workers, depending on the degree of financial constraints. Section 3 describes the empirical setting and administrative data. Section 4 includes the empirical strategy and identification assumptions used in the analysis. Section 5 presents the overall effects of the policy. Section 6 studies the role of cash constraints in firm adjustments, and how this varies with the time to anticipate the policy. Section 7 concludes.
2 Theoretical Framework

This section outlines a basic model of firm factor demand which incorporates financial frictions. I use this model to examine how firms adjust their younger workforce and investments in response to retaining more older workers, depending on whether firms are cash constrained or not.

Firms produce output $F$ using three inputs: capital, $K$, younger workers, $L^Y$, and older workers, $L^O$. The firm’s objective is to maximize profit which is defined as:

$$\Pi(K, L^O, L^Y) = F(K, L^O, L^Y) - p^K K - w^O L^O - w^Y L^Y$$

$p^K$ represents the cost of capital, $w^O$ is the wage paid to older workers, and $w^Y$ is the wage paid to younger workers. For simplicity, I assume that firms are wage and price takers and normalize the price of the final good to 1.

The key deviation from standard models of firm production is that firms face financial frictions. Such frictions arise from a difference in timing between when firms pay wages and capital costs and when firms produce and generate revenue (following Greenwald and Stiglitz, 1988). For simplicity, I consider the extreme case in which firms cannot borrow against future revenue streams at all, and all costs must be financed from a firm’s current cash flow $CF$:

$$L^O w^O + w^Y L^Y + p^K K \leq CF$$

In the context of the model, firms affected by the retirement policy experience a positive shock to their older workforce, denoted $\Delta L^O > 0$. This corresponds to the fact that a treated older worker otherwise could have taken advantage of early retirement but is now more likely to work until the legal retirement age. I assume that the firm’s older workforce, $L^O$, is exogenous and only affected by the policy.\footnote{This is consistent with the notion that older workers are very costly to fire, and not a margin of adjustment for firms. This matches the empirical context, since firing costs are high in the Netherlands and I do not observe an increase in firing of affected older workers in the data. Allowing for older worker adjustments would affect how binding the treatment is. In the extreme case, if retained older workers could be fired costlessly, firms could not be made worse off from the policy change. Firms could fire those workers that were expected to retire absent the policy at no cost. What follows below assumes that firms are unable to set the number of older workers, and that this is only affected by the policy.}

Firms respond by making adjustments to their younger workforce and to capital, denoted $\Delta L^Y$ and $\Delta K$, respectively. Firms face costs associated with adjusting their younger workforce. This captures the idea that a firm may have to re-organize its workforce, pay search costs and train new workers when hiring, or pay costs of firing workers in order to adjust employment. For simplicity I assume a quadratic adjustment cost function: $C(\Delta L^Y) = \frac{a}{2} (\Delta L^Y)^2$, a commonly used adjustment function in the literature (Bond and Van Reenen, 2007).\footnote{Intuitively a convex adjustment cost function captures the idea that it is costlier to make larger adjustments to employment, because firms might have to re-organize and/or (re)train a larger share of their workforce.} The parameter $a$ captures the degree of adjustment costs faced. The costs are financed up front, before firms experience the resulting change in revenue and profits. Hence, any adjustment costs faced must also be financed from a firm’s cash flow, $CF$. Note that this setup also includes upfront adjustment costs associated with investments, but because the main focus of this paper is on labor adjustments for simplicity I assume that such costs are linear and captured in $p^K$. 

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Case 1: Financially Unconstrained Adjustments

First, I consider how firms respond to the policy when the cash constraint in (2) does not bind. In this case, firms face the unconstrained profit maximization problem:

\[
(\Delta L^*, \Delta K^*) = \arg \max_{\Delta L^*, \Delta K} \left\{ F(L^O + \Delta L^O, L^Y + \Delta L^Y, K + \Delta K) - \left( L^O + \Delta L^O \right) w^O - (L^Y + \Delta L^Y) w^Y - (K + \Delta K) p^K - \frac{\alpha}{2} (\Delta L^Y)^2 \right\}
\]

The first-order conditions for adjustments in younger workers and capital are:

\[
F_{L^Y} = \left( w^Y + a \Delta L^Y^* \right) \\
F_{K} = p^K
\]

Intuitively these first-order conditions state that firms adjust their younger workforce up until the point at which the marginal product equals the wage plus the adjustment cost faced. In addition, firms adjust capital up until the point that the marginal product of capital equals the cost of capital.

How do the optimal labor adjustments change with the retention of older workers, $\Delta L^O > 0$? Without financial frictions the effect on labor adjustments is:

\[
(\partial \Delta L^Y^*/\partial \Delta L^O)_{Unconstrained} = \frac{1}{a} \left( \frac{F_{L^Y L^O}}{\text{Substitutability}} \right)
\]

The comparative static in equation (3) demonstrates that in the absence of financial frictions, adjustments in the younger workforce depend on the substitutability or complementarity between younger workers and the retained older workers. When younger and older workers are substitutes, $F_{L^Y L^O} < 0$, firms will reduce employment of younger workers. When younger and older workers are complements, $F_{L^Y L^O} > 0$, firms will increase employment of younger workers.

Case 2: Financially Constrained Adjustments

Second, I examine firm response when the cash constraint in (2) does bind. In this case, firm operating expenses are restricted by the amount of cash flow, $CF$, at the firm. In terms of changes to its inputs, this implies that:

\[
\Delta L^O w^O + \Delta L^Y w^Y + \frac{\alpha}{2} (\Delta L^Y)^2 + \Delta K p^K = 0
\]

This equation shows intuitively that an increase in $\Delta L^O$ resulting from the policy forces firms to make

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6Note that I consider the case when the cash constraint already binds before the reform.
adjustments in their younger workforce, through $\Delta L^Y$, and capital, through $\Delta K$. Note that any choice of $\Delta L^Y$ also pins down $\Delta K$ through the constraint (4). Hence, in this case, firms set $\Delta L^Y$ so as to maximize revenue subject to the constraint (4):

$$\Delta L^Y^* = \arg \max_{\Delta L^Y} F\left(LO + \Delta LO, L^Y + \Delta L^Y, K + \Delta K\right)$$

where

$$\Delta K = -\frac{\left(\Delta LO w^O + \Delta L^Y w^Y + \frac{a}{2} (\Delta L^Y)^2\right)}{p^K}$$

The first-order condition is given by:

$$\frac{F_{Ly}}{F_{K}} = \frac{w^Y}{p^K} + \frac{a}{2} \Delta L^Y^*$$

This condition states that firms adjust labor and capital within the constraint so as to equalize the ratio of their marginal products to the ratio of input prices plus adjustment cost.

When firms retain more older workers, and $\Delta LO > 0$, the effect on younger worker adjustments is:

$$\left(\frac{\partial \Delta L^Y^*}{\partial \Delta LO}\right)_{\text{Constrained}} = \left(-\frac{w^O}{w^Y} - \frac{\partial \Delta K^*}{\partial \Delta LO} \cdot \frac{p^K}{w^Y} + \frac{\phi}{a} F_{LYLO}\right)$$

where $\phi = \frac{p^K}{F_{K}} \cdot \left(1 - \frac{p^K}{w^Y} F_{LY} + \frac{p^K}{w^Y} F_{LYLO}\right)$. The derivation of equation (5) can be found in Appendix D.

The comparative static in equation (5) shows that when financially constrained, firm response is driven by three channels: (1) a direct cash effect from retaining older workers, (2) the investment response, and (3) the substitutability between older and younger workers. The first and second channel are unique to financially constrained firms.

First, the direct cash effect captures the notion that for every additional older worker retained, the firm has to pay wage $w^O$. All else equal, since the cash constraint binds, from a cash flow perspective the firm has to reduce its younger workforce by $w^O/w^Y$. Another way of stating this is that absent any changes in capital, firms would have to fully offset the additional wage cost for older workers by reducing their younger workforce.

Second, the investment response matters because when financially constrained, adjustments to the younger workforce and capital are substitutes from a cash flow perspective. Intuitively, a reduction in investment relieves some of the constraints imposed on labor.

Third, even when financially constrained, firms re-optimize between labor and capital within the constraint, depending on the change in the marginal product of each input in relative terms. This is captured by the substitution effect in equation (5). For example, if older workers and younger workers are stronger substitutes than older workers and capital (i.e. $F_{LYLO} < F_{KLLO} < 0$) then this channel would cause firms to reduce their younger workforce and increase its capital.
Empirical Content/Predictions

The key observation from comparative static (3) is that when financially unconstrained, firm response depends on the substitutability between older workers and younger workers. Comparative static (5) demonstrates that when financially constrained, firm response additionally depends on the effect of increased older worker wage costs on firm cash flow (“direct cash effect”). These results have several implications for the empirical analysis that follows.

First, financially unconstrained firm adjustments identify the substitutability between older workers and younger workers or capital.

- **Prediction 1: Financially Unconstrained - Substitutability Channel**
  \[
  \left( \frac{\partial \Delta L^Y}{\partial \Delta L^O} \right)_{\text{Unconstrained}} > 0 \text{ if and only if } F_{LYLO} > 0
  \]
  Financially unconstrained firms will respond to an exogenous increase in the number of older workers by increasing (decreasing) the employment of younger workers when younger and older workers are complements (substitutes).

Second, the differential response between financially constrained and unconstrained firms identifies the direct cash flow effect from retaining more older workers. Note that this requires the assumption that financially constrained and unconstrained firms face the same production function \( F \).\(^7\)

- **Prediction 2: Financially Constrained - Additional Cash Channel**
  \[
  \left( \frac{\partial \Delta L^Y}{\partial \Delta L^O} \right)_{\text{Constrained}} - \left( \frac{\partial \Delta L^Y}{\partial \Delta L^O} \right)_{\text{Unconstrained}} = - \frac{w^O}{w^Y} - \frac{\partial \Delta K^*}{\partial \Delta L^O} \frac{p^K}{w^Y} + \frac{\phi - 1}{a} F_{LYLO}
  \]
  The difference in younger worker adjustments between financially constrained and unconstrained firms captures the cash effect of the policy. For \( \phi = 1 \) the difference in observed response is exactly equal to the cash channel. For \( \phi \neq 1 \) the difference is approximately equal to the cash channel as long as \( F_{LYLO} \) is small.\(^8\)

Third, the comparative static in equation (5) implies that when financially constrained, adjustments to the younger workforce and capital are substitutes from a cash flow perspective. One parameter in particular that could affect the margin of adjustment is the magnitude of labor adjustment costs, captured by \( a \). If higher labor adjustment costs mute adjustments along this margin, firms will have to cut investment more in order to satisfy the cash constraint in equation (4).

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7 More precisely, the assumption is that \( F_{LYLO} \) is the same for constrained and unconstrained firms. Note that \( F_{LYLO} \) is a local property of the production function \( F() \).

8 As shown in the empirical results section I find evidence consistent with zero, or at most small, substitutability between older and younger workers, suggesting this holds.
• Prediction 3: Financially Constrained - Margin of Adjustment

\[
\frac{\partial (\frac{\partial LY^*}{\partial \Delta LY})}{\partial a} = - \frac{\partial (\frac{\partial F_L^Y \Delta LO}{\partial a})}{\partial a}
\]

Financially constrained firms trade off adjustments to their younger workforce and capital. Absent large changes in the relative substitutability of inputs, if higher labor adjustment costs reduce the extent to which firms cut their younger workforce in response to the policy, firms will have to make larger cuts to investments.

Note lastly that predictions 1 and 2 demonstrate that estimates of the substitutability between older and younger workers may be biased when failing to take into account the role of cash constraints in firm responses. Theoretically, cash constraints could lead to large firm response to the policy even if from a production function perspective older and younger workers are not strong substitutes.

I examine each of these predictions empirically in Section 6 of the paper.

3 Institutional Setting and Data

3.1 Policy Change: Early Retirement Reform

In this paper I study a policy change that severely limited early retirement options for individuals born in 1950 or after, but not individuals born before. In practice the policy change postponed the effective retirement age for the affected cohorts by approximately two years. In this section I briefly describe the early retirement scheme, and the 2005 law that abolished early retirement for the affected cohorts. I then outline the implications of the policy change for affected workers and firms.

The Dutch pension system consists of three pillars: the state pension (AOW), supplementary work-related pensions and private individual pension savings. The first pillar is a pay as you go old age pension provided by the government to all residents of the Netherlands, regardless of employment status, when they reach the statutory retirement age of 65. The second pillar consists of employer-employee pensions. Employers and employees jointly contribute to collective pension schemes managed by pension funds. While membership of a pension fund is not mandatory by law, 90% of Dutch employees belong to a pension fund. The third pillar consists of individual pensions, used mainly by self-employed individuals or as supplemental pension. Appendix B contains a more detailed overview of the pension system.

The early retirement scheme was first introduced in the 1980s as part of the second pillar of the pension system. The idea was that allowing older workers to retire at a younger age would “free up” space in the labor market, allowing firms to hire more younger workers. The scheme consisted of two main parts. The first was a pay as you go scheme (“VUT”) in which employees pay for current early retirees. The second was

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9 I.e. the second term in prediction 3, \( \frac{\partial (\frac{\partial F_L^Y \Delta LO}{\partial a})}{\partial a} \), is small. This implies that changes in optimal input choices resulting from higher labor adjustment costs would not generate large changes in the relative substitutability of older workers and younger workers or capital.

10 Note that in the analysis I rely on a pre-policy measure of free cash flow as a proxy for firm financial constraints - see Section 3.2 for more details.

11 This idea is not unique to the Netherlands: Gruber and Wise (2000) highlight that this is a common motivation for promoting early retirement among older cohorts of workers.
an employer-employee savings plan ("pre-pension") which enabled workers to save for early retirement during their employment. Together, the schemes gave individuals the opportunity to retire in their early 60s, rather than at the legal retirement age of 65. The exact early retirement age varied by sector and industry.

The scheme was jointly funded by employers and employees. Contributions were a share of wages earned by employees, typically 8%. Employees and employers contributed 3.5% of wages to fund the pay as you go scheme and 4.5% of wages to fund the employer-employee savings plan. Approximately 60% of these contributions came from employers, and 40% from employees. There was a fiscal advantage to these schemes as well: contributions to the early retirement scheme were tax deductible, meaning that the government was an important funder of early retirement.

On January 1, 2005, the Dutch government introduced a law that abolished both components of the early retirement scheme for individuals born on January 1, 1950, or after. The main reason for this policy change is that from a public finance perspective the plan became unsustainable due to population aging. As a result of the law, affected cohorts could no longer use the plan nor its fiscal advantages. In addition, the government imposed a 52% tax penalty on any alternative early retirement arrangements offered by firms to workers.

The main implication for workers born in 1950 or after is that the abolishment of the early retirement scheme made it much costlier to retire before the legal retirement age of 65. As a result, the share of workers retiring before 65 dropped considerably. Figure 1A shows that, close to the cohort boundary, individuals born in 1950 are about 20 percentage points less likely to retire before the legal retirement age of 65 than individuals born in 1949. While the policy change did not fully eliminate early retirement among affected workers, it substantially reduced early retirement rates. More than half of all workers born in 1949 retired before 65, compared to less than one-third of all workers born in 1950.

Figure 1B further breaks down retirement across different ages by cohort. It shows the cumulative retirement rates of workers born in 1948, 1949, 1950 and 1951. These figures demonstrate that individuals born in 1950 or 1951 are substantially less likely to retire before the age of 65. The gap starts to open up at 60, and the largest cohort difference can be found around 62-64. Over 40 percent of individuals born in 1948 or 1949 will have retired by then, compared to only about 20 percent among 1950 or 1951 cohorts.

In this paper I use this sharp cohort difference in retirement rates as a source of exogenous variation in the retention of older workers across firms. Section 4 outlines the empirical strategy used in the analysis.

3.2 Data

Main administrative data

I use administrative linked worker-firm data for the full population of the Netherlands, made available through Statistics Netherlands (CBS). I combine employment and demographic data at the individual level with firm-level investment records, balance sheets and income statements. The data used in this paper span

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12 A transcript of the law in Dutch can be found here: https://wetten.overheid.nl/BWBR0018053/2014-12-20.

13 Aside from increasing the effective retirement age, abolishing the early retirement scheme also had financial consequences for both affected workers and firms. These effects are small relative to the primary employment effect I exploit in this paper, however. I further discuss this in Appendix section B2.

11
2001 to 2017 (firm data) or 2001 to 2018 (employment data). The novel combination of worker and firm level data allows me to observe changes in firm worker composition, investment and capital over time and assess how these adjustments translate into changes in firm revenue and profits.

At the individual-level, the data consist of the universe of employment contracts in the Netherlands, which are based on employment records from the tax authorities. These include the contract start- and end date, monthly earnings, hours worked, hourly wage, and benefits. Each employment contract has a person identifier and a firm identifier. I use these to link the files to demographic data, allowing me to observe an individual’s birth year, birth month, and gender.

I aggregate these employment records to the firm-year level, to construct annual measures of the number of total- and full time workers, new hires, worker exits, mean hours worked, mean hourly wage and the firm’s total wage bill. I construct both overall measures and measures by cohort, both for each birth year separately and combined into three broader cohort groups: younger, middle-aged and older. Younger workers are defined as being born after 1965, middle-aged workers are defined as being born in 1955-1965, and older workers are defined as being born 1945-1955. The goal of this sub-division is to examine how firm worker composition changes after the policy change and study adjustments made by firms to each cohort of workers separately.

I then apply several restrictions to the data, with the goal of ensuring that I capture actual firms and not self-employed individuals, temporary or seasonal businesses, etc. In addition, I only consider firms that were operational in 2005, the year that the policy change was announced. Hence, I restrict attention to firms that: (1) have at least 5 full-time employees in 2005, (2) first appear in the data before 2005, (3) are in the data at least until 2005, (4) are observed in the data each year and (5) are in the private sector. There are a total of 99,240 such firms in the data.

Panel A of Table 1 shows descriptive statistics for these firms. A large share of the firms considered are relatively small. The median firm size is 18 employees, of which 10 are full time employees, and the median wage bill is 229K EUR. There is large variation across firms along each dimension, however, representing the broad set of firms considered in the analysis.

To study investment and firm production, I rely on firm-level investment, balance sheet and income statement data. These data cover about 80% of firms in the non-financial private sector of the Netherlands. The data are based on corporate tax records supplemented with data from surveys sent out by the tax authorities to all firms that are subject to corporate taxation. Coverage is almost universal among larger firms, but is worse when considering smaller firms. The data cover a wide range of firm-level outcomes. The investment data contain firm-level investments in material assets broken down by type. The balance sheet data contain assets, liabilities and equity. And the income statement consists of revenue, labor cost, other input cost and profits. In the analysis I primarily examine adjustments of investments in material assets, as well as effects on revenue and profits.

I link the firm-level data with the employment data using a national firm register. A challenge in linking these data is that the firm balance sheets and income statements are at the company level, whereas the employment and investment data are at the firm level. Companies are at a higher aggregation level, and

\[14\] Equivalently, these workers were 40 or younger, 40-50, or 50-60 years old when the policy change was announced in 2005.
can consist of multiple firms. Approximately 17 percent of firms in the data belong to a company with more than one firm. For the firm production and profit analysis, I therefore aggregate the corresponding employment data to the company level. About 8 percent of companies in the data have multiple balance sheet and income statement entries corresponding to separate legal entities. Summing such entries would not yield consolidated company-level data, because the balance sheets also contain within-company transfers. As a result I drop these 8 percent of companies from the analysis. In practice, this implies dropping mainly very large companies which have multiple legal entities. Altogether, there are a total of 63,469 companies in the production and profit data.

Panel B of Table 1 shows descriptive statistics for these companies. First, note that these companies tend to be slightly larger than the firms in panel A, due to the fact that coverage is incomplete for smaller firms and that some firms are aggregated into single companies. The median company employs 20 workers, of which 12 are full time employed, and faces a wage bill of 326K EUR. Revenues for the median company are 1.4 million EUR and profits about 77K EUR annually.

Measuring cash constraints

To capture the importance of financing constraints I create a measure of free cash flow prior to the policy. This proxy has been widely used in the literature studying sensitivity of investment to cash constraints (e.g. Fazzari et al., 1988; Alti, 2003; Richardson, 2006). Schoefer (2015) validates free cash flow as a proxy for financial constraints directly, and finds that in the US this is the dominant source of finance, accounting for more than 95% of total finance within a quarter.

I calculate free cash flow directly from the balance sheet and income statement for each firm. To compute free cash flow I use the following accounting definition:

\[
\text{Free Cash Flow} = \text{Net Income} + \text{Depreciation} + \text{Change in Provisions} - \text{Change in Working Capital} - \text{Net Investment}
\]

Table 1 demonstrates that the median firm has approximately 29,000 EUR in free cash flow in 2001-2004, the years before the policy. There is large variation across firms, however. About 20 percent of firms have negative free cash flow.

For the purpose of the analysis I scale free cash flow by assets in the previous year. This is important because firm free cash flow in levels is correlated with firm size. Smaller firms mechanically will have free cash flows closer to zero. I follow the literature on investment sensitivity to free cash flow (e.g. Fazzari et al., 1988) by scaling free cash flow in each year by assets in the previous year. I then take the mean of this scaled measure of free cash flow by firm for 2002-2004 to construct firm-level free cash flow prior to the policy.

The measure of free cash flow used in the analysis is a binary measure capturing whether firms have above or below median free cash flow at baseline.

Proxies for labor adjustment costs and productivity

I create two other measures of firm heterogeneity, capturing labor adjustment costs and productivity.
First, to examine the importance of asymmetric labor adjustment costs I establish whether a firm is growing or shrinking between 2001 and 2005. I consider changes in the number of full time employees between 2001 and 2005 to create a binary measure of whether the firm has experienced positive or negative growth in the size of its workforce. By this measure approximately 54 percent of firms were growing in the baseline period.

Second, I create a measure of return on assets prior to the policy (2001-2004), to capture firm productivity. I residualize this measure with respect to the within-industry group mean, to represent firm deviation in productivity from other firms in the industry.\(^\text{15}\) I compare this measure against pre-policy free cash flow to rule out productivity differences as an alternative driver of the results (section 6.2).

4 Empirical Strategy

In the analysis, I rely on quasi-random variation in the birth year of workers at firms to study how firms respond to retaining more older workers. The main idea is to compare outcomes and adjustments made by firms depending on the number of older workers born either in 1950 or after, who are ineligible for early retirement, or before 1950, who are still eligible. The key assumption is that close enough to the cohort boundary the number of workers with a given birth year at a firm is as good as random.

In this section I first describe how I identify affected workers at a firm. I show that the 1950 cohort boundary stands out at the firm level: employing an additional worker born in 1950 leads to a substantially higher retention of older workers over time than employing an additional worker born in 1949. Second, I describe the empirical approach taken in this paper and specify the estimating equations and the identification assumption.

4.1 Identifying firm-level treatment

To identify the number of workers that are affected by the policy at a firm level, I examine the firm’s workforce in 2005. This is the year in which the policy change was announced. I focus on the firm’s workforce in this year, rather than after, because firm composition after 2005 is endogenous to the policy change. Hence, I count the number of individuals working at a firm in 2005 of each birth cohort, and classify any worker born in 1950 or after as treated.

The key idea behind the approach in this paper is that having an additional treated rather than untreated worker causes firms to retain more older workers over time. Treated workers on average retire 2 years later than untreated workers (see section 3.1). Exploiting the cohort boundary, it should particularly be the case that having a 1950 versus 1949 worker has an effect on the retention rate of older workers, as opposed to having workers of two other neighboring cohorts.

I validate this in the data using a flexible approach which shows that also at a firm level the 1950 cohort boundary stands out. In this approach I run a saturated regression of the total number of older workers employed at a firm over time on the number of workers of each cohort employed at the firm in 2005. The

\(^{15}\)Industry groups are captured by 2-digit ISIC codes.
estimating equation is:

$$y_{jt} = \alpha_j + \tau_t + \sum_{c=1940}^{2017} \sum_{t=2001}^{2017} \beta_{c,t} \times 1(year = t) \times N_{c,j} + \epsilon_{jt}$$

where $y_{jt}$ is firm $j$’s number of older workers (born 1945-1955) in year $t$, $\alpha_j$ are firm fixed effects, $\tau_t$ are year fixed effects. The main coefficients of interest are $\beta_{c,t}$. These represent the effect of having an additional worker of cohort $c$ on the number of older workers at the firm over time.

Figure 2 plots the difference between the estimated $\beta_{c,t}$ coefficients, for 1948 and 1949, 1949 and 1950, and 1950 and 1951. Workers born in 1948 and 1949 are both untreated: both can still retire early. Workers born in 1950 and 1951 are both treated: neither can retire early. These two differences therefore represent falsification checks. The only difference in early retirement rates occurs between 1949 and 1950.

The figure shows that in the years in which the policy change had the biggest effect, 2010-2014, having an additional 1950 rather than 1949 worker has a substantial and statistically significant effect on number of older workers employed at a firm. For each worker born in 1950 rather than 1949, by 2014 firms have about 0.25 additional older workers. Once the 1950 cohort reaches the legal retirement age of 65 and does retire, there is a reduction in the number of older workers in 2015 and 2016. We do not observe similar effects for the two falsification checks. Note that in any given year, a worker born one cohort later will be a year younger. Hence, we expect there to be some small difference in the probability of working in any given year even if the rates of retirement at each age are exactly the same for the two cohorts. Altogether, however, the results demonstrate that at the firm level, too, there is a sharp change in the retention rate of older workers across the 1949-1950 cohort boundary.

4.2 Empirical approach and estimating equations

To study the causal impact of the policy I then take an empirical approach that relies on this sharp cohort difference in retirement rates. In particular I exploit quasi-random variation in the birth year of workers at firms close to the 1950 cutoff. This local approach is key because the overall age composition of firms is not random. Smaller and growing firms tend to employ more younger workers, whereas larger and established firms tend to employ more older workers. Hence, simply comparing firms with more workers born after 1950 to firms with more workers born before 1950 would conflate the causal impact of the policy with other effects of the firm’s age profile. Examining older workers born in a narrow window around 1950 helps to address these concerns, because variation in the birth years of workers close to this cutoff is arguably more arbitrary.

The key assumption underlying this approach is that the number of workers with a given birth year close to the 1950 cutoff is as good as random. Put simply, a firm with an additional worker born in 1950 should be very similar to a firm with an additional worker born in 1949, except that in the former case the worker is ineligible for the early retirement scheme whereas in the latter case the worker is eligible. In practice this assumption will be valid if firms did not anticipate the policy change, and hence did not hire workers differentially around this cohort boundary prior to 2005. While there was some general expectation in the years leading up to 2005 that eligibility for early retirement would change, the speed with which this was
implemented - the policy was announced January 1, 2005, and took effect immediately - and the sharp cohort boundary imposed were not anticipated. Furthermore, I show in Appendix Figure A1 that among firms with workers born in 1949 and 1950, the share born in 1950 is 50 percent - and that this is true for firms of different sizes. This further suggests that firms did not differentially employ 1950 versus 1949 workers before the policy was announced.

In determining the window size around 1950 that I consider, there is a trade-off between bias and variance. On the one hand, the closer to the 1950 cutoff I look, the more similar the workers and firms will be. However, there are very few individuals in the Dutch labor market born right around the cutoff. The main specification in this paper considers a 4 year window around 1950, i.e. workers born between 1948 and 1951. I call these older workers. Among these older workers, individuals born in 1950 or 1951 are defined as treated workers.

The ideal experiment, then, is to compare outcomes over time between two firms which differ in the extent to which they have treated workers, but otherwise are similar in terms of older workers and total firm size in 2005. The exact way in which I estimate this depends on the outcome studied. The reason is that depending on the outcome, the units in which we expect the treatment effects to be homogenous are different. When examining labor outcomes, such as the number of workers employed of different cohorts, I estimate the effect in levels. The estimating equation captures the effect of having an additional treated worker in 2005, holding constant the number of older workers and total workers in 2005. For firm production outcomes, however, effects are more likely to be homogenous in percentage terms. For these outcomes I examine the impact of an additional percent of the workforce being treated, holding constant the share of the workforce that is older. Appendix C2 further justifies these approaches by showing that the corresponding effects are homogeneous across firms of different sizes.

**Estimating equation for labor adjustments**

To study the impact of the policy on the firm’s workforce, I run a regression of the firm level outcome over time on the number of treated workers, controlling for the number of old workers and the total number of workers at a firm:

\[
y_{jt} = \alpha_j + \tau_t + \sum_{t=2001}^{2017} \beta_t \times \mathbb{1}(\text{year} = t) \times N_{j,\text{treat}} + \sum_{t=2001}^{2017} \gamma_t \times \mathbb{1}(\text{year} = t) \times N_{j,\text{old}} + \sum_{t=2001}^{2017} \delta_t \times \mathbb{1}(\text{year} = t) \times N_{j,\text{all}} + \epsilon_{jt} \tag{7}
\]

where \(y_{jt}\) is a firm \(j\)'s outcome in year \(t\), \(\alpha_j\) are firm fixed effects, \(\tau_t\) are year fixed effects, \(N_{j,\text{treat}}\) are the number of workers born in 1950 or 1951, \(N_{j,\text{old}}\) are the number of workers born between 1948 and 1951, and \(N_{j,\text{all}}\) are the total number of workers in 2005.

The coefficients of interest are \(\beta_t\): the effect of having an additional treated worker in 2005 on the outcome in each year \(t\), holding fixed the number of old and total workers. I cluster standard errors at the firm level to address potential serial correlation of outcomes across periods.

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16 I show in Figure A13 in Appendix C1 that the results are robust to changing this window size to 2 or 6 years.

17 More concretely, an additional treated worker has a different effect for a small firm, where that worker represents a relatively large share of the work force, than for a large firm, where one additional worker is likely insignificant.
Estimating equation for firm investment, production and profits

As stated, for the firm investment, production and profit effects I focus on the share of workers that are treated. Hence, to examine these effects the estimating equation is:

$$\ln(y_{jt}) = \alpha_j + \tau_t + \sum_{t=2001}^{2017} \beta_t \times \mathbb{1}(year = t) \times \text{Share}_{j,treat} + \sum_{t=2001}^{2017} \gamma_t \times \mathbb{1}(year = t) \times \text{Share}_{j,old} + \epsilon_{jt} \quad (8)$$

where $y_{jt}$ is a firm $j$’s outcome in year $t$, $\alpha_j$ are firm fixed effects, $\tau_t$ are year fixed effects, $\text{Share}_{j,treat}$ is the share of workers born in 1950 or 1951, $\text{Share}_{j,old}$ is the share of workers born between 1948 and 1951.

The coefficient of interest is $\beta_t$, which represents the effect of having an additional percent of the workforce treated in 2005 on the outcome in each year $t$, holding fixed the share of old workers.

Heterogeneity

In order to examine heterogeneity in adjustments depending on how constrained firms are, I augment equations (7) and (8) with variables interacting the treatment variables with baseline measures of firm constraints. These are described in section 3.2. The interaction term gives the difference in adjustments made by firms depending on the extent to which the firm is either cash constrained or faces greater labor adjustment costs due to firing constraints.

5 Overall Effects of the Policy

In this section I first document the average effect of the policy on firm worker composition and investments. The policy increased the retention of older workers, and in response firms reduced the number of younger workers employed and investments in machines and equipment. Altogether, the policy led to small increases in treated firms’ overall wage bill and revenue, but for a subset of firms decreased profitability.

Labor Adjustments

Figure 3A demonstrates the main effect of the policy on firm worker composition. The policy caused firms to retain more older workers and employ fewer younger workers over time. The plotted coefficients correspond to $\beta_t$ from equation (7), which represent the effect of having an additional treated worker at the firm in 2005, controlling for the number of old workers and total firm size in 2005. Each of the lines represents a separate regression, examining how an additional treated worker affects the number of older workers, middle-aged workers and younger workers at the firm over time.

First, each additional treated worker employed at a firm in 2005 caused firms to retain 0.25 more older workers by 2014. The pre-trend before 2005 is flat, suggesting that there were no pre-existing differences between firms that are more or less treated. The effect of having an additional treated worker leads to an increase in the number of older workers starting in 2009-2010. This is when untreated workers (born in 1948 or 1949) start to use the early retirement scheme, but treated workers (born in 1950 or 1951) are more likely
to continue to work. By 2015, when treated workers reach the legal retirement age of 65, the number of older workers at the firm starts to fall. By 2017, the effect of the treatment is gone. By this time all treated workers have reached the statutory retirement age of 65 and retirement rates across the cohorts are the same again.\footnote{Note that this pattern is very similar to the more flexible approach taken in section 4.1, where I show that the 1949-1950 cohort boundary is unique in terms of its effect on the retention rate of older workers - which is the basis for the empirical design in the paper. See Figure 2A for the results using the flexible model.}

Second, in response to the policy firms made substantial adjustments to the number of younger workers employed. For each additional treated worker employed in 2005, firms employ 0.15 fewer younger workers by 2014. This implies that for each retained older worker firms employ approximately 0.6 fewer younger workers, partially but not fully offsetting the additional older workers employed. Adjustments to the young work force start to occur in 2010, and over time firms with an additional treated worker gradually employ fewer younger workers. By 2016, when the treated older workers have reached 65, the firms increase their younger work force size again. By 2018 firms on average firms employ the same number of young workers again regardless of treatment.

Third, I do not find economically or statistically significant adjustments to the middle-aged workforce. For every treated worker, firms employ at most 0.05 fewer middle-aged in 2013. Generally, however, adjustments in the number of middle-aged workers are not significant and close to zero.

All of these adjustments in the younger workforce are driven by changes in new hires, rather than an increase in firing. Appendix Figure A2 plots the $\beta_t$ coefficients from equation (7) with the number of new hires at the firm in each year as the outcome variable. For each treated worker, firms hire 0.04 fewer workers annually in 2010-2014. Integrating over these effects across years, differences in hiring can explain virtually all of the reductions in employment of younger and middle-aged workers observed for firms with treated workers. This suggests that firing is not a common margin of adjustment.

Furthermore, I do not find considerable adjustments on the intensive margin, in terms of hours worked or hourly wages among either young or middle-aged co-workers. Appendix Figure A3 plots the $\beta_t$ coefficients from equation (7) with mean weekly hours worked (panel A) and mean hourly wages (panel B) among young and middle-aged co-workers as outcome variables. Note that the series starts in 2006, because I only observe hours worked or hourly wages since that year. The treatment effect on both hourly wages and hours worked are a precisely estimated zero. I can reject changes in hourly wages exceeding 0.2 EUR/hour, which is small relative to the median hourly wage of 17 EUR/hour. In addition, I reject changes in hours worked exceeding 0.3 hours/week. Note that hours worked and hourly wages are often set in collective labor agreements that are set for a fixed period of time and require union bargaining to change. So it may not be surprising that it is hard for firms to make adjustments along these margins. This is in line with evidence in other papers suggesting wage rigidity may prevent adjustments along this margin (Bewley 2002; Kaur 2014; Cahuc, Carcillo, and Le Barbanchon 2018; Johnston, 2018).

Taken together, these changes in firm composition lead to a slight increase in the average wage bill among firms with treated workers. Each additional treated worker raises a firms’ wage bill by 6,025 EUR annually, as shown in Figure 3. This is is equivalent to approximately 24,000 EUR per retained older worker, or about 10 percent of the median wage bill at these firms. The wage bill at firms with treated workers is increased
both because such firms employ slightly more workers in total, and because older workers tend to earn higher wages.

**Investment Effects**

A second margin of adjustment I consider is investment. On average, firms do not appear to make significant adjustments to total investments in response to the policy. Appendix Figure A4 demonstrates that for each percent of the workforce that is treated at a firm, overall investments are lower by an insignificant 0.15 percent each year.

The lack of significant adjustments to overall investment masks changes to investment in more specific types of capital, however. Total material assets include: (1) owned real estate, (2) infrastructure and related equipment, (3) transportation equipment, and (4) machines and equipment. Some of these assets, such as real estate or infrastructure, may be difficult to adjust in the short-run. Existing literature has instead found - mainly in the context of business cycles - that investments in machines in particular are more volatile and subject to adjustments over time (see e.g. Cooper et al., 1999). Investments meant to replace existing machines may particularly be easier to adjust, because firms can decide upon the timing of those investments quite flexibly.\(^{19}\)

Figure 4 demonstrates that firms indeed make statistically significant adjustments to investments in machines and installations. For each percent of the workforce that is treated, firms reduce the amount of investments in machines and installations by 0.28 percent. At the median treated firm in the sample, treated individuals represent about 13 percent of the full time work force. Hence, for the median treated firm investments in machines and installations decline by approximately 3 percent, or 1,477 EUR per year (Table 2).

**Firm Production and Profits**

Lastly, I show that the policy change led to a small increase in firm revenue, but for a subset of firms led to a reduction in profits.

Figure 5A shows that the policy change led to a modest increase in firm revenue. The figure plots the \(\beta_t\) coefficients from equation (8), which represent the effect on log revenue of having an additional percent of the firm’s work force treated in 2005, controlling for the share of old workers in 2005. The coefficients imply that for each percent of the work force that is treated, firm revenue increased by 0.11 percent in 2011-2014. At the median treated firm in the sample, treated individuals represent about 13 percent of the full time work force. This would imply a modest median revenue increase of about 2 percentage points among treated firms. These revenue effects appear to be driven almost entirely by an increase in the size of the firm’s work force: Appendix Figure A5 shows that there is no statistically or economically significant change in revenue per worker.

Figure 5B reports the effect of the policy on the probability of reporting positive accounting profit in

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\(^{19}\)Note that in the data I am unable to distinguish between replacements of existing machines and installations, or investments in new machines and installations.
any given year. The coefficients correspond to $\beta_t$ from equation (8) which represent the effect on the probability of reporting a positive profit of having an additional percent of the firm’s work force treated in 2005, controlling for the share of old workers in 2005. For each percent of the workforce that is treated, the probability of reporting a positive profit declines by 0.07 percentage points in 2011-2014. At baseline approximately 85 percent of firms in the subpopulation report a positive profit. For the median treated firm, the implied decline in the probability of making a profit is approximately 1 percentage point, or about a 7 percent decline relative to baseline.

6 The Role of Cash Constraints

Having established the overall firm response to the policy, in this section I assess the role of cash constraints as a driver of response. The theoretical framework presented in Section 2 identifies two channels: (1) substitutability between older workers and young workers or capital (substitution effect), and (2) the effect on cash flow of paying retained older worker wages (direct cash flow effect). Only cash constrained firms are affected by the second channel.

6.1 Heterogeneity: pre-policy free cash flow

To examine the role of cash constraints empirically I rely on pre-policy free cash flow at the firm as a proxy for firm cash constraints. Adjustments made by high free cash flow firms allow me to identify the substitution channel, and differential adjustments made by low free cash flow firms identify the cash channel.

I find that firms with high free cash flow made virtually no labor and investment adjustments in response to the policy. Figure 6A displays this result for changes to the younger workforce, and Figure 6B for investments in machines and installations. For every additional treated worker high free cash flow firms reduced their younger workforce by 0.02 workers, which is statistically indistinguishable from zero. Similarly, for every percent of the work force that is treated, high free cash flow firms reduced investments by an insignificant 0.07 percent. This is equivalent to a 1 percent reduction at the median treated firm. Table 2 summarizes the response in terms of cash flow effects, showing that in euro terms the adjustments made are negligible. Every additional treated worker led to a reduction in the younger worker wage bill of 407 EUR and investments of 322 EUR.

Low free cash flow firms, on the other hand, make large adjustments to labor and investments that drive the entire response to the policy. Figure 6A demonstrates that for every additional treated worker employed in 2005, such firms employ 0.25 fewer younger workers by 2015, offsetting the additional retainment of older workers at approximately a one-to-one ratio. Figure 6B additionally shows that all of the observed reductions in investments in response to the policy are also concentrated in low free cash flow firms. For every additional percent of the workforce that is treated, such firms experience a reduction in investment of up to 0.5 percent annually, about a 6 percent reduction relative to baseline at the median treated firm. Table 2 shows that these adjustments imply a reduction of 6,100 EUR in the younger worker wage bill and

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20 To deal with noise in the data I discretized this measure into whether firms make any profits at all. Figure A6 shows a similar, though noisier, patterns for a continuous measure of profits as a share of last year’s assets.
1,800 EUR in investments for each additional treated worker at a firm. The difference in younger worker adjustments between high and low free cash flow firms is significant at the 5% level, and the difference in investments at the 10% level.

In fact, low free cash flow firms fully offset any additional wage costs associated with retaining older workers through adjustments to their younger workforce and investments. Figure 7 shows that consistently across years low free cash flow firms do not experience any increase in total costs in response to the policy, where total costs are defined as total labor costs plus investments. This demonstrates that the increase in older worker wage bill from the policy is exactly equal to the decrease in younger worker wage bill and investment costs resulting from firm adjustments made. High free cash flow firms, on the other hand, experience a total cost increase of 8,300 EUR in the main years that the policy had an effect, driven by the increased wage cost for older workers.

Through the lens of the model in Section 2, these results have two main implications for the economic drivers of firm response.

First, the lack of labor and capital adjustments among high free cash flow firms suggests that substitutability between older workers and younger workers or capital is not a significant driver of firm response to the policy. In fact, the implied elasticity of substitution would be biased by at least a factor of seven when failing to account for the direct cash flow effect from retaining older workers. Overall for every retained older workers firm reduce their younger workforce by about 0.6 workers (Section 5) whereas cash unconstrained firms - whose response is driven by substitutability alone - only reduce their younger workforce by 0.08 workers. This differs by a factor of 7.

Second, the large difference in response between high and low free cash flow firms suggests a key role for cash constraints in firm response to the policy. This is most apparent when considering firm adjustments in terms of cash flow effects. Table 2 displays the adjustments made by firms in terms of younger worker wage bill and investments made in euros. Taking the ratio of these adjustments with the increase in older worker wages, the results demonstrate that for every 1 EUR increase in the older worker wage bill, low free cash flow firms reduce their younger wage bill by 0.7 EUR and investments by 0.2 EUR. High free cash flow firms, on the other hand, only reduce their younger worker wage bill by only 0.05 EUR and their investments by 0.04 EUR for every 1 EUR increase in the older worker wage bill. Hence, while more cash constrained firms offset approximately 90% of the additional wage costs from retaining older workers through labor and capital adjustments, less cash constrained firms offset only (an insignificant) 10% of these costs.

The difference in response between these two sets of firms identifies the cash channel. For every 1 EUR increase in older worker wages, I estimate that when financially constrained this channel leads firms to reduce their younger worker wage bill by 0.66 EUR (95% CI: 0.34 - 0.98) and their investments by 0.16 EUR (95% CI: -0.08 - 0.4). The key assumption underlying this estimate is that high- and low free cash flow firms face the same production function. This is required for the substitution effects identified from high free cash flow to be informative about the substitution effects experienced by low free cash flow firms. Note that the estimated cash flow sensitivity for employment is slightly higher than others in the literature. For example, Schoefer (2015) estimates an employment-cash flow sensitivity between 0.2 and 0.6. The estimated investment sensitivity, on the other hand, is lower than typically found. For example, Rauh (2006) estimates
that every dollar decrease in cash flow causes a decrease in capital expenditures of $0.6-$0.7.²¹

**Margin of adjustment: younger workforce or investment**

What determines which margin firms adjust, their younger workforce or investment? Theoretically, one factor that might drive the choice of margin is the magnitude of labor adjustment costs faced by firms. To examine this empirically I exploit asymmetries in adjustment costs faced depending on whether a firm is growing or shrinking at baseline. Intuitively, if firing costs exceed hiring costs, then firms that can reduce hiring might be more likely to adjust labor than firms that would need to fire workers. Growing firms can adjust labor by reducing the rate of hiring, whereas shrinking firms can only further downward adjust by firing - which is much costlier. Such firms may opt to cut investments instead.

Figure 9a shows that indeed only low free cash flow firms that were growing adjusted their younger workforce in response to the policy. The figure shows the mean adjustment in the young workforce in 2011-2014, when the policy had the largest effect. For each additional treated worker employed in 2005, growing low free cash flow firms reduce their younger workforce by 0.35 workers. On the other hand, the coefficient for young workforce adjustments is 0.008 for low free cash flow firms that were shrinking, suggesting that labor is not a feasible margin of adjustment when the only option is to fire workers. Table 2 shows that in cash flow terms, growing firms reduce their younger workforce by 11,000 EUR whereas shrinking firms make an adjustment of only 1500 EUR, which is statistically indistinguishable from zero. The difference in response between growing and shrinking firms is significant at the 1% level.

Low free cash flow firms that are shrinking, then, can only make adjustments along other margins, notably by adjusting investments. Figure 9b shows that, indeed, the investment response to the policy is concentrated in low cash flow shrinking firms. In this set of firms on average investments decline by 0.5 percent for each percent of the workforce that is treated. Table 2 shows that this is equivalent to a 4,500 EUR reduction in investment for each additional treated worker. Growing firms only reduce their investment by an insignificant 500 EUR. This difference in investment response between growing and shrinking firms is significant at the 5% level.

**Effects on firm production and profitability**

Lastly, I establish that cash constraints also have important implications for firm production and profits. Figure 8A shows that the positive revenue effects observed in the reduced form results of section 5.1 are all concentrated in high free cash flow firms. For each percent of the workforce that is treated, such firms see a revenue increase of 0.15 percent, which corresponds to about a 3 percentage point or 24,000 EUR increase annually at the median firm. Firms with lower cash flow at baseline, on the other hand, do not see such revenue growth. This translates into differences in firm profitability, as shown in Figure 8B. Firms with low

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²¹There may be several reasons for this. First, other papers have typically relied on firm financial data from sources such as Compustat which include much larger firms than the firms in my dataset. It is possible that such large firms are more likely to respond by adjusting investment. Another possibility is that the nature of the cash flow shock affects the channel through which firms respond. The fact that in the context of this paper the cash flow shock came through an increase in older worker wages might make firms more likely to respond by adjusting other types of labor, rather than capital. I am unable to test this empirically, however.
free cash flow experience a decline of 0.14 percent in the probability of reporting a positive profit for each percent of the work force that is treated. For the median treated firm this corresponds to a decline of nearly 2 percentage points, or about a 14 percent increase in the probability of reporting a loss relative to the average baseline rate in this subpopulation of firms. High free cash flow firms, on the other hand, maintain their profits.

Among low free cash flow firms, those firms that were shrinking and had only one margin to adjust, namely investment, are the most affected by the policy. Figure 9c suggests that this set of firms is the only that does not experience an increase in revenue, and in fact may see a small revenue decline (though not significantly so). In addition Figure 9d demonstrates that these firms are hardest hit in terms of profit. For each percent of the work force that is treated, such firms see a decline of 0.37 percent in any given year. For the median treated firm, this corresponds to about a 3 percentage point decline, which is equivalent to a 20 percent higher probability of making a loss in the main years that the policy had an effect.

6.2 Alternative mechanisms

An important concern is that low cash flow firms may respond more strongly to the policy not because they are more financially constrained but because of other reasons correlated with financial constraints. A key argument in favor of cash constraints being the true mechanism underlying the results is that cash constrained firms experience no increase in total costs over time (Figure 7). Any alternative driver would therefore also have to cause these constrained firms to exactly offset the additional wage costs for older workers through reductions in their younger workforce and investments. While this seems unlikely, I cannot rule this out in general. In this section I address specific alternative stories. Note that any alternative explanation would not just have to affect a firm’s trajectory over time, but do so differentially depending on the extent to which a firm is affected by the policy.

First, I show that high free cash flow firms experienced the same first stage effect in terms of older workers retained. One worry is that high free cash flow firms respond more strongly to the policy because they were more affected by it. Appendix Figure A8 show that both high and low free cash flow retained approximately 0.2 additional older workers for every additional treated worker employed in 2005. If anything, the coefficients for low free cash flow firms are slightly smaller, which is the set of firms responding more strongly to the policy. Table 2 similarly shows that in cash flow terms, the additional wage costs for older workers are very similar between more (column 2) and less (column 3) cash constrained firms.

Second, I address concerns that high free cash flow firms might be more productive prior to the policy and this is why they have higher free cash flow. Such firms may want to grow over time, and hence respond less strongly to retaining an additional older worker. As further explained in Section 3.2, I approximate a firm’s productivity by constructing a measure of return on assets prior to the policy. While the data shows that higher free cash flow firms were slightly more productive prior to the policy, this correlation is relatively weak (0.11). In addition, Appendix Figure A9 shows that productivity alone is not a predictor of response. Firms with above and below median ROA made similar younger worker adjustments in response to the policy.
Third, I examine the possibility that low free cash flow firms expanded their workforce too much prior to the policy, and this is why such firms make larger reductions to their young workforce in response to the policy. While pre-policy employment growth is a predictor of labor adjustments conditional on being cash constrained (see the results in section 6.1), pre-policy employment growth alone is not a predictor of response. Furthermore, the correlation between pre-policy free cash flow and employment growth in the data is only -0.03, suggesting low free cash flow is unlikely to be driven by excessive expansion before 2005.

Lastly, since the data do not contain bank lending, I am unable to assess to what extent firm free cash flow correlates with access to external finance. One piece of evidence in support of internal funds being the driver of response, and not correlated access to external finance, is provided by Schoefer (2015). The author finds that in the context of the US free cash flow is the dominant source of finance, accounting for more than 95% of total finance within a quarter.

6.3 Anticipation

Having demonstrated the importance of cash constraints for firm response to the policy, this section explores a possible policy response: giving firms more time to anticipate. I examine this empirically by relying on variation in the timing of the treatment resulting from differences in the treated worker’s exact birth year.

First, note that the results presented above suggest that firms did not make labor or capital adjustments before the policy first took effect. This is perhaps surprising given that all firms had at least 5 years to anticipate the policy change: the policy was announced in 2005, but the first affected cohort born in 1950 would not have reached the early retirement age until around 2010. Figure 3A shows that firms only start to make adjustments to their younger workforce by 2010, once the policy starts to have a substantial effect on the retainment of older workers. Even low free cash flow firms do not appear to exhibit any anticipatory behavior prior to 2010, as shown in Figure 6A.

Two potential explanations may underlie this result. First, it may be that firms in general are not forward looking and are myopic in their response to retaining an older worker. Second, it may be that firms were unaware of the policy until it had its first effect in 2010, or alternatively did not expect that the policy would actually be implemented until the first cohort was affected. If the latter is the case, it is possible that additional time to anticipate the policy might have a different effect.

Anecdotally there is some evidence that firms did not change their behavior in anticipation because retirement policies change frequently and, hence, there was a non-negligible probability that the proposed measures would be reversed before they first took effect. In addition, it appears as though most of the public attention to the reform occurred when it first took effect, not when it was announced: there is a large Google trends spike in search for the policy in 2010, and only a small spike in 2005 when it was announced. This suggests that once it became clear that the policy would actually be implemented, workers and firms paid more attention to it. From that moment on additional time to prepare for the policy may have a different effect than the initial 5 years since the policy was announced.

To study how more time to anticipate affects firm adjustments in the data, I examine firm response depending on the exact birth year of treated workers. Each consecutive birth year shifts the treatment
window by one year. Intuitively, consider that early retirement typically occurred between the ages of 60 and 64. A worker born in 1951 turns 60 in 2011, whereas a worker born in 1950 turns 60 in 2010. Hence, workers born in 1951 would have started early retirement one year later than workers born in 1950. Each consecutive birth year shifts the treatment window, and therefore the firm’s time to anticipate the policy change, by one year.

I examine firm adjustments to the workforce depending on the exact birth year of treated workers born between 1950 and 1953. The key object of interest in each case is how firms adjust their workforce relative to what their workforce would have been absent the policy change. To capture this counterfactual I rely on firms with 1949 workers, which were not affected by the policy change. I restrict my sample to firms with exactly one worker born in 1949-1953. I then compare outcomes for the firms with a 1950-1953 worker to outcomes for firms with a 1949 worker. To establish the correct counterfactual I shift the 1949 control firms by 1, 2, 3, or 4 years to serve as controls for the firms with 1950, 1951, 1952, 1953 workers, respectively. In effect, this means I compare firm outcomes for the firms with a 1950-1953 worker to outcomes for firms with a 1949 worker, when those workers were of the same age.

The estimating equation is:

\[ y_{ja} = \alpha_j + \tau_a + \sum_{a=55}^{68} \sum_{c=1950}^{1953} \beta_{c,a} \times 1(\text{age} = a) \times 1(\text{cohort} = c) + \epsilon_{ja} \]  \hspace{1cm} (9)

where \( y_{ja} \) is firm \( j \)'s outcome when the treated worker is of age \( a \), \( \alpha_j \) are firm fixed effects and \( \tau_a \) are age fixed effects. The coefficient of interest is \( \beta_{c,a} \) which represents the difference in the outcome of a firm employing a treated worker of cohort \( c = \{1950, 1951, 1952, 1953\} \) relative to the outcome of a firm employing a control worker born in 1949 when both workers were of the same age \( a \).

Appendix Figure A12 shows the first stage plot demonstrating that each consecutive birth year shifts the treatment window by one year. Panel A shows the effect of having one more worker of each treated cohort 1950-1953 on the retention rate of older workers, relative to a firm with a 1949 worker. The plot demonstrates that the onset of the treatment at the firm level occurs one year later for each one-year shift in the treated worker’s birth year. Panel B shows the same results but with age of the treated worker on the x-axis. This figure makes it clearer that the size of the first stage is similar for workers of different cohorts, and that it is just the timing that is different.

To examine anticipatory behavior, then, I compare adjustments in the number of younger workers employed depending on the birth year of the treated worker at each firm, and hence the time to anticipate the policy. Figure 10 shows these effects by age of the treated worker. The results demonstrate that firms that had more time to anticipate appear to make smaller and somewhat smoother adjustments to their younger workforce. The point estimates suggest that firms with a 1950 worker reduce the number of younger workers by approximately 0.2, which is in line with the results found in section 5. Firms with a 1953 worker, on the other hand, reduce their younger workforce by about half of that. Note that while somewhat noisy, the observed magnitude of response appears to be monotonic in the amount of time firms had to anticipate:

\[ \text{Note that my data ends in 2018, so I run into data censoring issues when considering more recent cohorts. For this reason I only consider cohorts born up to and including 1953, as these workers turn 65 in the last year of my data.} \]
each consecutive birth year - and hence additional year to anticipate - reduces the observed adjustment to the younger workforce.

In addition I find that the differential response due to anticipation translates into differences in firm profitability. Figure 11 shows that, while noisier, it also appears that firms that have more time to anticipate the policy experience smaller declines in their probability of reporting a positive profit. Similar to the labor adjustments in Figure 11, firms with a 1953 worker experience profit declines that are about half as large as firms with a 1950 worker.

To capture the effects of anticipation with more precision, I then estimate a linear cohort trend relying on variation at the firm level in the mean birth year of treated workers. This allows me to extend the analysis to all firms in my sample with workers born in 1950-1953, rather than firms with exactly one such worker. I again compare the outcomes of a firm with mean birth cohort \( c \) to a shifted version of a firm with a 1949 worker.\(^{23}\) In this part of the analysis I treat the cohort variable \( c \) as a continuous variable and estimate how the firm’s outcome varies with each one year shift in \( c \):

\[
y_{ja} = \alpha_j + \tau_a + \sum_{a=55}^{68} \sum_{c=1950}^{1953} \beta_a \times 1(\text{age} = a) \times c + \epsilon_{ja}
\]  

(10)

Table 3 reports the results, collapsing the \( \beta_a \) to the mean between ages 60-64 - when the policy was most binding. Column (1) shows that for each additional year to anticipate the policy, the estimated adjustments in the younger workforce are reduced by 0.04 workers. Given that firms with a 1950 worker adjusts its young workforce by -0.22 workers, this means that three additional years to anticipate approximately cuts the adjustment made by firms in half. In addition, column (2) suggests that for each additional year to anticipate, the negative effect on the probability of reporting a positive profit is reduced by 1 percentage point, relative to a reduction of 5 percentage points for firms with a 1950 worker.

Lastly, a puzzling fact about the anticipation effects observed here is that firms do not begin to adjust their younger workforce prior to the year in which the treated worker turns 60. Rather than affecting the timing of the response, anticipation appears to only affect the magnitude of the response.

How do firms smooth instead? I find suggestive evidence in the data that firms with workers born in later cohorts build up more cash reserves in anticipation of the policy. Examining free cash flow for these firms in the years leading up to the treatment, firms with 1953 workers appear to have approximately 32K EUR (95% CI: 8K, 56K) higher free cash flow each year than firms with 1950 workers. Given the large confidence interval on this estimate, however, this result is at best suggestive.\(^{24}\)

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\(^{23}\)Note that Appendix C3 validates that the mean is the correct transformation by showing that the plots by birth year obtained from equation (9) are similar to those one would get when rounding mean birth year at a firm to the nearest integer. Other transformations, notably taking the minimum birth year of treated workers (which might capture the notion that the first treated worker is what matters, and not the average timing of the policy) do not yield similar adjustment patterns. Figures available upon request.

\(^{24}\)Note that this finding is consistent with a result in Midrigan and Xu (2014) that firms can mitigate financing constraints by accumulating savings during good economic times.
7 Conclusion

In this paper I highlight a financial channel through which labor market policies may affect firms. If firms are financially constrained, labor market policies that directly affect firm cash flow may lead to large firm adjustments in response, and alter the economic interpretation of these responses. I demonstrate this in the context of a change in the legal retirement age in the Netherlands, which caused firms to retain more older workers. Relying on detailed administrative data that combines employment contracts with firm balance sheets, I demonstrate that this policy caused firms to make substantial adjustments to their younger workforce and investments. All of these adjustments are concentrated in cash constrained firms. Economically, the results are consistent with cash flow effects being a key driver of firm response, rather than strong substitutability between different cohorts of workers or workers and capital. From a policy perspective, understanding the role of cash constraints may inform which firms are most affected by labor market policies. In the context of this retirement policy, I find that all observed negative profit effects are concentrated in cash constrained firms. The results also suggest a potential avenue to alleviating cash constraints, by giving firms more time to anticipate policies. I find that more time to anticipate the retention of older workers helped firms smooth adjustments to their younger workforce and reduced negative profit effects.
References


Fazzari, Steven, R Glenn Hubbard, and Bruce C Petersen, “Financing constraints and corporate investment,” 1987.


# Tables and Figures

## Table 1: Summary Statistics: Firms

<table>
<thead>
<tr>
<th>Panel A: Labor and Investment</th>
<th>Median</th>
<th>Standard Deviation</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Employees</td>
<td>18</td>
<td>55.72</td>
<td>99,240</td>
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<tr>
<td>Full Time Employees</td>
<td>10</td>
<td>17.89</td>
<td>99,240</td>
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<tr>
<td>Wage bill (1000 EUR)</td>
<td>229</td>
<td>534</td>
<td>99,240</td>
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<tr>
<td>Material Investments (1000 EUR)</td>
<td>42.16</td>
<td>93.89</td>
<td>85,732</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Panel B: Production</th>
<th>Median</th>
<th>Standard Deviation</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Employees</td>
<td>20</td>
<td>30.78</td>
<td>63,469</td>
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<tr>
<td>Full Time Employees</td>
<td>12</td>
<td>15.15</td>
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<tr>
<td>Wage bill (1000 EUR)</td>
<td>326</td>
<td>653</td>
<td>63,469</td>
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<tr>
<td>Revenue (1000 EUR)</td>
<td>1,414</td>
<td>4,107</td>
<td>63,469</td>
</tr>
<tr>
<td>Profits (1000 EUR)</td>
<td>77</td>
<td>306</td>
<td>63,469</td>
</tr>
<tr>
<td>Free Cash Flow (1000 EUR)</td>
<td>29</td>
<td>1,322</td>
<td>63,469</td>
</tr>
</tbody>
</table>

*Note*: This table shows summary statistics for 2005 for the firms included in the subpopulation studied in this paper. Panel A displays the labor and investment data. Panel B displays the production data. The production data is at the company rather than the firm level (higher level of aggregation). In addition, both the investment and production data are more restrictive in terms of coverage because they do not contain the universe of smaller firms and exclude the financial sector. Sample sizes differ for these reasons. See Section 3.2 for more details.

## Table 2: Overview: Cash Flow Effects of Policy

<table>
<thead>
<tr>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>P-Value: (2)=(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>P-Value: (4)=(5)</th>
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</thead>
<tbody>
<tr>
<td>Overall</td>
<td>High Cash Flow</td>
<td>Low Cash Flow</td>
<td>Older Worker Wage Bill</td>
<td>8497.74***</td>
<td>8280.94***</td>
<td>8614.36***</td>
</tr>
<tr>
<td></td>
<td>(783.02)</td>
<td>(1512.18)</td>
<td>(915.43)</td>
<td>(1564.41)</td>
<td>(1153.51)</td>
<td></td>
</tr>
<tr>
<td>Younger Worker Wage Bill</td>
<td>-3381.15***</td>
<td>-406.68</td>
<td>-6122.63***</td>
<td>0.021</td>
<td>-11536.46***</td>
<td>-1464.01</td>
</tr>
<tr>
<td></td>
<td>(1342.04)</td>
<td>(2166.21)</td>
<td>(1652.37)</td>
<td>(3287.67)</td>
<td>(1850.16)</td>
<td></td>
</tr>
<tr>
<td>Investments</td>
<td>-1477.17***</td>
<td>-321.78</td>
<td>-1847.32**</td>
<td>0.089</td>
<td>-478.56</td>
<td>-4586.65**</td>
</tr>
<tr>
<td></td>
<td>(690.75)</td>
<td>(1273.27)</td>
<td>(830.78)</td>
<td>(2432.57)</td>
<td>(2000.87)</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>144,851</td>
<td>73,566</td>
<td>71,285</td>
<td>38,493</td>
<td>32,792</td>
<td></td>
</tr>
</tbody>
</table>

*Note*: This table summarizes the cash flow effect of the policy in terms of the older worker wage bill, younger worker wage bill and investments in machines and installations in euros. The reported effects are from separate regressions. The coefficients represent mean effects in 2011-2014 - when the policy was most binding - of having an additional treated worker (born 1950 or 1951) at the firm in 2005, controlling for the number of old workers (born 1948-1951) and the total number of workers at the firm in 2005. The outcomes are the older worker wage bill, the younger worker wage bill and investments in machines and equipment. The regressions are run for all firms (column 1), and run separately for above (column 2) and below (column 3) median free cash flow firms. In addition, among below median free cash flow firms those that were growing (column 4) - and hence could reduce labor by reducing hiring - versus shrinking (column 5) - and had to fire workers to adjust labor - prior to the policy. Standard errors are clustered at the firm level. P-values significance: * = 0.1, ** = 0.05, *** = 0.01.
Table 3: **Anticipation Effects**

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>β: Effect of additional year to anticipate</td>
<td>0.0462**  (0.0166)</td>
<td>0.0095*  (0.0053)</td>
</tr>
<tr>
<td>Mean adjustment/effect for 1950 worker</td>
<td>-0.2247***  (0.0591)</td>
<td>-0.0524**  (0.0249)</td>
</tr>
</tbody>
</table>

*Note:* This table reports the estimated β coefficient from equation (10). The coefficient represents the difference in outcome for each one unit increase in mean birth cohort of treated workers c at a firm, when that mean birth cohort is of age 61-64. Conceptually, it captures the effect of having an additional year to anticipate the policy change, during the time frame when the policy has the largest impact. In addition, the table reports the mean difference in outcome between treated firms with a worker born in 1950 - firms with the least time to anticipate - relative to untreated firms with a 1949 worker. The outcome variable in column (1) is the number of younger workers employed at the firm when the treated worker was 61-64, and in column (2) the probability of the firm reporting a profit when the treated worker was 61-64. Standard errors are in parentheses and are clustered at the firm level. P-values significance: * = 0.1, ** = 0.05, *** = 0.01.
Figure 1: Individual Level First Stage: Retirement by Cohort

Panel A: Share of Individuals Retiring Before 65

Panel B: Retirement by Age and Cohort

Notes: This figure shows individual-level retirement rates and highlights the sharp difference in retirement rates between workers born in 1949 and 1950. Panel A depicts the share of workers retiring before the age of 65, the legal retirement age in the Netherlands. Panel B depicts the cumulative retirement rate by age, for individuals born in 1948, 1949, 1950 and 1951. The population is restricted to all individuals observed working in the data at age 55 to capture the group affected by the policy: employed individuals.
Notes: The unit of observation is the firm-year. The figure demonstrates that at a firm level having an additional 1950 rather than 1949 worker has a substantial and significant effect on number of older workers employed. This is not true for the 1949-1948 difference, when both cohorts can retire early, or the 1951-1950 difference, when neither cohort can retire early. The coefficients plotted represent the difference in the effect in each year $t$ of having an additional treated worker born in 1949 versus 1948, 1950 versus 1949, or 1951 versus 1951, controlling for the number of workers of each other cohort at the firm in 2005. These correspond to the difference between the estimated $\beta_{k,t}$ coefficients, for 1948 and 1949, 1949 and 1950, and 1950 and 1951 from equation (6). All workers considered are full time employed. Standard errors are clustered at the firm level.
Figure 3: Overall firm labor adjustments

Panel A: Employment of workers of different cohorts

Panel B: Firm total wage bill

Notes: The unit of observation is the firm-year. The figure demonstrates the effect of the policy on firm worker composition and the firm’s wage bill. The coefficients plotted represent the effect in each year $t$ of having an additional treated worker (born 1950 or 1951) at the firm in 2005, controlling for the number of old workers (born 1948-1951) and the total number of workers. These correspond to $\beta_t$ from equation (7). The coefficient for $t = 2005$ is normalized to 0. For panel A, the three lines represent three separate regressions. The outcome variables are the number of older workers (born 1945-1955), the number of middle-aged workers (born 1955-1965) and the number of younger workers (born 1965 and after) at the firm over time. All workers considered are full time employed. For panel B the outcome variable is the total wage bill for full time workers at the firm. The legend reports the mean of the coefficients between 2011-2014: $\bar{\beta}^{2011-2014}$ and the corresponding standard error in parentheses. The dotted lines represent key timing of the policy: the policy was announced in 2005 and had its main impact in 2010-2015. Standard errors are clustered at the firm level.
**Figure 4: Overall investment adjustments**

Investment in Machines and Installations

Notes: The unit of observation is the firm-year. The figure demonstrates the effect of the policy on investments in machines and installations. The coefficients represent the effect in each year \( t \) of having an additional percent of the 2005 workforce treated (born 1950-1951), controlling for the share of old workers (born 1948-1950) at the firm. This corresponds to \( \beta_t \) from equation (8). The coefficient for \( t = 2005 \) is normalized to 0. The outcome variable is log investment in machines and installations. See section 3.2 for more details. The dotted lines represent key timing of the policy: the policy was announced in 2005 and had its main impact in 2010-2015. The legend reports the mean of the coefficients between 2011-2014: \( \bar{\beta}_{2011-2014} \) and the corresponding standard error in parentheses. Standard errors are clustered at the firm level.
Figure 5: Overall firm production and profit effects

Panel A: Revenue

Panel B: Reporting Positive Accounting Profit

Notes: The unit of observation is the firm-year. The figure demonstrates the effect of the policy on revenue and the probability of reporting a positive profit. The coefficients represent the effect in each year $t$ of having an additional percent of the 2005 workforce treated (born 1950-1951), controlling for the share of old workers (born 1948-1951) at the firm. This corresponds to $\beta_t$ from equation (8). The coefficient for $t = 2005$ is normalized to 0. In Panel A the outcome variable is log revenue. I windosize revenue per worker at the 1st and 99th percentile to take out extreme outliers. In Panel B the outcome is the probability of reporting a positive profit in any given year. The dotted lines represent key timing of the policy: the policy was announced in 2005 and had its main impact in 2010-2015. The legend reports the mean of the coefficients between 2011-2014: $\beta_{2011-2014}$ and the corresponding standard error in parentheses. Standard errors are clustered at the firm level.
Figure 6: Cash constraints: labor and investment adjustments

Panel A: Younger Workers

Panel B: Investment in Machines and Installations

Notes: The unit of observation is the firm-year. The figure demonstrates the effect of the policy on the number of younger workers and investment for high and low free cash flow firms, highlighting the role of cash constraints in firm adjustments. The coefficients in panel A represent the effect on the number of young workers in each year $t$ of having an additional treated worker (born 1950 or 1951) at the firm in 2005, controlling for the number of old workers (born 1948-1951) and the total number of workers. These correspond to $\beta_t$ from equation (7). The coefficients in Panel B represent the effect on log investment in machines and installations in each year $t$ of having an additional percent of the 2005 workforce treated (born 1950-1951), controlling for the share of old workers (born 1948-1951) at the firm. This corresponds to $\beta_t$ from equation (8). The coefficient for $t = 2005$ is normalized to 0. The dotted lines represent key timing of the policy: the policy was announced in 2005 and had its main impact in 2010-2015. The legend reports the mean of the coefficients between 2011-2014: $\bar{\beta}_{2011-2014}$ and the corresponding standard error in parentheses. Standard errors are clustered at the firm level.
Figure 7: Cash constraints: total costs

Notes: The unit of observation is the firm-year. The figure demonstrates the effect of the policy on total firm cost (total wage bill + investments) for high and low free cash flow firms, highlighting that low free cash flow firms fully offset the additional older worker wage costs through reductions in the younger workforce and investments. The coefficients represent the effect on total firm labor and investment cost in each year $t$ of having an additional treated worker (born 1950 or 1951) at the firm in 2005, controlling for the number of old workers (born 1948-1951) and the total number of workers. These correspond to $\beta_t$ from equation (7). The coefficient for $t = 2005$ is normalized to 0. The dotted lines represent key timing of the policy: the policy was announced in 2005 and had its main impact in 2010-2015. The legend reports the mean of the coefficients between 2011-2014: $\bar{\beta}_{2011-2014}$ and the corresponding standard error in parentheses. Standard errors are clustered at the firm level.

Mean Effects 2011-2014:
- High Free Cash Flow: 8349.49 (1927.49)
- Low Free Cash Flow: 439.27 (1437.05)
Figure 8: Cash constraints: firm production and profit

Panel A: Revenue

Panel B: Reporting Positive Accounting Profit

Notes: The unit of observation is the firm-year. The figure demonstrates the effect of the policy on revenue and the probability of reporting a positive profit for high and low free cash flow firms, highlighting the role of cash constraints in firm adjustments. The coefficients represent the effect in each year $t$ of having an additional percent of the 2005 workforce treated (born 1950-1951), controlling for the share of old workers (born 1948-1951) at the firm. This corresponds to $\beta_t$ from equation (8). The coefficient for $t = 2005$ is normalized to 0. In Panel A the outcome variable is log revenue. I windsorize revenue per worker at the 1st and 99th percentile to take out extreme outliers. In Panel B the outcome is the probability of reporting a positive profit in any given year. In each case I run two separate regressions for high and below median free cash flow firms at baseline. The dotted lines represent key timing of the policy: the policy was announced in 2005 and had its main impact in 2010-2015. The legend reports the mean of the coefficients between 2011-2014: $\beta_{2011-2014}$ and the corresponding standard error in parentheses. Standard errors are clustered at the firm level.
Figure 9: Interactions: Labor Adjustment Costs and Cash Constraints

(a) Young Worker Adjustments

(b) Investments in Machines and Installations

(c) Revenue

(d) Reporting Positive Accounting Profit

Notes: This figure demonstrates the effect of the policy on the number of younger workers, investments in machines and installations, revenue, and the probability of reporting a positive profit for the two way interaction between pre-policy free cash flow and employment growth. The reported effects represent the mean effect in 2011-2014, when the policy was most binding. The coefficients in panel A represent the average effect in 2010-2015 of having an additional treated worker (born 1950 or 1951) at the firm in 2005, controlling for the number of old workers (born 1948-1951) and the total number of workers. The outcome is the number of younger workers employed. The coefficients in panel B-D represent the average effect in 2010-2015 of having an additional percent of the 2005 workforce treated (born 1950-1951), controlling for the share of old workers (born 1948-1951) at the firm. The outcomes are log investment in machines and installations (panel B), log revenue (panel C) and the probability of reporting a positive profit (panel D). Standard errors are clustered at the firm level.
Figure 10: Anticipation: Young Worker Adjustments

(a) Born 1950  (b) Born 1951

(c) Born 1952  (d) Born 1953

Notes: The sample is restricted to firms with below median free cashflow at baseline that have exactly one worker born between 1949 and 1953. The figure demonstrates the effect of anticipation on the firm’s labor adjustments. Each consecutive cohort $c$ gives the firm an additional year to anticipate the policy change (see Appendix Figure A12 for the first stage plots by birth year). The coefficients represent the difference in the outcome of a firm employing a treated worker of cohort $c = \{1950, 1951, 1952, 1953\}$ relative to the outcome of a firm employing a control worker born in 1949, when both workers were of the same age $a$. These correspond to coefficients $\beta_{c,a}$ from equation (9), which represent firm adjustments in the number of younger workers depending on the treated worker’s cohort $c$. The dotted lines represent the window within which a treated worker could have retired early absent the policy change, but is now more likely to work. Note that data are censored for younger cohorts. The last year in the data is 2018, for individuals born in 1953 are observed until they are 65 years old. Standard errors are clustered at the firm level.
Notes: The sample is restricted to firms with below median free cashflow at baseline that have exactly one worker born between 1949 and 1953. The figure demonstrates the effect of anticipation on the firm’s probability of reporting a positive profit. Each consecutive cohort $c$ gives the firm an additional year to anticipate the policy change (see Appendix Figure A12 for the first stage plots by birth year). The coefficients represent the difference in the outcome of a firm employing a treated worker of cohort $c = \{1950, 1951, 1952, 1953\}$ relative to the outcome of a firm employing a control worker born in 1949, when both workers were of the same age $a$. These correspond to coefficients $\beta_{c,a}$ from equation (9), which represent the firm’s probability of reporting a positive profit depending on the treated worker’s cohort $c$. The dotted lines represent the window within which a treated worker could have retired early absent the policy change, but is now more likely to work. Note that data are censored for younger cohorts. The last year in the data is 2018, for individuals born in 1953 are observed until they are 65 years old. Standard errors are clustered at the firm level.
Appendix A: Additional Tables and Figures

Figure A1: Firm-level Treatment: Share Born After Cutoff

Notes: This figure shows the share of all 2005 full-time workers (1) born 1948-1951 (older workers), (2) born 1950 or 1951 (treated workers) by firm size. In addition, it shows the share of treated workers among old workers. The key observation from this figure is that the share of treated workers (born 1950-1951) among older workers (born 1948-1951) is consistently 0.5 for firms of different sizes. This suggests there is no excess mass of workers born either before or after the 1950 cohort boundary.
Figure A2: Overall firm hiring effects

Notes: The unit of observation is the firm-year. The figure coefficients $\beta_t$ from equation (7), which represents the effect in each year $t$ of having an additional percent of the 2005 workforce treated, controlling for the share of old workers at the firm. The coefficient for $t = 2005$ is normalized to 0. The outcome variable is the number of new hires at the firm. The dotted lines represent key timing of the policy: the policy was announced in 2005 and had its main impact in 2010-2015. Standard errors are clustered at the firm level.
Figure A3: Overall changes in hours worked and hourly wages - young and middle-aged

Panel A: Hours Worked

Panel B: Hourly Wages

Notes: The unit of observation is the firm-year. The figure coefficients \( \beta_t \) from equation (7), which represents the effect in each year \( t \) of having an additional percent of the 2005 workforce treated, controlling for the share of old workers at the firm. The coefficient for \( t = 2005 \) is normalized to 0. The outcome variable is the hours worked and hourly wages at the firm. The dotted lines represent key timing of the policy: the policy was announced in 2005 and had its main impact in 2010-2015. Standard errors are clustered at the firm level.
Figure A4: **Overall firm material investment effects**

![Log Investment: Total Material Asset](image)

**Notes:** The unit of observation is the firm-year. The figure coefficients $\beta_t$ from equation (8), which represents the effect in each year $t$ of having an additional percent of the 2005 workforce treated, controlling for the share of old workers at the firm. The coefficient for $t = 2005$ is normalized to 0. The outcome variable is log investment in total material assets. Standard errors are clustered at the firm level.
Notes: The unit of observation is the firm-year. The figure coefficients $\beta_t$ from equation (8), which represents the effect in each year $t$ of having an additional percent of the 2005 workforce treated, controlling for the share of old workers at the firm. The coefficient for $t = 2005$ is normalized to 0. The outcome variable is log revenue per worker. I windsorize revenue per worker at the 1st and 99th percentile to take out extreme outliers. The dotted lines represent key timing of the policy: the policy was announced in 2005 and had its main impact in 2010-2015. Standard errors are clustered at the firm level.
Figure A6: Overall profit effects

Notes: The unit of observation is the firm-year. The figure coefficients $\beta_t$ from equation (8), which represents the effect in each year $t$ of having an additional percent of the 2005 workforce treated, controlling for the share of old workers at the firm. The coefficient for $t = 2005$ is normalized to 0. The outcome variable is profits as a share of last year’s assets. I windsorize this measure at the 1st and 99th percentile to take out extreme outliers. The dotted lines represent key timing of the policy: the policy was announced in 2005 and had its main impact in 2010-2015. Standard errors are clustered at the firm level.
Figure A7: Overall effects on firm shutdown

Notes: The unit of observation is the firm-year. The figure coefficients $\beta_t$ from equation (8), which represents the effect in each year $t$ of having an additional percent of the 2005 workforce treated, controlling for the share of old workers at the firm. The coefficient for $t = 2005$ is normalized to 0. The outcome variable is firm shutdown. The dotted lines represent key timing of the policy: the policy was announced in 2005 and had its main impact in 2010-2015. Standard errors are clustered at the firm level.
Notes: The unit of observation is the firm-year. The figure demonstrates the effect of the policy on the number of older workers at the firm, depending on whether firms had above or below median free cash flow prior to the policy. The coefficients plotted represent the effect in each year $t$ of having an additional treated worker (born 1950 or 1951) at the firm in 2005, controlling for the number of old workers (born 1948-1951) and the total number of workers. These correspond to $\beta_t$ from equation (7). The coefficient for $t = 2005$ is normalized to 0. Standard errors are clustered at the firm level.
Figure A9: Young Worker Adjustments - By Baseline Productivity

Notes: The unit of observation is the firm-year. The figure demonstrates the effect of the policy on the number of younger workers at the firm, depending on whether firms had above or below median return on assets prior to the policy. The return on assets measure is residualized with respect to the firm’s industry mean. The coefficients plotted represent the effect in each year $t$ of having an additional treated worker (born 1950 or 1951) at the firm in 2005, controlling for the number of old workers (born 1948-1951) and the total number of workers. These correspond to $\beta_t$ from equation (7). The coefficient for $t = 2005$ is normalized to 0. Standard errors are clustered at the firm level.
Figure A10: Interaction: Labor Adjustment Costs and Cash Constraints

Panel A: Employment of Younger Workers

Panel B: Log Investment in Machines and Installations

Notes: The unit of observation is the firm-year. Panel A plots coefficients $\beta_t$ from equation (7), which represents the effect in each year $t$ of having an additional treated worker at the firm in 2005, controlling for the number of old workers and the total number of workers. The outcome variable is the number of young workers. Panel B plots coefficients $\beta_t$ from equation (8), which represents the effect in each year $t$ of having an additional percent of the 2005 workforce treated, controlling for the share of old workers at the firm. The outcome variable is log investment in machines and equipment. The coefficient for $t = 2005$ is normalized to 0. In each case I run four separate regressions for the two-way interaction between high and below median free cash flow firms at baseline and growing/shrinking firms. The dotted lines represent key timing of the policy: the policy was announced in 2005 and had its main impact in 2010-2015. Standard errors are clustered at the firm level.
Figure A11: Interaction: Labor Adjustment Costs and Cash Constraints

Panel A: Log Revenue

Panel B: Reporting Positive Accounting Profit

Notes: The unit of observation is the firm-year. The figure plots coefficients $\beta_t$ from equation (8), which represents the effect in each year $t$ of having an additional percent of the 2005 workforce treated, controlling for the share of old workers at the firm. The coefficient for $t = 2005$ is normalized to 0. In Panel A the outcome variable is log revenue. I windsorize revenue per worker at the 1st and 99th percentile to take out extreme outliers. In Panel B the outcome is the probability of reporting a positive profit in any given year. In each case I run four separate regressions for the two-way interaction between high and below median free cash flow firms at baseline and growing/shrinking firms. The dotted lines represent key timing of the policy: the policy was announced in 2005 and had its main impact in 2010-2015. Standard errors are clustered at the firm level.
Figure A12: Single Worker Level: Anticipation First Stage

Panel A: By Calendar Year

Panel B: By Age of the Treated Worker

The sample is restricted to firms with below median free cashflow at baseline that have exactly one worker born between 1949 and 1953. The figure shows the first stage effect of anticipation on the firm’s retention of older workers over time. Each consecutive cohort \( c \) gives the firm an additional year to anticipate the policy change. The coefficients represent the difference in the number of older workers of a firm employing a treated worker of cohort \( c = \{1950, 1951, 1952, 1953\} \) relative to the outcome of a firm employing a control worker born in 1949. Panel A shows the first stage by calendar year, demonstrating that the onset of the treatment is shifted by a year for each consecutive cohort \( c \). Panel B shows the first stage by age of the treated worker, demonstrating that the magnitude of the first stage is similar. Note that data are censored for younger cohorts. The last year in the data is 2018, for individuals born in 1953 are observed until they are 65 years old. Standard errors are clustered at the firm level.
Appendix B: Background on Dutch Pension System

B1. Dutch Pension System

The Dutch pension system consists of three pillars.

The first pillar is a public old age pension provided by the government to all residents of the Netherlands when they reach the legal retirement age of 65. This is a pay-as-you-go system financed through income taxation which provides pension benefits that are tagged to the minimum wage.

The second pillar of the pension system consists of employer-employee pensions. Pensions agreements are negotiated between unions and employers at the sector or firm level and are set in collective agreements. While membership of a pension fund is not mandatory by law, 90% of Dutch employees belong to a pension fund. Prior to 2005, workers were able to retire early (before the legal retirement age of 65) through the second pillar of the pension system. These early retirement schemes were tax deductible, and the tax advantage was approximately 25% of early retirement benefits. Typically, before 2005 workers could retire in their early 60s and get a large share of their final earned wage as pension benefits. For example, in the public sector a worker who had served for 40 years in the public sector could retire at the age of 62 and three months at a replacement rate of 70%. As a result, early retirement, was the social norm in the Netherlands.

The third pillar consists of individual pensions, used mainly by self-employed individuals or as supplemental pension. This pillar is relatively insignificant in the Netherlands. By comparison, the retirement benefits belonging to the second pillar are about twenty times as large as retirement benefits belonging to the third pillar (Bovenberg and Gradus, 2015).

B2. Financial Consequences of Reform for Workers and Firms

Aside from increasing the effective retirement age, abolishing the early retirement scheme also had financial consequences for both affected workers and firms. These effects are small relative to the primary employment effect I exploit in this paper, however.

First, affected individuals no longer had to make contributions to the employer-employee savings scheme, which accounted for approximately 1.8% of their wage. Until 2014 these cohorts still made contributions to the pay-as-you-go component to fund current early retirees, however. Second, the affected workers got to use any benefits they accumulated up to 2005 in the employer-employee savings plan for early retirement or to increase the benefits in their old age pension. Such contributions were no longer tax deductible, however. In practice this likely contributed to the fact that some affected workers still retired before the legal retirement age of 65, but not at as high a rate as they would have absent the policy change. The difference in post-retirement income is negligible, however. The tax data - described below - shows that the difference in mean income from pensions after retirement between individuals born in 1950 and 1949 is less than 200 euros (220 USD) annually (less than 1% of mean annual pension income).

Second, affected firms faced a small reduction in the early retirement benefits paid for by employers. Firms no longer had to contribute to the employer-employee savings scheme, which accounted for approximately 2.7 percent of each affected worker’s wage. Similar to workers, firms continued to contribute to the pay as you go component until 2014. These reductions in contributions were small relative to the wages firms continued to pay when retaining an older worker. These direct effects of retaining an older worker on firm (labor) costs are a key part of the analysis of this paper.

Note that 2014 is the year in which the last eligible cohort, born in 1949, reached the statutory pension age of 65.
Appendix C: Empirical Approach

C1. Robustness to window size
Figure A13: Robustness: window size around 1950

Panel A: 1949 vs. 1950

Panel B: 1947-1949 vs. 1950-1952

Notes: The unit of observation is the firm-year. The figures demonstrate robustness to adjusting the window size around 1950 which are used for identification. The main analysis takes a two year window on either side and compares the effect of having additional workers born in 1950/1951 (treated) to workers born in 1948/1949 (control). Panel A replicates this using only 1950 versus 1949 (one year window) and Panel B using 1950-1952 versus 1947-1949 (three year window). The coefficients plotted represent the effect in each year $t$ of having an additional treated worker (born 1950 or 1951) at the firm in 2005, controlling for the number of old workers (born 1948-1951) and the total number of workers. These correspond to $\beta_t$ from equation (7). The coefficient for $t = 2005$ is normalized to 0. In each case the three lines represent three separate regressions. The outcome variables are the number of older workers (born 1945-1955), the number of middle-aged workers (born 1955-1965) and the number of younger workers (born 1965 and after) at the firm over time. All workers considered are full time employed. The dotted lines represent key timing of the policy: the policy was announced in 2005 and had its main impact in 2010-2015. Standard errors are clustered at the firm level.
C2. Labor and Production Specification: Levels and Shares

As specified in section 4.2, the exact empirical specification differs slightly depending on the outcome studied. The primary reason for this is that I study firms of different sizes. We might expect that the units in which effects are homogenous across different firms might be different depending on the outcome.

For labor adjustments I study the effects in terms of the number of treated workers employed at a firm. Figure A14 shows that this approach yields roughly the same treatment effect across firms of different sizes.

Figure A14: First Stage by Firm Size Decile

Notes: The figure demonstrates that the treatment effect of the policy in terms of the number of older workers retained is homogenous in the size of firms. The coefficients plotted represent the mean effect on the number of older workers in 2011-2014 of having an additional treated worker (born 1950 or 1951) at the firm in 2005, controlling for the number of old workers (born 1948-1951) and the total number of workers. Standard errors are clustered at the firm level.

Second, I examine the effect of having an additional percent of the workforce treated for firm investment, production and profits. Similarly, Figure A15 shows that this approach yields similar treatment effects across firms of different sizes.
Figure A15: **First Stage by Firm Size Decile**

Notes: The figure demonstrates that the treatment effect of the policy in terms of log revenue is homogenous in the size of firms. The coefficients plotted represent the mean effect on log revenue in 2011-2014 of having an additional percent of the workforce treated (born 1950 or 1951) at the firm in 2005, controlling for the share of old workers (born 1948-1951) at the firm. Standard errors are clustered at the firm level.

Studying the effect of the number of treated workers for these outcomes would lead to mis-specification. This makes sense intuitively given that a levels approach would imply that adding a worker would have the same effect on production no matter the firm’s size, which would only hold for the specific case in which firms faced constant returns to labor.

**C3. Firm Level Anticipation Approach**

In Section 6.3 I use the mean birth year among treated born 1950-1953 workers at firms. To validate that the mean is the appropriate transformation I compare rounded mean birth year plots to the plots in Figure 10. The latter plots show adjustments for firms with exactly one treated worker born 1950-1953. The Figure below shows that the rounded mean birth year approach yields adjustments very similar to those found in Figure 10. This suggests that the mean birth year of treated workers is the appropriate measure to use when examining the effect of anticipation at the firm level.
Notes: The sample is restricted to firms with below median free cashflow at baseline. The figure shows adjustments in the younger workforce by rounded mean birth year of treated workers at the firm. The plot demonstrates the effect of anticipation on the firm’s labor adjustments. Each consecutive cohort $c$ gives the firm an additional year to anticipate the policy change (see Appendix Figure A12 for the first stage plots by birth year). The coefficients represent the difference in the outcome of a firm employing a treated worker with rounded mean cohort $c = \{1950, 1951, 1952, 1953\}$ relative to the outcome of a firm employing a control worker born in 1949, when both workers were of the same age $a$. These correspond to coefficients $\beta_{c, a}$ from equation (9), which represent firm adjustments in the number of younger workers depending on the treated worker’s cohort $c$. The dotted lines represent the window within which a treated worker could have retired early absent the policy change, but is now more likely to work. Note that data are censored for younger cohorts. The last year in the data is 2018, for individuals born in 1953 are observed until they are 65 years old. Standard errors are clustered at the firm level.

Appendix D: Theoretical Framework Derivations

Case 2: Financially Constrained Adjustments

For constrained firms the cash constraint binds, so that:

$$L^O w^O + L^Y w^Y + KpK = CF$$

And hence in terms of changes:

$$\Delta L^O w^O + \Delta L^Y w^Y + \frac{a}{2} (\Delta L^Y)^2 + \Delta KpK = 0$$

We can therefore re-write capital adjustment as a function of the other changes:

$$\Delta K = -\frac{\left(\Delta L^O w^O + \Delta L^Y w^Y + \frac{a}{2} (\Delta L^Y)^2\right)}{pK}$$

The firm maximizes revenue given this constraint, which I substitute in:

$$\Delta L^*_1 = \arg\max_{\Delta L^*_1} \left(L^O + \Delta L^O, L^Y + \Delta L^Y, K - \frac{\left(\Delta L^O w^O + \Delta L^Y w^Y + \frac{a}{2} (\Delta L^Y)^2\right)}{pK}\right)$$

FOC:
\[ \frac{\partial F}{\partial L^Y} - \frac{\partial F}{\partial K} \left( \frac{w^Y}{p^K} + \frac{a \Delta L^Y}{p^K} \right) = 0 \]

I.e.

\[ \frac{F_{LY}}{F_K} = \frac{w^Y + a \Delta L^Y}{p^K} \]

Firms adjust labor and capital within the constraint so as to equalize the ratio of their marginal products to the ratio of input prices plus adjustment cost. Equivalently:

\[ \Delta L^Y = \frac{1}{a} \left( \frac{p^K F_{LY}}{F_K} - w^Y \right) \]

Substituting \( w^Y \) from the budget constraint we find:

\[ -\Delta L^O w^O - \frac{a}{2} (\Delta L^Y)^2 - \Delta K p^K = \frac{p^K F_{LY}}{F_K} \Delta L^Y - a (\Delta L^Y)^2 \]

Taking the derivative w.r.t. \( \Delta L^O \) on both sides:

\[ -w^O - a \Delta L^Y \frac{\partial \Delta L^Y}{\partial \Delta L^O} - \frac{\partial \Delta K}{\partial \Delta L^O} p^K = \frac{\partial \Delta L^Y}{\partial \Delta L^O} \frac{p^K F_{LY}}{F_K} + p^K \Delta L^Y \left( \frac{F_{LY} w^O F_K - F_{KLO} F_{LY}}{F_K^2} \right) - 2a \Delta L^Y \frac{\partial \Delta L^Y}{\partial \Delta L^O} \]

Rearranging:

\[ \left( \frac{p^K F_{LY}}{F_K} - a \Delta L^Y \right) \frac{\partial \Delta L^Y}{\partial \Delta L^O} = -w^O - \frac{\partial \Delta K}{\partial \Delta L^O} p^K - \frac{p^K}{F_K} \Delta L^Y \left( \frac{F_{LY} w^O F_K - F_{KLO} F_{LY}}{F_K} \right) \]

Note that from the FOC \( \frac{p^K F_{LY}}{F_K} = w^Y + a \Delta L^Y \). Hence:

\[ \frac{\partial \Delta L^Y}{\partial \Delta L^O} = \left( \frac{w^O}{w^Y} + \frac{\partial \Delta K}{\partial \Delta L^O} \frac{p^K}{w^Y} + \Delta L^Y \frac{p^K}{F_K w^Y} \left( \frac{F_{LY} w^O F_K - F_{KLO} F_{LY}}{F_K} \right) \right) \]

where from the FOC \( \Delta L^Y = \frac{1}{a} \left( \frac{p^K F_{LY}}{F_K} - w^Y \right) \) so that:

\[
\frac{\partial \Delta L^Y}{\partial \Delta L^O} = \begin{cases} \frac{w^O}{w^Y} & \text{Direct Cash Effect} \\ \frac{\partial \Delta K}{\partial \Delta L^O} \frac{p^K}{w^Y} & \text{Indirect Cash Effect (Investment)} \end{cases} + \frac{F_{LY} w^O F_K}{F_K} \frac{p^K}{w^Y} \left( \frac{1}{a} \left( \frac{p^K F_{LY}}{F_K} - 1 \right) \left( 1 - \frac{F_{KLO} F_{LY}}{F_{LY} w^O F_K} \right) \right)
\]

\[
\frac{\partial \Delta L^Y}{\partial \Delta L^O} = \begin{cases} -\frac{w^O}{w^Y} & \text{Direct Cash Effect} \\ -\frac{\partial \Delta K}{\partial \Delta L^O} \frac{p^K}{w^Y} & \text{Indirect Cash Effect (Investment)} \end{cases} + \frac{\phi F_{LY} w^O}{a F_K} \left( \frac{F_{KLO} F_{LY}}{F_{LY} w^O F_K} \right)
\]

where \( \phi = \frac{p^K}{F_K} \left( 1 - \frac{p^K F_{LY}^2}{F_{LY} w^O F_K} \right) \left( 1 - \frac{F_{KLO} F_{LY}}{F_{LY} w^O F_K} \right) \)