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Abstract

When financial constraints bind, firms adjust employment in response to cash flow shocks. A 2010 revaluation of business rates, a United Kingdom tax levied on business-occupied properties, implied that similar firms, occupying similar properties in narrow geographical locations, experienced different tax changes. I find that, on average, for every £1 of additional cash flow triggered by the tax change, 39 pence were spent on employment, with small and leveraged firms responding the most. A general equilibrium model with firm heterogeneity and financial frictions rationalizes these findings, and quantitatively determines the aggregate effects of a fiscal transfer to firms.

Key words: financial frictions, employment, heterogeneous firms

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1 Introduction

The rise in unemployment following the financial crisis has underscored the importance of links between financial and labor markets. Understanding the role of financial constraints in firms' employment decisions is important not only for macroeconomic dynamics, but also to evaluate the effectiveness of policies aimed at alleviating firms' cash flow disruptions, as those implemented during the COVID-19 pandemic. Yet, while there is extensive research on household fiscal stimulus, we know much less about firms' responsiveness to fiscal policy. In particular, the link between hiring and financing constraints remains elusive, as it is complicated to identify financially constrained firms.

To overcome this issue, I use the idea that, when financial constraints bind, a firm adjusts its employment in response to cash flow shocks. I label this response the marginal propensity to hire (MPH). Consider a cash flow shock that is uncorrelated with the firm's production frontier and demand. When unconstrained, the firm is already at its optimal size and therefore its employment decisions are unaffected by the additional cash flow. When constrained, however, the firm uses the additional cash flow to hire more workers and expand its size: the MPH is positive in this case.

This paper entails two main contributions. First, I use a novel combination of three large data sets from the UK and a new source of variation to estimate how employment responds to cash flow shocks and how the MPH varies across firms. Second, I use this empirical evidence as an input to discipline a theoretical model that combines firm heterogeneity and financial frictions. The model links MPH heterogeneity to the aggregate employment effects of credit tightening and fiscal policy, showing how general equilibrium channels interact with the distributional consequences of fiscal transfers.

Although cash flows can be measured, it is difficult to come by exogenous variation. I identify cash flow shocks from changes to *business rates*, a UK tax based on a periodically estimated value of the property occupied by the firm. When re-estimating these values, properties are grouped in valuation schemes by a government agency, which then makes assumptions over the standard property in each scheme; this forms the basis of the revaluation. Hence, these hypothetical rental values will be different from the rent that may actually be paid on the property; importantly, business rates are not explicitly related to firm performance, making changes to this tax a good candidate for the identification of cash flow shocks. Estimated rental values used to compute the business rates are typically re-assessed every five years, and the infrequency of the revaluation may cause sharp changes to the tax liability.[1] Focusing on the revaluation which took place in 2010, I show that the creation of more than 60 thousand valuation schemes implied that even firms at a

[1]See, for instance, the IFS 2014 Green Budget and the article "Southwold: welcome to the town where business rates are set to rise 177%", published by The Guardian on 9 March 2017.

narrow geographical level and within similar types of properties faced very different tax bill changes. I can therefore exploit this variation while controlling for relevant confounding factors such as local demand shocks. I estimate the MPH by comparing the net hiring of similar firms, occupying similar properties, in the same geographical area, but facing different revaluations.

I construct a unique dataset that combines employment data at the establishment and firm level with balance sheet data at the firm level and tax data at the property level. Employment data is sourced from the Business Structure Database (BSD), a confidential panel that comprises the near universe of UK firms - around 2.5 million per year - from 1997 to 2016. Balance sheet data between 2006 and 2015, for around 1.5 million firms, are taken from FAME (Financial Analysis Made Easy). Finally, tax bills are calculated using information from the Valuation Office Agency (VOA), which covers 1.9 million business property valuations in England and Wales for 2005 and 2010. My dataset has several advantages. First, it allows for the identification of cash flow shocks in a very broad sample, while addressing relevant endogeneity concerns. Second, it enables me to study the role of financial constraints on employment, which has received much less attention than the vast literature on investment-cash flow sensitivity arising from Fazzari et al. (1988). Third, since the dataset encompasses the entire distribution of firms, it mainly consists of small firms, often young, and that are typically not publicly listed. Private firms may rely more heavily on external finance, as documented by Zetlin-Jones and Shourideh (2017). These features make FAME and the BSD particularly suitable for the study of financial frictions.

I estimate that, for every additional £1 of cash flow generated by the tax revaluation, on average 39 pence are spent on employment. Moreover, the MPH varies by firm characteristics: I find that employment at small and more leveraged firms is more responsive to cash flow shocks. The richness of the data allows me to address relevant endogeneity issues, such as local and idiosyncratic shocks, and anticipation. Firms' employment does not respond to future cash flow shocks and the results are not driven by the non-tradable sector, which is typically more sensitive to local demand. Results are also robust to local house prices and past cycles, and more granular geographical controls strengthen the sensitivities, suggesting that unobserved factors, if relevant, typically lead to attenuation bias. By ruling out relocations and physical changes to the property following the revaluation, I exclude the possibility that the employment response is driven by endogenous location motives or changes to the cost of capital, rather than by the cash flow channel.

A general-equilibrium heterogeneous-firm model with financial frictions rationalizes the empirical findings. Firms in the model are heterogeneous ex-post due to persistent idiosyncratic productivity and face two financial frictions. First, they cannot issue equity.[2] Second, they need to pay the wage bill in advance of production and face a working capital collateral constraint as in Jermann and Quadrini (2012). The model is rich enough to match a wide range of micro features of the data; at the same time, its tractability enables me to derive a closed-form analytical formula for the MPH. When both financial constraints bind, firms are willing to use additional cash flow to increase their future wealth. This increases their ability to take up working capital loans and thus allows them to hire more workers, implying a positive MPH. Moreover, constrained firms have a marginal product of labor that is greater than the wage, and I find that this gap is positively correlated with the MPH. The model matches the average MPH estimated in the empirical analysis, and endogenously replicates the MPH heterogeneity found in the data.

Having established that the model can rationalize the empirical evidence, I show how the MPH can be used to shed light on two macroeconomic questions: what is the employment effect of financial crises, and what are the aggregate effects of fiscal policy directed at firms? First, I theoretically show that aggregate employment is more responsive to credit tightening the larger the average MPH, all else equal. However, this aggregate sensitivity is lower if small firms are more likely to be constrained. This finding underscores the fact that evidence on both average and heterogeneous sensitivities of employment to cash flow is important to sharpen our understanding of aggregate employment dynamics.

I then use the model to tease out the general-equilibrium (GE) effects of cash transfers to firms. First, I look at the steady state effects of a uniform lump-sum transfer. Each £ of transfer translates into 77 pence of additional employment, thus implying a higher sensitivity than in partial equilibrium. Indeed, there are two GE channels, which work in opposite directions. On the one hand, the increase in labor demand pushes up wages which, ceteris paribus, further increases firms' expenditures on employment. On the other hand, the increase in wages reduces labor demand, which reduces employment expenditures. The first effect dominates. These general equilibrium effects also amplify the empirically observed MPH heterogeneity: the aggregate transfer increases employment at small firms, and reduces it at large firms. Furthermore, I find that the elasticity to fiscal policy falls with the size of the transfer. Intuitively, the larger the uniform transfer the higher the likelihood that a firm will be moved to a region with an MPH close to zero. Moreover, in line with the intuition for the effects of credit tightening, I find that economies with larger partial-equilibrium MPH display greater GE fiscal multipliers.

Fiscal transfers are often transitory and implemented during recessions, as experienced in the aftermath of the COVID-19 pandemic. During a large recession, in which aggregate

[2] In various extensions I show how both the MPH findings and the effectiveness of fiscal policy are affected by equity issuance.

TFP drops 10% unexpectedly, an empirically calibrated transfer equivalent to 3.9% of aggregate output boosts employment by 1.6% and output by 1.1% upon impact. The transfer also sustains higher aggregate output for several years out. Finally, I find that a transfer targeted at small firms is only marginally more effective in raising aggregate employment. The additional boost in the aggregate wage, via GE, implies that large firms are negatively affected by targeting, and cut employment further.

Taken together, the large partial-equilibrium MPH found in the data implies a significant GE fiscal transfer multiplier in the model. A lump-sum transfer alone, however, cannot overturn entirely the negative employment effects of a recession, since it affects only the component of firms' decisions that is cash-flow constrained. The model results also show that fiscal policy not only can have distributional impacts, further intensified by GE indirect effects, but that this heterogeneity is also important for assessing the aggregate effects of fiscal policy and financial crises.

The paper is organized as follows. In Section 2, I describe the business rates, the revaluation process and document evidence of the extent of the variation in tax changes. After describing the data in section 3, I present the main reduced-form findings, in the form of average MPH and its robustness to a wide set of confounding factors (section 4). Sections 4.3 and 4.4 investigate the response of balance sheet variables other than employment and the MPH heterogeneity in the data. The model is presented thereafter (section 5). After having shown that the model can quantitatively replicate various empirical facts on the MPH, section 6.3 relates the MPH to the aggregate effects of credit tightening, while section 6.4 deals with the macroeconomic effects of fiscal transfers to firms.

Related literature

A large body of academic work has studied the sensitivity of investment to cash flow and its relation with financial constraints. The long-standing issue faced with this literature is that cash flow may contain information on future profitability, thus driving a spurious correlation with investment.[3] Identification of exogenous shocks to internal funds is empirically difficult and often requires one to focus on very specific occurrences. In addition, while most of the empirical research has focused on investment, fewer papers have looked at employment. For instance, Bakke and Whited (2012) revisit Rauh (2006)'s identification and estimate hiring effects of pension refunding shocks. Chodorow-Reich (2014)

[3] Seminal work includes the survey by Hubbard (1998) and Kaplan and Zingales (1997).

investigates the effect of bank lending frictions on employment outcomes.[4] In my paper, I propose a new source of exogenous variation and obtain a robust estimate of the employment response to £1 of additional cash flow. In addition, I leverage a large dataset which allows me to study the response of the entire distribution of firms. This includes private, small and young firms, which are expected to be more affected by financial frictions.

My paper also fits into the vast literature that incorporates firm-level financial frictions in models of firm dynamics. In corporate finance, most of the existing research focuses on the role played by financial constraints in distorting investment decisions, as surveyed by Strebulaev and Whited (2012), while labor is typically set frictionlessly.[5] Quadrini (2011) surveys the macroeconomic literature on firm-level financial frictions; seminal and influential contributions include the financial accelerator mechanism proposed by Gertler and Gilchrist (1994) and Bernanke et al. (1999). As in Jermann and Quadrini (2012), the financial constraint considered in my model shows up as a labor wedge. As in Khan and Thomas (2013) and Buera et al. (2015), firms are heterogeneous. I combine the two elements in order to shed light on the interaction between labor and finance in the cross-section, formalize the concept of a marginal propensity to hire out of cash flow shocks, and study its theoretical and quantitative properties.

I use the model to show how empirical micro evidence on the MPH and its heterogeneity are instrumental to assess the aggregate effects of financial crises and fiscal policy. As such, the approach used in this paper is close in spirit to recent work that has highlighted the importance of household heterogeneity in the marginal propensity to consume for macroeconomic outcomes – among others, Kaplan and Violante (2014), Kaplan et al. (2018), and Auclert (2019) – and a more limited literature that adopts a conceptually similar approach in firm models (e.g., Winberry (2021) and Koby and Wolf (2020)). While there is an extensive literature on households' responses to fiscal stimulus,[6] evidence on firm behavior is more limited. Most of the literature has focused on fiscal policies related to bonus depreciation (House and Shapiro (2008) and Zwick and Mahon (2017)) or tax refunds (Dobridge (2015)). Barrot and Nanda (2018) empirically assess the employment effects of a federal reform that accelerated payments from the U.S. government to small business contractors. Autor et al. (2020), Bartik et al. (2020), Chetty et al. (2020),

[4] Bentolila et al. (2017) find that solvency problems of Spanish banks hampered job creation. Cingano et al. (2016) show a causal link between liquidity drought in interbank markets and reduction in investment and employment at Italian firms. Benmelech et al. (2015) also test for the causal effect of financial constraints on firm employment decisions looking at three quasi experiments: exploiting heterogeneity in the maturity of long-term debt, analyzing the impact of bank deregulation across the United States in the 1970s and exploiting a loan supply shock originating in Japan in the 1990s.

[5] An exception is Michaels et al. (2018), who integrate costly external finance with both labor and capital demand, and study the relationship between wages and financial leverage.

[6] For instance, Johnson et al. (2006), Parker et al. (2013), Kaplan and Violante (2014) and Lewis et al. (2019) study households' marginal propensities to consume out of tax rebates.

and Granja et al. (2020) have recently studied the employment effects of the Paycheck Protection Program implemented in the U.S. during the COVID-19 pandemic.

2 Business Rates revaluation

Each year, occupiers of business property in the UK pay a tax, the *business rates*, which is a percentage of the estimated market rental value of the property.[7] Occupiers are liable to pay the tax regardless of whether they own or rent the property. Business rates raised £26.1 billion in 2012-13, which was 4.5% of total fiscal revenues and the equivalent of two thirds of the amount raised by corporate tax. Recurrent taxes levied on business property in the UK are among the highest in the OECD.[8]

The tax liability is calculated by multiplying a percentage, called *business rates multiplier*, by the *rateable value*, which is the estimated market rental value of the property. Precisely, it is a hypothetical annual rent the property could have been let for on the open market on the reference date, on full repairing and insuring terms. Hence the rateable value will typically be different from the rent that is actually paid on the property. Every five years, the Valuation Office Agency (VOA) re-estimates the rateable values for English and Welsh properties, and this revaluation triggers the tax changes studied in this paper.[9] Multipliers are instead updated every year in line with the Retail Price Index (RPI). In revaluation years, the multiplier is adjusted so that the average bills increase in line with RPI inflation. This implies that the impact of revaluations is purely redistributive, creating winners - properties for which the tax liability falls after the revaluation - and losers - properties that experience an increase in their tax bills. Since business rates are set nationally, the revaluation is not affected by discretionary incentives of the policymaker.

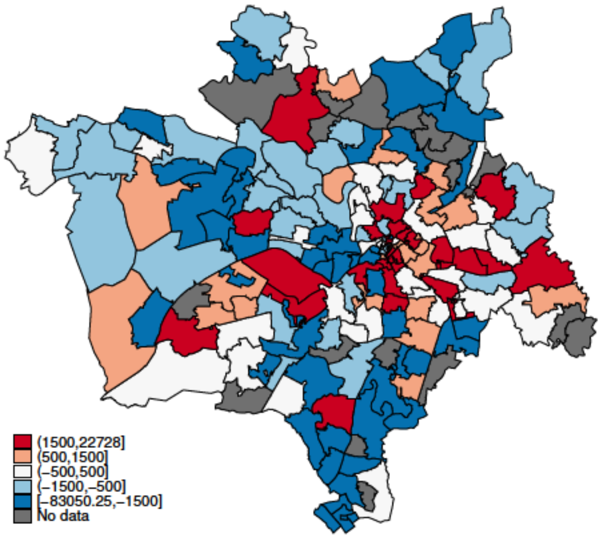
The revaluation that took effect on 1 April 2010 is the object of this study. I document a large degree of variation in tax changes even at fine local level and among similar properties. As an illustrative example, figure 1 shows the average change in the business rates liability due to the revaluation, at the postcode sector level for large offices in the Manchester area. Although there is some spatial correlation across postcode sectors, it is not uncommon to observe neighboring areas with very different average tax changes. Moreover, tax changes vary significantly even at narrower geographical level. For each postcode sector in England and Wales, I compute the standard deviation of tax changes for large offices. The average standard deviation is £8,150 (12% in growth terms) and the

[7] Business rates is the common denomination for non-domestic rates. This study uses data for England and Wales. Business rates are also levied in Scotland and Northern Ireland, but they are handled differently.

[8] OECD data on receipts from recurrent taxes on immovable property, levied on non-households, as a share of national income in 2011. Data is not available for a small set of countries as US, Japan and Italy.

[9] The 2015 revaluation was delayed by two years and took place in 2017.

Figure 1: Business rates revaluation: £ change in tax liability for large offices in Manchester



Notes: Maps plot postcode sectors (e.g.: M1 1). In 2014, there were approximately 12,381 postcode sectors in the UK. Sample of offices in postcode area M, whose size is above the 75th of offices distribution (i.e.: 178 m^2). Properties undergoing material change of circumstances before 2012 are excluded, as well as properties without a valuation scheme and whose 2005 rating list has been altered after 2010. Additional maps shown in Appendix B.

average range £29,771 (32%).[10]

What is the source of this large variation? To answer this question, it is useful to present the 2010 revaluation process in more detail. The VOA collected rent information from business tenants and used this to estimate the rateable values, defined as a reasonable rent as of 1 April 2008, under full repairing and insurance terms. Similar properties in an area were grouped together in a valuation scheme; within each scheme, the VOA made assumptions about the standard property, which formed the basis for the valuation of each property in the scheme. Finally, each rateable value was adjusted to account for idiosyncratic differences within the scheme.[11] Hence the source of variation is twofold: it is partly due to the assignment to different valuation schemes, and partly down to property-specific differences within each scheme.

The creation of 60,022 valuation schemes introduced many discontinuities and the large local variation in tax changes shown in the data. More than half of these schemes were smaller than three postcode units or no bigger than one postcode sector, which is typically equivalent to a portion of a street or a few blocks.[12] It is not very plausible, therefore, that there are important local demand shocks that are unique to valuation areas.

[10]On average there are 10 large offices in a postcode sector (median is 4). The average standard deviation increases to £12,763, and the range to £64,960, when looking at postcode sectors with at least 10 properties.

[11]For example a property without air conditioning belonging to a scheme which assumes it.

[12]A postcode unit consists, on average, of 15 properties - either residential or non-domestic. On average, a valuation scheme is found to contain 4 postcode sectors.

In addition, the VOA does not hold rent information for all properties, hence it might happen that reported rents drive the representative rateable value of an area away from firms' fundamentals.[13] The rental evidence used to create the valuation schemes and the details of the process are not disclosed, mainly given their confidential nature. As a result, taxpayers are left with little or no explanation to assess the correctness of their rateable value, as suggested by work by the Department for Communities and Local Government.[14] This also suggests that firms find it very hard to anticipate the cash flow shock induced by the revaluation. Finally, the infrequency of the revaluation and the fact that it is based on an antecedent date – two years before the tax change takes place – further disconnects rateable values from current firms' fundamentals.[15]

The features of the revaluation and the fact that similar properties in the same geographical area experienced different tax changes make the latter a good candidate for the identification of plausibly exogenous cash flow shocks. Most importantly, this relies on the fact that business rates "bear little or no relation to (firms') turnover, profits or ability to pay. Instead, it is arbitrarily based upon notional property values."[16] Section 4 discusses the identification assumptions in detail.

3 Data

I construct a unique dataset that combines employment data at the establishment and firm level with business rates tax data at the property level and balance sheet data at the firm level. The employment data are provided by the Office for National Statistics (ONS) Business Structure Database (BSD). This dataset contains a small number of variables for almost all business organizations in the UK. It consists of a series of annual snapshots, taken around April, of the Inter-Departmental Business Register (IDBR). The IDBR is a live register of data collected via administrative records. I combine them in a longitudinal panel of establishments and firms for the years 1997-2016. The tax data comes from the Valuation Office Agency and contains nearly all - 1.9 million - business property

[13]The property consulting Ramidus presents the case study of a business in Cambridge Circus, central London. In a parade of six shops, five paid a rent around £30,000 while one £50,000 on a short lease. The VOA used the top rent as the valuation reference. The business owner says: "Our Armaggedon was the 2010 revaluation, when our valuation went from £21,000 to £53,000. [...] The one across the road can get a high rent and we get the increase (in rates). The ultimate result is that I will cut back on staff." (source: "The Business Rates Revaluation in London", 2017).

[14]"The Government's proposals to improve transparency in the business rates valuation and formal challenge system", December 2013.

[15]Dentons, the world's largest law firm, commented that commercial property rents fluctuate constantly while business rates are slow to respond, "creating unrealistic rateable values" (source: "Rating – the road to revaluation: Reform", Lexology, March 30 2017).

[16]Source: "Business Rates - an Unfair System", 16 February 2017, Federation of Small Businesses.

valuations in England and Wales for the 2005 and 2010 rating lists, linked by a property identifier.[17] It contains details of the location and rateable values of each property, as well as property characteristics and the valuation scheme numbers as contained in the Summary Valuation (SMV) files. Balance sheet and income statement data are taken from FAME (Financial Analysis Made Easy), as provided by the Bureau van Dijk. I consider a panel of roughly 1.2 million UK firms, for the years 2006 - 2014, which can be merged with the BSD data. This is a much broader sample than other alternatives often used in literature, as it is not limited to publicly listed firms, as US Compustat, but it mainly contains private limited companies (96% of the sample). Indeed, the UK Companies House requires all incorporated companies to disclose balance sheet information. Appendix A.1 provides extensive information on each data source and the details of the dataset creation.

The main bulk of the analysis uses information from the first two datasets. Tax data at the property level is matched with BSD establishment data; given the confidential nature of the BSD data, business rates unique addresses cannot be used. Hence, I merge the datasets using postcode unit information and create a mapping between establishment-level industry codes and property type. In the UK, a postcode unit is typically very small, generally representing a street, part of a street or even a single property. There are approximately 1.75 million postcodes in the United Kingdom according to the ONS. I keep the establishments that remain active between 2009 and 2011 and do not change location. I am able to match 174,726 establishments with the properties they occupy; this is associated with 135,139 firms. This matching strategy allows me to evaluate firms' responses to *a change in the tax liability they actually face*. On the other hand, it leaves out the establishments that cannot be uniquely matched to their properties. For instance, if in the same postcode unit there is more than one shop and more than one establishment in the retail or wholesale sector. Appendix A.4 shows that the estimated coefficients are qualitatively similar to the benchmark estimates when averaging over postcodes-industry-property type groups.

Appendix A.1 describes the sampling strategy in detail. I exclude the properties incurring physical changes after the revaluation and before 2012, given that firms have the possibility to reduce their tax bill by changing the features of the property and then reporting a material change of circumstances to the Valuation Office Agency.[18] This may imply a change in employment due to the complementarity with fixed assets and follow-

[17] This allows me to construct only one tax change. Extending the dataset over time, thus incorporating information on revaluations at different years, would help significantly the identification of the MPH and its heterogeneity, besides the features of the MPH distribution. This data, however, is currently unavailable.

[18] Material change of circumstances typically involve matters affecting the physical state or physical enjoyment of the hereditament and the category of occupation of hereditament (Rating Manual Volume 2 Section 5). While potentially still working through the balance sheet, the cash flow shock may depend on the marginal product of capital and driven by other reasons such as endogenous location choices.

ing a response to a change in the user cost of capital; since, instead, I am interested in the balance sheet channel of cash flow shocks, I exclude this possibility. Tax increases may also make firms unprofitable and prompt them to exit or relocate. I find that business rates revaluations mildly increase the share of establishments relocating or exiting in a given postcode unit, but the relationship is statistically insignificant. Overall, it is reasonable to expect that the employment to cash flow sensitivity estimated in this paper is a conservative measure of the overall effect of business rates revaluations. Finally, I drop the construction sector, because of its specific nature when it comes to a property tax. After these sample selections, the dataset contains 82,506 establishment-tax observations.

4 Empirical strategy

The empirical strategy aims at estimating the effect of cash flow shocks induced by the business rates revaluation on firms' employment decisions. I consider the following benchmark specification for a firm i, in the industry sector k occupying a property j in the geographical area m:

$$\Delta_{2009,11}E_{i,k,j,m} = \alpha + \beta\Delta_{2009,10}T_j + \gamma x_{i,2008} + \theta z_{j,2008} + \mu_{k,2008} + P_m + \varepsilon_{i,k,j,m} \tag{1}$$

where the outcome variable $\Delta_{2009,11}E_{i,k,j,m}$ is the change in employment at the firm i between 2009 and 2011 and $\Delta_{2009,10}T_j$ is the £ change in the tax liability at the property j, induced by the business rates revaluation in 2010. Both variables are rescaled by past sales as explained in the following section. The dependent variable is rescaled by a median wage, as explained later, to reinterpret β as a pound-for-pound MPH. Firms may have multiple establishments and thus occupy multiple properties. In order to directly exploit property and geographic characteristics used for identification, for each firm i I retain the property j associated with the largest tax change (in absolute value). In appendix A.3 I show that the results are robust to different specifications for multiple-establishment firms, also because 86% of firms in the sample have only one establishment. x, z, μ and P are sets of firm, property, industry and geographical controls, respectively, which are discussed below.[19]

I identify the effects of cash flow shocks on employment changes by comparing similar firms, occupying similar properties, in the same geographical area. The coefficient of interest is β. Identification hinges on the fact that there is neither an omitted vari-

[19] All controls are measured before the tax change takes place. Property features may be different before and after the revaluation; moreover, firms may change industry. Section 4.2 looks specifically at these cases.

able simultaneously affecting the business rates and employment, nor reverse causality. There are three main possible confounding factors that could affect identification. First, there could be local shocks that simultaneously affect employment and the business rates. Second, shocks idiosyncratic to the firm may affect employment and - via physical improvements - the estimated rateable value of the property. Finally, cash flow changes induced by the revaluation may be anticipated. I now discuss how different controls are aimed at addressing these issues.

The inclusion of postcode area dummies P_m for the location of the property is motivated by the attempt to control for local shocks and anticipation. Being based on rental evidence, tax changes vary across geographical areas. I consider geographical units for which it is reasonable to think that a firm may be aware of the trends in rents and anticipate at least part of the tax change. The benchmark specification therefore includes postcode area dummies. A postcode area is formed by the initial characters of the alphanumeric UK postcode. For instance, the postcode area N stands for North London. In 2014 there were 124 postcode areas in the UK (source: ONS). Standard errors are clustered at this level. I also consider more granular specifications at the postcode district level.[20]

Industry-specific shocks may simultaneously affect tax changes and employment. While business rates in levels could be correlated with firm industry through real estate intensity, it is less clear ex ante how business rates revaluations could reflect industry-specific shocks. A certain industry may have, for instance, experienced a boom which boosted employment and the rents of properties typically used in that industry, thus in turn implying a tax increase upon revaluation. This may lead to attenuation bias if the shock and its effects are persistent, or may inflate the MPH if there is systematic mean reversion, as extensively discussed later. To block this possible channel, I control for firm-level industry dummies $\mu_{k,2008}$ defined at the section level of UK SIC 2007 codes.[21]

Finally, I introduce firm controls measured in 2008 and property controls before the revaluation. Property controls consist of property type, the tax bill in 2008 and the property size measured in square meters. I define three dummies for the property type: whether a property is an office, a shop or a factory/warehouse.[22] These dummies play a similar role

[20] A postcode district typically identifies a town and the surrounding villages (e.g.: BA6 for the area of Glastonbury), most part of a bigger city (e.g.: GL1 for the centre of Gloucester, a city with a population of around 130,000 people) or part of a local authority/borough in London (e.g.: N3 for Barnet). In 2014 there were 3,114 postcode districts in the UK according to the ONS.

[21] Examples of section levels are manufacturing, education, information and communication. There are 18 sector sections in the sample. Results are robust to a finer industry classification, using divisions.

[22] I construct these dummies by pooling together similar categories, which are by far the most recurrent and represent almost half of the sample. Sometimes a valuation scheme pools different property types together; hence adding these dummies may be "controlling away" some of the effects I am trying to estimate. In unreported results, I show that the estimation results are robust to a broader definition of shops, such that 60% of the properties in the sample are assigned to one of the three property types. Similarly, the MPH coefficient is slightly lower but still significant at 1% if we control for all categories as defined by the VOA.

Table 1: The average MPH

	$\Delta_{2009,11}Emp$				
	(I)	(II)	(III)	(IV)	(V)
$\Delta_{2009,10}T$	-0.34^{***}	-0.40^{***}	-0.39^{***}	-0.36^{***}	-0.41^{***}
	(0.10)	(0.11)	(0.11)	(0.11)	(0.16)
Postcode area FE	✓	✓	✓		
Industry dummies		✓	✓		
Firm controls			✓	✓	✓
Property controls			✓	✓	✓
Postcode area x industry FE				✓	
Postcode district x industry FE					✓
Observations	63,242	63,242	63,242	63,242	63,242
R^2	0.00	0.01	0.01	0.02	0.03

Note: $\Delta_{2009,11}Emp$ is the change in the number of employees at firm i, rescaled as explained in the text. $\Delta_{2009,10}T$ is the scaled tax change as explained in the text. Industry dummies are measured in 2008, at the firm-level, and defined at the section level of UK SIC 2007 codes. Firm controls include firm i number of employees in 2008 and the inverse of average sales between 2007 and 2008. Given the timing of the data, it should be noted that I define firm sales in 2008 as the value reported in the business register in April 2008, hence typically referring to the financial year 2007-2008. Property controls consist of the size of the property measured in m^2, the business rates liability in 2008, industry dummies at the establishment level and dummies for whether the property is a factory/warehouse, a shop or an office. Interacting industry dummies at the establishment-level, instead of firm-level, in column (IV) and (V) delivers the same results. Standard errors (in parentheses) are clustered at the postcode area level, except for column (V) in which they are clustered at the postcode district level. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

to industry dummies. Moreover, they control for the possibility that firms partly anticipate the tax change by having information on rent trends for specific types of properties. I complement these dummies with a set of industry dummies before the revaluation at the establishment level.[23] The size of the property and the tax bill may correlate with the size of the tax change. Since identification exploits both the sign and the size of the tax change, it seems sensible to control for these features. The same applies to firm pre-determined characteristics, namely the inverse of average sales of firm i in 2007 and 2008 and the number of firm employees in 2008. Moreover, controlling for firm size helps addressing the concern that the ability to predict the tax change may correlate with firm characteristics, with different anticipation effects and a possible threat to correct identification.[24]

4.1 The average MPH

Table 1 shows the employment effects of the changes in the business rates liability induced by the 2010 revaluation. The explanatory variable of interest, $\Delta_{2009,10}T_{j,m}$, is the difference in tax bill to be paid at the property j before and after the revaluation. The tax

[23]These may differ from firm-level industry dummies only for firms with multiple establishments. Their inclusion leaves the MPH coefficient basically unchanged.

[24]Results are unchanged when considering nonlinear functions of firm employees such as logs and second order polynomial.

bill is obtained by multiplying the multiplier (tax rate) for the specific year by the rateable value estimated by the VOA in that year. After the 2010 revaluation, a transitional relief was introduced in England, aimed at phasing in sharp changes in the tax bills. Tax shocks calculated here are before any relief: appendix A.2 deals extensively with this. The tax change is scaled by firm i average sales in 2007 and 2008, to improve comparability across firms.[25] The dependent variable is the level change in employment at the firm i between 2009 and 2011. I multiply this by a single, constant wage, and divide it by firm i average sales in 2007 and 2008. This rescaling allows me to express the MPH coefficient β as the negative of the pound-for-pound sensitivity of employment to the cash flow changes induced by business revaluation in 2010. The effect still stems from the employment response, but it is measured in wage-equivalent bodies. For the rescaling, I use the median gross annual earning of all employees in 2010, as recorded by the Annual Survey of Hours and Earnings;[26] this amounts to £21,024. The 2009-2011 horizon for employment changes is chosen due to the timeline of the revaluation. Draft revaluations were made public on 30 September 2009, while becoming effective on the 1st April 2010. BSD employment data is a snapshot of the business register as at April each year.

The estimated MPH is fairly insensitive to the inclusion of different sets of controls. Column (III) suggests that, for every £1 of additional cash flow, 39 pence are spent on employment. This sensitivity increases slightly as we control for a narrower geographical area, the postcode district, interacted with the industry dummies. This tighter specification controls for local shocks specific to an industry in a narrow geographical area, which might have simultaneously affected firms' employment and the estimated rateable values. Those shocks are likely to simultaneously increase the business rates and employment changes, thus biasing the MPH towards zero. This interpretation is confirmed by the increase in the coefficient when considering more granular localities. The same is true when estimating responses via spatial differencing, as in Appendix A.5 and A.6.

In Appendix A.2, I also express the results in terms of semi-elasticity. A revaluation that increases the tax bill by 1 percentage point of firm sales reduces employment at the firm, on average, by 0.72 percent.

[25] Results are robust to rescaling by either year.

[26] See Appendix A.1 for more details. While being convenient in terms of interpretation, a single wage masks a good deal of heterogeneity, which may affect the MPH. For instance, the fact that small firms typically pay lower wages and employ more part-time employees (ASHE 2016) may lead to the overestimation of the MPH. For this reason, the estimated coefficient should be referred to employment changes only, and the wage transformation only as a way to express those changes in £ terms.

4.2 Endogeneity, anticipation and local demand

The correct estimation of the MPH crucially depends on the extent to which the identification assumptions are violated. In this section I explore this issue in greater detail, show the robustness of the results and argue that possible endogeneity issues, if present, should bias the MPH to zero.

I start by testing whether past employment responds to future cash flow shocks as a direct check for reverse causality problems and anticipation effects. In Column (I) of Table 2 I re-estimate equation (1), using as the dependent variable employment changes prior to the tax change, precisely between 2007 and 2009. The estimated sensitivity is small and insignificantly different from zero. The same result holds if considering different time periods before 2009, or estimating a fixed-effects panel regression, and thus provides empirical support for the identification assumptions. First, it alleviates the concern that the estimated MPH is affected by reverse causality: that would be the case, for instance, if cash flow shocks were systematically induced by physical improvements to the property, also correlated with employment changes. Second, the placebo test suggests that there are no significant local shocks simultaneously affecting employment and the revaluation shocks, which would make the research design invalid. This is particularly relevant considered the fact that rateable values are re-estimated using rental evidence measured in 2008, two years before the tax actually changes, as I discuss later. Finally, the insignificance of pre-treatment responses downplays the role of anticipation effects. In appendix A.9, I also show that firms' do not adjust other variables ahead of the tax change. In particular, past capital investment does not significantly respond to future cash flow shocks. Moreover, firms' adjustment in cash holdings before the revaluation is not significantly correlated with the realized shock, further alleviating the concern related to potential anticipation effects.

I next consider additional robustness checks addressed at specific endogeneity issues. To further check for the possibility that local demand shocks confound the estimates, I test whether the non-tradable sector responds in a systematically different way to tax changes. In the spirit of Mian and Sufi (2014) and Giroud and Mueller (2017), I isolate the MPH of the non-tradable sector, by interacting the tax shock with a non-tradable sector dummy. In contrast to a possible downward bias from local demand, non-tradable firms display an even greater MPH, although not significant, as shown in Column (II) of Table 2. There may clearly be other reasons behind this finding; for instance, firms in the non-tradable sector may have, on average, a different balance sheet structure. As shown in column (III), the results are also unchanged if excluding shops as defined at the property level.

As revaluations are based on estimated rental changes between 2003 and 2008, it could be argued that any omitted firm-level or regional change over the same period may

Table 2: Anticipation, local demand and mean reversion

	$\Delta_{2007,09}Emp$	$\Delta_{2009,11}Emp$			
	(I)	(II)	(III)	(IV)	(V)
$\Delta_{2009,10}T$	0.09	-0.34^{***}	-0.41^{***}	-0.36^{***}	-0.42^{***}
	(0.17)	(0.12)	(0.11)	(0.11)	(0.15)
$\Delta_{2009,10}T$ x (Non-tradable)		-0.25			
		(0.30)			
Non-tradable		0.001			
		(0.002)			
$\Delta_{2007,09}Emp$ x $\Delta_{2009,10}T$				-0.31	
				(0.78)	
$\Delta_{2007,09}Emp$				-0.06^{***}	
				(0.01)	
$\Delta_{2003,08}Emp$ x $\Delta_{2009,10}T$					0.60
					(0.60)
$\Delta_{2003,08}Emp$					-0.03^{***}
					(0.01)
No shops			✓		
Observations	58,252	63,242	55,592	58,252	44,555
R^2	0.01	0.01	0.01	0.01	0.01

Note: Same notes and controls of column (III) of Table 1 apply besides those explicitly mentioned. $\Delta_{2007,09}Emp$ is also rescaled as in Table 1. Non-tradable sector comprises establishments in the food service activities (SIC codes 56101-56302) and retail sector (SIC codes 47110-47990). Different sample sizes are due to the fact that some firms are born in 2008. Standard errors (in parentheses) are clustered at the postcode area level. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

be correlated with the tax change and bias the MPH estimates. I find that this bias is likely small and, if present, attenuates the MPH towards zero. First, I consider firm-level employment changes. Following Giroud and Mueller (2017), in column (IV) I explicitly control for 2007-09 employment growth, as well as its interaction with the tax shock, and in column (V) I repeat the analysis for changes between 2003 and 2008. The MPH is very similar and even slightly higher in the last column. Hence, these results dismiss the concern that the estimated effects are due to systematic mean reversion, by which positive employment growth before 2008 would inflate tax liabilities and then spuriously manifest in a subsequent drop in employment. Controlling for $\Delta_{2003,08}Emp$ also leaves the placebo test of column (I) roughly unchanged. Second, I show in appendix A.7 that the results are robust to controlling for local house price growth between 2003 and 2008.[27] Third, I look at other possible idiosyncratic shocks that may affect firm employment and - via physical improvements - the tax change through the estimated rateable value. Column

[27]Local data on rents are not available at higher granularity than the area dummies included in the specification. Appendix A.10 discusses the incidence of the business rates and attempts at identifying differences in responses between renters and owners using balance sheet data.

Table 3: Idiosyncratic shocks

	$\Delta_{2009,11}Emp$	
	(I)	(II)
$\Delta_{2009,10}T$	-0.40^{***}	-0.39^{***}
	(0.12)	(0.11)
Industry change dummy		-0.008**
		(0.003)
Property type change dummy		-0.005
		(0.004)
Increase in m^2 dummy		0.001
		(0.002)
Property size unchanged	✓	
Observations	53,444	63,242
R^2	0.01	0.01

Note: Same notes and controls of column (III) of Table 1 apply besides those explicitly mentioned. Standard errors (in parentheses) are clustered at the postcode area level. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

(I) of Table 3 restricts the sample to the cases in which the size of a property, measured in square meters, is the same before and after the revaluation. The estimated MPH is unchanged, further limiting the concerns about idiosyncratic shocks and anticipation. In column (II), I explicitly control for property-specific changes around the revaluation. In particular, I augment specification (1) by including three additional controls: a dummy that takes 1 if the firm changed industry between 2008 and 2010, another dummy taking 1 for changes to the property type before and after the revaluation and a third dummy taking 1 when the post-revaluation property size is larger than before. None of these events affects the employment response to the cash flow shock.

The data allow me to control for observable property characteristics. Although unobservable features, like quality, may drive part of the tax change, it is unlikely that this can systematically bias the relationship between employment and tax changes.[28]

4.3 Balance sheet responses

I now examine how firms' balance sheets and other key variables are affected by cash flow shocks induced by the business rates revaluations. I match the BSD-VOA sample used in

[28] A business occupying a property without air conditioning, for example, may anticipate to be included in a valuation scheme that assumes air conditioning for the representative property. This seems to be beyond the firm capabilities, however, especially given the absence of underlying rental information. In the same way, it is hard to think about a mechanism by which a business adds air conditioning to its property, this translates into an increase in the tax bill, and then reverberates into a negative change in employment through a channel different than the tax change.

the previous section with the FAME dataset. Since balance sheet reporting requirements depend on the legal status of the firm and its features, I am able to match roughly half of the sample. Appendix A.8 describes the FAME dataset in detail.[29]

Balance sheet data can be used to estimate the response of firm variables other than employment to cash flow shocks, which are shown in Table 4. Column (I) shows the pound-for-pound sensitivity of employment to tax shocks, as estimated previously, for the restricted balance sheet sample. The coefficient is of similar magnitude and significance.

I then estimate equation (1) for different outcome variables related to the balance sheet of the firms. The response of investment to cash flow shocks has been the object of a very extensive literature, since the seminal contributions of Fazzari et al. (1988) and Kaplan and Zingales (1997). In order to have the largest possible sample, I define investment as the difference in fixed assets plus depreciation, when the latter is reported. To be in line with earlier analysis for employment, the time frame is 2009-11.

The estimated coefficient suggests that business rates revaluations that increase the firm tax liability imply a reduction in capital investment, although insignificantly different from zero. To be more in line with the existing literature on investment - cash flow sensitivity, column (III) uses as a dependent variable capital investment between 2009 and 2011 net of capital investment between 2006 and 2008. The estimated coefficient is still negative and insignificant. In terms of magnitude, it suggests that for every additional £1 of cash flow, 47 pence transmit into additional investment. This is within the range of sensitivities typically estimated in the literature.[30] Many reasons may lie behind the insignificant response of investment. Among others, the sampling strategy, which excludes material change of circumstances, strongly restricts the response of investment that accrues to property and plant. Furthermore, constructing investment from fixed assets makes it noisier than if capital expenditures were directly available. Moreover, the majority of the firms in the sample are small and own little if no fixed capital.

Finally, it seems that firms act as financially constrained and reduce their debt when faced with an increase in the tax liability. Column (IV) suggests that firms borrow 53 pence more for every £1 of additional cash flow, although the coefficient is insignificantly different from 0. Such response could be the result of adjustments to production inputs; for instance, a binding financial constraint may prevent firms to absorb the tax hike by raising their leverage ratio, and thus force them to reduce their stock of debt. Column (V) looks at the response of net debt, defined as debt minus firm cash holdings. The estimated

[29]While the UK Data service was able to match 80% of BSD firms to FAME, I further restrict the sample to exclude company types whose balance sheets might not be reliable due to reporting requirements. Incidentally, this effectively serves as an additional robustness check to the exclusion of sole proprietors.

[30]Rauh (2006), for instance, estimates a 0.65 dollar-for-dollar sensitivity of investment to cash flow, using mandatory defined-benefit pension refunding shocks.

Table 4: Balance sheet responses

	$\Delta_{2009,11}Emp$	$I_{2009-11}$	$I_{2009-11}-I_{2006-08}$	$\Delta_{2009,11}Debt$	$\Delta_{2009,11}NetDebt$
	(I)	(II)	(III)	(IV)	(V)
$\Delta_{2009,10}T$	-0.40^{**}	-0.24	-0.47	-0.53	-0.57
	(0.18)	(0.26)	(0.42)	(0.34)	(0.41)
Observations	24,646	24,646	19,771	24,609	24,609
R^2	0.02	0.02	0.01	0.01	0.01

Note: $I_{a-(a+k)}$ is fixed assets in $a+k$ minus fixed assets in a plus depreciation in $a+k$, when reported. Debt is current liabilities plus long-term debt. Appendix A.8 describes the variable creation in detail, especially in relation with balance sheet reporting requirements. All dependent variables are rescaled by past sales. Standard errors (in parentheses) are clustered at the postcode area level. Same notes and controls of column (III) of Table 1 apply. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

propensity is slightly greater, although still insignificant.[31]

4.4 MPH heterogeneity

How does the MPH vary across firms? The model in section 5 will formalize the link between MPH and financial constraints, and its resulting heterogeneity by firm characteristics. The richness of the data, however, also allows me to test whether firm features associated with financial constraints in the literature are associated with stronger employment sensitivity. Table 5 decomposes the coefficients by a set of proxies.

Small firms appear to be the main determinant of the estimated MPH. In column (I) firms have been grouped according to their number of employees in 2008, defining small firms as those with less than 25 employees. When interacting the tax shock by a firm age dummy, the difference is less stark; young firms (5 years of age or less) display the same MPH as old firms. Employment at productive firms, classified as those whose sales-employment ratio in 2008 was above median, responds more to tax shocks.

Finally, more leveraged firms display a greater MPH on average. Column (IV) classifies as leveraged the firms whose total debt to total assets ratio before the tax revaluation was above the cross-sectional median of the sample. In column (V) I show that if we net leverage ratio with cash holdings, the difference in MPH among groups is even more pronounced. This finding suggests the importance of firms' liquid assets in assessing the link between financial constraints and employment. Melcangi (2019) shows that cash-intensive firms in the UK cut their workforces by less during the Great Recession.

In unreported findings, I further interact firms' characteristics and find that firms' size and financial position both matter for the employment to cash–flow sensitivity. Indeed,

[31] In unreported results I find that firms hoard slightly more cash when faced with a tax hike, although the coefficient is insignificantly different from 0.

Table 5: MPH heterogeneity in the data

	$\Delta_{2009,11}Emp$				
	A = Size	A = Age	A = Labor productivity	A = Leverage ratio	A = Net leverage ratio
Samples:	Whole	Whole	Whole	FAME	FAME
	(I)	(II)	(III)	(IV)	(V)
$\Delta_{2009,10}T$ x $(A \leq \underline{A})$	-0.42^{***}	-0.40^{**}	-0.38^{**}	-0.32	-0.16
	(0.11)	(0.16)	(0.14)	(0.26)	(0.23)
$\Delta_{2009,10}T$ x $(A > \underline{A})$	1.24	-0.38^{**}	-0.52^{***}	-0.46^{**}	-0.64^{**}
	(0.82)	(0.14)	(0.14)	(0.26)	(0.25)
$(A \leq \underline{A})$	-0.001	-0.001	-0.02^{***}	0.002	0.003
	(0.002)	(0.002)	(0.01)	(0.002)	(0.002)
Observations	63,242	63,242	63,242	24,633	24,633
R^2	0.01	0.01	0.01	0.02	0.02

Note: Standard errors (in parentheses) are clustered at the postcode area level. Same notes and controls of column (III) of Table 1 apply. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. Size is the number of firm i employees in 2008; the cutoff $\underline{A}$ is 25 employees. Small firms are 87% of the whole sample. Age is the firm age in 2008. The cutoff is 5 years of age; 26% of firms are classified as young in the whole sample. Labor productivity is the ratio between firm sales in 2008 and the number of employees at the firm in 2008. The cutoff is the median in the whole sample, which is roughly £66,000 per employee. Median values have been rounded to the nearest hundred to avoid disclosure issues. Leverage ratio is the ratio of total debt (current liabilities and long-term debt) over total assets. I consider the firm average leverage ratio between 2007 and 2008. The cutoff is the median, 0.60. Net leverage ratio is the ratio of total debt (current liabilities and long-term debt) net of cash over total assets. I consider the firm average net leverage ratio between 2007 and 2008. The cutoff is the median, 0.395.

small *and* more net leveraged firms display the greatest MPH.

The ex-ante classification of firms by financial constraint proxies has been the object of controversy in the literature, as discussed, among others, by Farre-Mensa and Ljungqvist (2016). The findings shown in table 5 suggest that small firms are more affected by financial frictions. Gertler and Gilchrist (1994) proposed size as a proxy for financial constraints, motivated by the fact that small firms exhibit a higher degree of idiosyncratic risk and are more bank-dependent. Since then, the literature has debated over the differential tightness of financial constraints by firm size, and the resulting sensitivity of small and large firms over the business cycle. Recent work on this include Crouzet and Mehrotra (2020). The MPH heterogeneity also suggests that balance sheet positions may be related to the endogenous tightness of financial constraints. My findings echo Giroud and Mueller (2017), who find that more leveraged firms displayed a greater sensitivity to consumer demand in the Great Recession. Differently from demand shocks, however, only financially constrained firms should respond to cash flow shocks. The structural model presented in the next section formally shows this, linking the MPH with financial constraints and endogenously reproducing the heterogeneity observed in the data.

5 The model

The empirical findings presented in the previous sections motivate a model of firm dynamics in which financial constraints affect hiring decisions directly. In this section I propose a model that combines a working capital collateral constraint, as in Jermann and Quadrini (2012), with firm heterogeneity. The model is tractable enough to derive an analytical form for the MPH; at the same time, it generates rich cross-sectional dynamics that are consistent with the empirical findings. I start by describing the firms' problem, and then turn to households and the equilibrium.

5.1 The firm problem

The economy is populated by a large number of firms, each using pre-determined capital stock k and labor n to produce a final good. Each firm operates a decreasing returns to scale production function and produces output y according to:

$$y_t = z_{j,t} k_t^{\nu} n_t^{\alpha} \quad , \nu + \alpha < 1 \tag{2}$$

where $z_{j,t}$ is a stochastic and persistent idiosyncratic productivity that follows a Markov chain: $z \in Z \equiv z_1, .., z_{N_z}$, with $Pr(z_{t+1} = z_i | z_t = z_j) = \pi^z_{ji} \geq 0$ and $\sum_{i=1}^{N_z} \pi^z_{ji} = 1$. Capital k_t is chosen at time $t-1$ while labor n_t can be flexibly changed at time t. Capital evolves according to $k_{t+1} = (1-\delta_k)k_t + i_t$ where i_t is investment and δ_k is the depreciation rate. Each firm can also invest in a financial asset. When b is positive, the firm is borrowing, at an interest rate r. When b is negative, the firm is saving and the asset earns an interest income $r(1-\upsilon)$. This tax penalty of savings ensures that currently unconstrained firms distribute positive dividends even when attaching a positive probability to be constrained in the future.[32] Firms discount the future at the stochastic discount factor Λ_t. The firm distributes dividends d_t to their shareholders and cannot issue equity: hence $d_t \geq 0$. While this is certainly a stringent assumption, it helps to match the average MPH estimated in the data. Moreover, it ensures it is possible to derive a closed-form analytical formula for the marginal propensity to hire. In section 6.2 Appendix E.1 I show that the properties of the model are qualitatively preserved as long as equity issuance remains costly.

Finally, the firm pays a lump-sum tax τ_t. I normalize this tax to 0. In the following section I will define the MPH as marginal changes in employment that stem from marginal changes in τ_t. While business rates may depend on firm's capital, the revaluation changes considered in the empirical analysis are effectively akin lump-sum cash flow shocks, espe-

[32] A tax penalty is commonly used in corporate finance literature (e.g.: Riddick and Whited (2009)). Section 6.1 deals with the quantitative relevance of this assumption. Most importantly, the average MPH is not affected: υ limits net financial savings of firms paying dividends, whose MPH is 0 anyway.

cially given the sample selection that excludes relocations and establishment closures. By modeling the MPH this way, I can generalize its implications to a generic cash flow shock and, more broadly, relate them to the link between financial constraints and employment.

The firm budget constraint reads as follows:

$$y_t - w_t n_t - \tau_t - i_t + b_{t+1} - R(b_t)b_t = d_t \tag{3}$$

Where $R(b_t) = \begin{cases} 1+r & \text{if } b_t > 0 \\ 1+r(1-\upsilon) & \text{if } b_t \leq 0 \end{cases}$.

The focus of the model is on understanding how financial frictions affect firms' employment decisions. In order to limit the possibility that firms accumulate sufficient resources such that the enforcement constraint is never binding, I follow Khan and Thomas (2013) and assume that each firm faces a constant probability π^e of being forced to exit the economy in any given period. The timing goes as follows. A firm starts a period with pre-determined capital stock k_t, inter-temporal debt b_t it incurred in the previous period and its current idiosyncratic productivity level $z_{j,t}$. The firm learns immediately whether it will survive to the following period.

I will start by focusing on the firms that survive to the following period. Following Jermann and Quadrini (2012), I assume that there is a cash flow mismatch between payments made at the beginning of the period and the realization of revenues. In particular, I assume that the wage bill needs to be financed in advance of production, so that worker compensation is financed by intra-period loans, such that $l_t = w_t n_t$. I assume that the firm does not pay any interest on these loans. Before producing, a firm chooses labor n_t, investment i_t, dividend payment d_t and the new inter-temporal debt b_{t+1}. At the end of the period revenues are realized, the firm pays investment, the lump-sum tax, dividend payout and the debt liabilities $R(b_t)b_t$. Before repaying the intra-period loan l_t, the firm decides whether it wants to default or not.

Since firms can default on their obligations, their ability to borrow is bounded by the limited enforceability of debt contracts. I follow Jermann and Quadrini (2012) and assume that, at the time of contracting the loan, the recovery value of capital is uncertain. In case of default, the lender may be able to recover the full value k_{t+1} with probability ϕ, while with the complement probability the lender recovers nothing from the borrower. Appendix C describes how we can derive the following enforcement constraint based on the predicted outcome of renegotiation between the firm and the lender in case of default:

$$l_t \leq \phi(k_{t+1} - b_{t+1}) \tag{4}$$

As for most of the collateral constraints used in the literature, more capital relaxes the constraint, while more debt makes it tighter. The specific choice of this constraint is entirely motivated by its analytical tractability, since it allows me to derive a closed-form analytical formula for the MPH. The crucial feature required for the results of this paper is that working capital depends on labor. In other words, that the financial friction affects employment decisions directly.

If the firm learns that it will not survive, I assume that will not carry capital and debt to the following period.[33] This implies that the exiting firm cannot hire any worker, and thus cannot produce. The value of exiting firms is just their current stream of dividends: $V_e(k_t, b_t) = (1-\delta_k)k_t - R(b_t)b_t$. Since dividends cannot go negative, the value of exiting firms cannot be negative either. This introduces an additional constraint $\frac{b_t}{k_t} \leq \frac{(1-\delta_k)}{1+r}$. Note that this constraint applies to all firms: I want to rule out the possibility that surviving firms take up too much debt and find themselves insolvent after learning about their exit.

Every period, the fraction π^e of firms that exits the economy is replaced by the same number of new firms. Each new firm is assumed to enter the economy with zero debt b_t, initial capital stock $k_t = k_0$ and idiosyncratic productivity drawn from the ergodic distribution implied by $\left\{\pi^z_{ij}\right\}$.

We can summarize the optimization problem for surviving firms - those that learn, at the beginning of the period, they will survive to the following period - as follows:

$$V(k_t, b_t, z_{j,t}) = \max_{d_t, k_{t+1}, b_{t+1}, n_t} \left\{ d_t + \Lambda_t \sum_{i=1}^{N_z} \pi^z_{ji} V_0(k_{t+1}, b_{t+1}, z_{i,t+1}) \right\}$$

subject to:

$$z_{j,t} k_t^{\nu} n_t^{\alpha} - w_t n_t - \tau_t - k_{t+1} + (1-\delta_k)k_t + b_{t+1} - R(b_t)b_t = d_t \geq 0 \tag{5}$$

$$w_t n_t \leq \phi(k_{t+1} - b_{t+1}) \tag{6}$$

$$V_0(k_{t+1}, b_{t+1}, z_{i,t+1}) = \pi^e V_e(k_{t+1}, b_{t+1}, z_{i,t+1}) + (1-\pi^e) V(k_{t+1}, b_{t+1}, z_{i,t+1}) \tag{7}$$

$$V_e(k_t, b_t, z_{j,t}) = [(1-\delta_k)k_t - R(b_t)b_t] \geq 0 \tag{8}$$

5.2 Households

A unit measure of identical households hold one-period shares of firms, η. I define the dividend-inclusive value of firm shares, currently held by households, as γ_0, whereas next period ex-dividend share price is γ_1. Shares held by households, as well as their

[33] In principle, exiting firms may have the incentive to do so in order to take up an intra-period loan and produce. I assume that the lender also observes that the firm will be dead in the following period, and thus does not believe any promise of the firm to repay new inter-temporal debt next period.

prices, depend on the distribution over firms' states, which for compactness is defined as $d[k' \text{ x } b' \text{ x } z_i]$. Households receive two lump-sum subsidies, T^l and T^b, equivalent to the lump-sum tax raised at firms and the tax penalty on firm savings, respectively. The representative household optimization problem is summarized as follows:

$$V^h(\eta_t) = \max_{c_t,\eta_{t+1},n_t^h} \left\{ U\left(c_t, 1-n_t^h\right) + \beta V_h(\eta_{t+1}) \right\}$$

subject to:

$$c_t + \int_S \gamma_1\left(k',b',z_i\right)\eta_{t+1}\left(d[k' \text{ x } b' \text{ x } z_i]\right) \leq w_t n_t^h + T_t^b + T_t^l + \int_S \gamma_0\left(k,b,z_j\right)\eta_t\left(d[k \text{ x } b \text{ x } z_j]\right)$$

5.3 Equilibrium

Given the law of motion for the exogenous state $\{z_t\}$ and a sequence of government policies $\left\{T_t^b, T_t^l\right\}$, the competitive equilibrium is defined as the joint law of motion for households' choices $\left\{C, N^h, \Upsilon\right\}$, firms choices $\{D,N,K,B\}$ and prices $\{p_t, w_t\}$, such that firm and households' choices solve firm and households' problems, respectively, taking prices as given, and markets clear as described below. As in a small open economy, bonds are bought by foreign investors, and its interest rate r is constant. I set r to $\frac{1}{\beta}-1$, the value it would take in steady state if the bond market cleared domestically.

I summarize the distribution of firms over (k,b,z) using the probability measure λ on the Borel algebra $S = K \text{ x } B \text{ x } Z$, where $k \in K$, $b \in B$ and $z \in Z$. For brevity, I drop the subscript t for current values; k' denote next period instead. The law motion of the firms' distribution follows:

$$\lambda'(A,z_i) = (1-\pi^e)\int_M \pi_{ji}^z \lambda\left(d[k \text{ x } b \text{ x } z_j]\right) + \pi^e \chi(k_0) H(z_i)\ , \forall (A,z_i) \in S$$

where $M = (k,b,z_j)|(K(k,b,z_j),B(k,b,z_j)) \in A$, K and B are the policy functions for capital and debt respectively. $\chi(k_0) = \{1 \text{ if } (k_0,0) \in A\ ;\ 0 \text{ otherwise }\}$, which implies that new entrants are born with k_0 capital and 0 debt. They also draw an idiosyncratic productivity from the ergodic distribution $H(z_i)$. Households' holdings of firms' shares are chosen such that:

$$\Upsilon\left(k',b',z_i'\right) = \lambda'\left(k',b',z_i'\right)\ , \forall (k',b',z_i') \in S \tag{9}$$

Markets for labor and output clear as follows, respectively:[34]

[34]The equations take into account the assumption that exiting firms do not hire nor produce. The last integral in the output clearing condition refers to net exports to foreign investors.

$$N^h(\lambda) = (1-\pi^e)\int_S N(k,b,z_j)\,\lambda(d[k \text{ x } b \text{ x } z_j]) \tag{10}$$

$$C(\lambda) = \int_S \left[(1-\pi^e)z_j k^\nu (N(k,b,z_j))^\alpha - (1-\pi^e)K(k,b,z_j) - \pi^e k_0 + (1-\delta_k)k\right]\lambda(d[k \text{ x } b \text{ x } z_j]) + \\ - \int_S \left[(1+r)b - (1-\pi^e)B(k,b,z_j)\right]\lambda(d[k \text{ x } b \text{ x } z_j])$$

5.4 Model solution

Following Khan and Thomas (2013), I solve for the equilibrium by combining together the firms' and households' problem. Households' first order conditions and market clearing require that the real wage is equal to the household marginal rate of substitution between consumption and leisure. Moreover, firms' stochastic discount factors are consistent with the household marginal rate of inter-temporal substitution of consumption. Firms are assumed to value current dividends at an output price p. As a result, firms discount their future values by the household subjective discount factor. The following two conditions hold in equilibrium, ensuring that all markets clear:

$$p(\lambda_t) = \frac{\partial U(C, 1-N)}{\partial C} \tag{11}$$

$$w(\lambda_t) = -\frac{\partial U(C, 1-N)}{\partial C}\frac{1}{p(\lambda_t)} \tag{12}$$

$$\tag{13}$$

I solve the model by reformulating the firm problem such that each firm's value is measured in units of marginal utility, rather than output. Decision rules do not change. The combined problem becomes:

$$V(k_t, b_t, z_{j,t}) = \max_{d_t, k_{t+1}, b_{t+1}, n_t} \left\{ p(\lambda_t)d_t + \beta \sum_{i=1}^{N_z} \pi^z_{ji} V_0(k_{t+1}, b_{t+1}, z_{i,t+1}) \right\}$$

And also the value of exiting firms is measured in units of marginal utility: $V_e(k_t, b_t, z_{j,t}) = p(\lambda_t)\left[(1-\delta_k)k_t - R(b_t)b_t\right]$.

5.5 The analytical MPH

Firms' optimal employment decisions are given by the following first order condition:

$$p_t\left(\alpha z_{j,t}k_t^{\nu}n_t^{\alpha-1}-w_t\right)(1+\xi_t)=w_t\mu_t \tag{14}$$

Where ξ is the Lagrange multiplier associated with the non-negativity of dividends, while μ the Lagrange multiplier on the working capital collateral constraint. Let us consider the prices that are consistent with the stationary distribution in general equilibrium, and define with $n^*=g(k_t,b_t,z_{j,t})$ the policy function for employment that solves the firm problem. Then, I define the marginal propensity to hire out of cash flow shocks as the negative of the derivative of optimal employment with respect to the lump-sum tax: $MPH=w_t\frac{\partial n^*}{\partial(-\tau_t)}$.

In order to derive an analytical formula for this object, I first solve the model assuming that $\tau_t=0$. Then, I consider a local perturbation of τ, keeping the distribution and prices constant. By doing so, the experiment has the partial equilibrium nature of the cross-sectional empirical estimation in reduced-form, as outlined in section 4. As done in the data, I compute the sensitivity of employment to the cash flow shock, and then I rescale it by the aggregate wage w_t.

I divide the firms in two groups: I define positive-MPH firms those for which *both* the working capital constraint and the non-negativity of dividends are binding. I can combine the two binding constraints and derive the following expression:

$$z_{j,t}k_t^{\nu}\left(n^*\right)^{\alpha}-w_tn^*-\frac{w_tn^*}{\phi}-\tau_t+(1-\delta_k)k_t-R(b_t)b_t=0$$

Differentiating this equation with respect to $-\tau_t$, we get:[35]

$$MPH=\frac{w_t}{w_t+\frac{w_t}{\phi}-MPL} \tag{15}$$

Where $MPL=\alpha z_{j,t}k_t^{\nu}\left(n^*\right)^{\alpha-1}$. These derivations rely on the assumption that a marginal change in τ_t does not make one of the two constraints slack. In other words, I am assuming that the marginal cash flow shock does not affect the constraint status of the firms. This may instead happen in reality; in appendix E.1 I show that the MPH can be calculated to take this into account, at the price of losing its analytical tractability.

The formula derived above could be defined as the MPH for already-constrained firms. Most importantly, it holds only if $\mu_t>0$ and $\xi_t>0$. When the collateral constraint is slack, firms choose labor in an unconstrained way. They set the marginal product of labor equal to the wage, and so the MPH is 0.

To summarize, taking μ_t and ξ_t as given, the MPH is:

[35]Using the negative of the tax change is done entirely for presentation purposes. This facilitates the interpretation of the MPH as the sensitivity of employment to cash flow.

$$MPH = \begin{cases} \frac{w_t}{w_t + \frac{w_t}{\phi} - MPL} & \text{if } \mu_t > 0 \text{ and } \xi_t > 0 \\ 0 & \text{otherwise} \end{cases} \tag{16}$$

6 Quantitative exploration

6.1 Calibration

One period is one year, in line with the data used to estimate the MPH. The probability of exit π^e is set to 0.1, in order to match an average firm exit rate of 10% in the UK. This is the average death rate of businesses between 2010 and 2015 as published by the ONS Business demography bulletin. I estimate the firm death rate for earlier years using the Business Structure Database, finding similar magnitudes: 10% in 2005, 9.7% in 2006. The household's discount factor β is 0.96, as in Khan and Thomas (2013). The tax on interest savings υ is set to 20% following Michaels et al. (2018).[36] As in Khan and Thomas (2013) and Rogerson (1988), the representative household's utility features indivisible labor, such that $U(C, 1-N) = \log C + \kappa (1-N)$. The parameter governing the preference for leisure, κ, is set such that households work one third of the available time.

The remaining parameters are calibrated jointly to match the same number of moments. Table 6 lists the parameter values, while the upper panel of Table 7 the model fit to the targeted moments. Although all parameters affect all targeted moments, we can identify more pronounced dependence of some parameters on a particular moment.

First, I target a labor share of 0.6. This the 1987-2013 average of the ratio between private non-financial corporations (PNFCs) total compensation of employees over the PNFCs gross value added in the UK. Although financial frictions imply that not all firms set their marginal product of labor to the wage, α is still particularly informative of this moment. The depreciation rate δ_k pins down the aggregate investment to capital ratio. The 1997-2013 average of the ratio between PNFCs gross fixed capital formation and PNFCs net capital stock is 0.107. The targeted capital-output ratio is the average of the ratio between the PNFCs net capital stock and the PNFCs gross value added over the same period. In spite of the presence of financial frictions and exogenous exit, ν is still very

[36] A positive υ implies that firms at the optimal size do not carry a large amount of net financial savings. Its quantitative role, however, is negligible: driving υ to 0 slightly rises the share of net savers, lowers the average net leverage ratio but rises its standard deviation. Most importantly, leaves the average MPH basically unaffected. Indeed, a positive υ increases the share of firms facing a binding working capital constraint and a slack non-negativity of dividends. Both constraints are required to bind for the MPH to be positive, which implies it is not very sensitive to this parameter.

Table 6: Parameter values

β	υ	π^e	δ_k	α	ν	ρ_z	σ_ε	ϕ	χ	κ
0.96	0.20	0.10	0.107	0.65	0.25	0.66	0.11	0.50	0.06	2.40

Notes: β is the household discount factor, π^e the exogenous probability of firm exit, δ_k the depreciation rate, α and ν the exponents on labor and capital in the production function, ρ_z is the persistence of firm-level productivity, σ_ε the standard deviation of its innovations, ϕ governs the financial friction, χ is the share of average capital that pins down the capital endowment of entrants, and κ governs the household preference for leisure.

informative of this moment, conditional on the depreciation rate.[37]

The remaining moments are calculated using the BSD-VOA and FAME-BSD-VOA samples used for the empirical findings at section 4. The parameter governing the financial friction, ϕ, has a role in determining many moments related to the debt position of the economy. I decide to target the share of net savers, defined as the share of firms whose net financial debt b is negative. In the lower panel of Table 7 I show that the model performs well also with respect to other moments of the net leverage ratio distribution.

The model economy matches the average MPH, computed at the firm-level as explained in the previous section. While all parameters affect the MPH, the capital endowment of new entrants - as a share of aggregate capital - is particularly informative. Increasing the share decreases the average MPH. This parameter can be thought as governing an additional financial friction on startups, which defines the startup capital of new firms. A larger initial capital stock implies that firms take less time to mature. In other words, more firms accumulate enough wealth - before exiting - to be able to absorb a negative cash flow shock by reducing dividends or taking up more debt (i.e.: have an MPH equal to 0). Greater χ, however, also acts on the intensive margin of the MPH, through the negative correlation with the marginal product of labor. The latter is indeed larger for smaller firms. As a result, lower χ also turns the correlation between MPH and size negative, a finding which I come back to later in the paper. The parameter delivered by the benchmark calibration, $\chi = 6\%$, implies a ratio of newly-born average employment to average employment of 11%, very close to Davis and Haltiwanger (1992) findings.

I assume that the log of idiosyncratic productivity follows an AR(1) process, such that $\log(z_{t+1}) = \rho_z \log(z_t) + \varepsilon_{t+1}$, with $\varepsilon_{t+1} \sim N\left(0, \sigma_\varepsilon^2\right)$. When solving and simulating the model, I discretize the firms' log-normal productivity process by the means of Tauchen and Hussey (1991), using 7 values. The calibrated standard deviation of innovations to idiosyncratic productivity, σ, allows the model to match the standard deviation of employment growth rates. Finally, I set the persistence of firm-level productivity, ρ, to the

[37] Without any frictions, the capital-output ratio would be $\frac{\nu}{r+\delta_k}$. Financial frictions and firm exit affect the capital stock. Assuming that exiting firms do not produce, however, lowers aggregate output relative to the capital stock, and thus bring the capital-output ratio closer to its frictionless counterpart.

Table 7: Model fit

Targeted Moments	Model	Data
Labor share	0.60	0.60
Capital-output ratio	1.73	1.68
Share of net savers	0.20	0.21
Standard deviation of employment growth rates	0.32	0.30
Average MPH	0.39	0.39
Non-targeted Moments	**Model**	**Data**
Autocorrelation of TFP growth rates	-0.19	-0.23
Standard deviation of sales growth rates	0.36	0.33
Standard deviation of net leverage ratios	0.34	0.43
Average net leverage ratio	0.27	0.35

Notes: Labor share, capital-output ratio and investment ratio in the data are calculated using data from the United Kingdom National accounts, blue book 2016, published by the ONS. All the other moments are computed using the BSD-VOA and the FAME-BSD-VOA samples used in section 4. Firm-level values for debt and capital are end-of-period, to be in line with balance sheet data. See Appendix D for the calculation of the moments. Employment growth rates are calculated both in the model and in the data as the symmetric weighted employment growth $\frac{2(n_{i,t}-n_{i,t-1})}{n_{i,t}+n_{i,t-1}}$, as in Moscarini and Postel-Vinay (2012)

same value estimated by Khan and Thomas (2013). This value gets the model very close to the serial correlation of TFP growth rates. In the data, I estimate the log of TFP as a Solow residual, using the calibrated values for α and ν as labor and capital share.

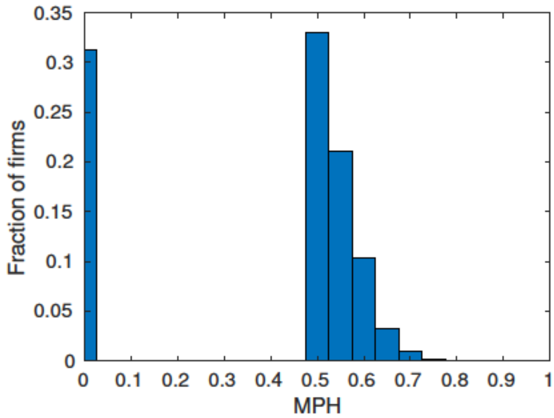
The lower panel of Table 7 shows that the model does a good job in matching additional moments, although not explicitly targeted in the calibration. In particular, both the standard deviation and the average of net leverage ratios are very close to the data.

6.2 Can the model replicate the MPH heterogeneity?

Section 5.5 already presented some of the properties of the MPH in the model. In this section I show explicitly how the model can endogenously replicate the MPH heterogeneity observed in the data.

First, the model generates a distribution of MPHs, as shown in figure 2. ϕ determines the lower bound of positive propensities, as can be seen in equation (11). 69% of the firms in the calibrated model display a positive MPH; the largest firm-level MPH is 0.84. The share of constrained firms may seem high; the implied share of firms not paying dividends, however, seems in line with existing evidence, especially given the fact that the model is

Figure 2: Distribution of MPH in the model



calibrated to data heavily skewed towards small and private firms.[38]

As in the data, small firms have a greater MPH. The correlation with lagged employment is -0.25 and can be visualized in figure 3a. Two forces affect this correlation; first, conditional on being positive, the MPH is negatively correlated with size, due to the relationship with the MPL shown in section 5.5. Second, smaller firms are more likely to have a positive MPH. On average, firms with MPH equal to 0 are 66% larger than firms with positive marginal propensity to hire. It is important to notice that firm exit contributes to this finding.[39] Nevertheless, even in presence of firm exit, the correlation can become positive under certain calibrations, especially with higher χ.

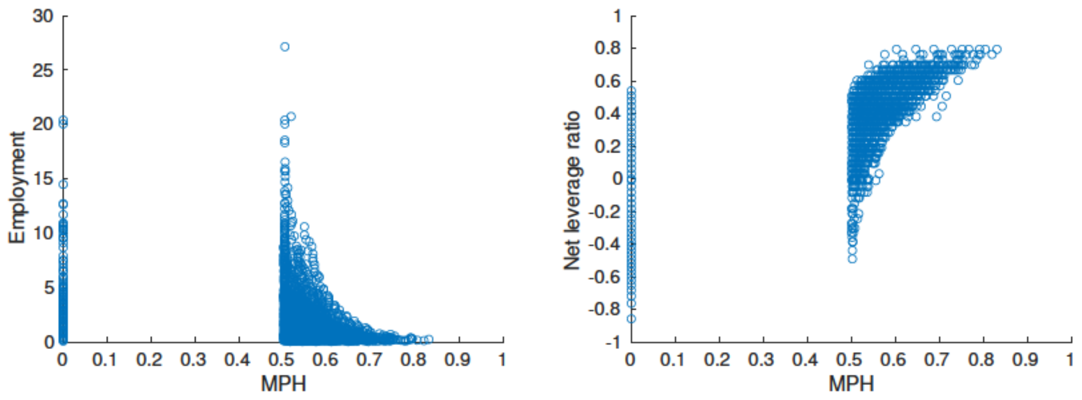
The model also predicts that more leveraged firms have a greater MPH, as found in the data. The correlation with net leverage ratio is 0.81, and figure 3b shows that there even exists a cutoff ratio above which all firms have a positive MPH. As noticed for size, the relationship between MPH and leverage is sustained through two different channels. On the extensive margin, highly leveraged firms face a binding collateral constraint and therefore are more likely to display a positive MPH. Conditional on this, more leveraged firms are also smaller and, most importantly, have a large MPL, which results in greater firm-level MPH. Finally, higher labor productivity in the model is associated with greater MPH. Indeed, the firms in the model will have a binding working capital collateral constraint when their marginal product of labor is greater than the wage.

The model results are not only qualitatively, but also quantitatively close to the empirical findings shown in the previous sections. The average MPH for firms with net leverage

[38] Michaely and Roberts (2011) find that 59% of UK private firms do not pay any dividend, while the share falls to 29% for publicly listed firms. Their sample of private firms, moreover, excludes small and medium firms.

[39] Without exit, the model typically displays a firm-level productivity z cutoff, above which firms have a positive MPH. If the endogenous tightness of the financial frictions is weak, the correlation between productivity and size is positive enough that the correlation between size and MPH is also positive.

Figure 3: MPH heterogeneity in the model



(a) MPH and size

(b) MPH and net leverage ratios

Notes: Figures plot simulated data for the sample of surviving firms used to compute the moments in Table 7. Size is measured in terms of employment. In panel (a), model-generated employment has been rescaled so that 1 is the mean employment in the model-generated distribution. To be in line with the data, size and net leverage ratios are lagged one period with respect to the MPH, to identify pre-determined conditions. The contemporaneous correlation between MPH and size is -0.16. See appendix D for further details.

ratio above the median is 0.58 in the model, very close to the 0.64 sensitivity estimate in table 5. The model fit is even better for low net-leverage firms, having an average MPH of 0.19 in the model and 0.16 in the data. Also note that the median net leverage ratio in the model, 0.38, is very close to the data point of 0.40. The model does also relatively well when it comes to size. Rescaling the model–average size to the data, firms with less than 25 employees have an MPH of 0.55, slightly above the empirical estimate of 0.42.

The properties highlighted in this section refer to the analytical MPH, derived as in section 5.5 and making use of the fact that firms cannot issue equity.[40] Appendix E.1 solves the model for different tax shocks and numerically estimates the propensities of labor, capital and debt. In line with the empirical findings, firms do not only cut labor in response to negative cash flow shocks, but also reduce capital and debt. The appendix also shows how these responses, as well as the MPH moments, are affected by equity issuance costs. As an additional robustness along these lines, I add to the economy a group of firms that are allowed to freely issue equity. Appendix E.2 shows that the average MPH among the remaining firms falls only slightly, due to general equilibrium effects. Even considering an extreme experiment in which equity issuers always have the highest productivity, and thus grow very large, has quantitatively limited effects on the main results shown in this section.

Armed with a general equilibrium model disciplined by firm-level empirical evidence, in the next two sections I investigate how the MPH can be used to shed light on two

[40]In order to check for accuracy, I numerically evaluate the MPH out of a change in the net financial asset b using the policy functions that solve the model and confirm the results.

macroeconomic questions: what is the employment effect of financial crises, and what are the aggregate effects of fiscal policy directed at firms.

6.3 The MPH and financial crises

In this section I show how the MPH is useful to make predictions about the effects of financial crises, modeled by an unexpected drop in ϕ. Conversely, I also show how financial crises affect the MPH.

Do economies with different MPH respond differently to a credit tightening?

In order to start answering this question, I differentiate aggregate employment with respect to ϕ. I then exploit the analytical formula of the MPH to work out how employment at financially constrained firms responds to a change in ϕ. With a slight abuse of notation, I sort the firms in the economy by their constraint status and define $\underline{c}$ as the cutoff below which all firms are constrained. I summarize the relevant channels below, and discuss the derivations in full in Appendix E.4:

$$\frac{\partial N}{\partial \phi} = \Gamma \underbrace{\left[E\left(MPH\right)E\left(n\right) + COV\left(MPH, n\right)\right]}_{\text{(I)}} + \underbrace{\int_{\underline{c}}^{1} \left(\frac{\partial n_i^u}{\partial w}\frac{\partial w}{\partial \phi}\right) di}_{\text{(II)}} + \underbrace{\frac{\partial \underline{c}}{\partial \phi}\left[n^c\left(\underline{c}\right) - n^u\left(\underline{c}\right)\right]}_{\text{(III)}} \tag{17}$$

Term (I) is mostly governed by the response of financially constrained firms, which has been decomposed in the spirit of Olley and Pakes (1996). This term increases with the average MPH, but also with the covariance between MPH and firm size. Since $\Gamma = \left(\frac{1}{\phi^2} - \frac{1}{w}\frac{\partial w}{\partial \phi}\left(1+\frac{1}{\phi}\right)\right)$, the importance of term (I) is larger the more inelastic the wage is to ϕ. Term (II) summarizes the general equilibrium dampening effects: financially unconstrained firms can take advantage of lower wages when the collateral constraint tightens and thus increase employment. Finally, term (III) gauges the fact that a tightening of financial conditions will typically increase the share of constrained firms.

As previously mentioned, model parameters such as χ affect the average MPH and covariance between MPH and firm size in opposite directions. Equation (17) theoretically shows that these two moments have opposite effects on the sensitivity of aggregate employment to ϕ. Intuitively, a credit tightening may trigger a large drop in aggregate employment in an economy in which only few, large firms, have a high MPH or, in line with what empirically estimated, a large average MPH is driven by small, constrained, firms. Which dimension prevails is a quantitative question, which I tackle by considering an experiment in which the economy starts at the equilibrium distribution and is hit by an unexpected and transitory 10% drop in ϕ; thereafter, all agents have perfect foresight. When the model is calibrated as in Section 6.1, aggregate employment drops by 5.1% upon impact. I then repeat the same experiment, but in an economy in which χ is raised to 0.25. This lowers the average MPH to 0.25, but makes the correlation between MPH and firm size turn positive. The first effect prevails, implying a smaller drop of aggregate employment, equal to 4.5%.

The MPH during a credit tightening

I then explore how the MPH is affected by a credit tightening. For a given wage, ϕ affects the MPH in two opposite ways. When the collateral constraint is tighter, more firms will be at the binding constraint, which implies that the share of firms with positive MPH will increase. On the other hand, ϕ is negatively correlated with the firm-level analytical MPH. Indeed, ϕ measures the firm's capacity to leverage up on future wealth and borrow intra-temporally. For a given £1 of additional cash flow, firms will be able to borrow less the lower ϕ, thus transmitting in fewer additional employment expenditures and therefore a lower MPH. Finally, a drop in ϕ is recessionary and reduces the wage, and this in turn has various direct and indirect effects on the MPH.

Overall, I find that these channels offset each other, and the average MPH is barely changed during periods of tight credit. This finding alleviates the concerns that the empirically estimated MPH could be extraordinarily high because it was estimated in the aftermath of a financial crisis. In fact, it provides a theoretical reason for why its value is likely to be little sensitive to the business cycle.

6.4 Policy experiment: fiscal transfer to firms

In this final set of quantitative exercises, I use the model, disciplined by firm-level empirical evidence, to tease out the general-equilibrium effects of cash transfers to firms.

What are the macro effects of a transfer?

First, I consider the effects of a permanent transfer, comparing steady states in general equilibrium. All firms receive the same lump-sum transfer, which is financed by raising a lump-sum tax from households.[41] In calibrating the amount, I look at recent fiscal packages implemented by the US and the UK in 2020, following the COVID-19 pandemic and associated recessions. As of July 2020, the US allocated \$660 billion for the Paycheck

[41] Note that the representative household is not liquidity constrained, hence the model is silent about the potential feedback channel due to heterogeneity in the marginal propensity to consume.

Protection Program (PPP), roughly 3.9% of aggregate revenues at non-financial corporate and non-corporate firms in 2019. As a whole, the US fiscal package targeted at firms has been larger than PPP, and featured different types of fiscal transfer.[42] The UK government has also expanded their fiscal support to firms, albeit for a smaller share of economic activity.[43] Actual policies in different countries have their own specificities, which I abstract from for transparency, although they could be built into the model.[44]

A uniform, unconditional, transfer equal to 3.9% of pre-transfer steady state aggregate output increases aggregate employment by 1.9%, as shown in the first column of Table 8. For each £ transferred to firms, 77 pence are spent on employment. This value is much higher than the average partial-equilibrium (PE) MPH previously analyzed. Indeed, the transfer increases the wage via equilibrium effects, which implies a higher sensitivity of the wage bill in GE. This effect dominates the fact that wage increases affect the stationary distribution of firms and harm unconstrained firms. Small firms - whose employment is below median - increase employment by 10%. Large firms (upper quartile), in contrast, experience an average reduction of 7%. General equilibrium therefore amplifies the empirically observed heterogeneity in the employment to cash flow sensitivity. The output elasticity of this policy is 0.75, and consumption also increases by a significant amount. Both aggregates implicitly account for the fact that the transfer is not necessarily spent on employment, but also on capital investment.

The results discussed so far are quantitatively affected by the assumed elasticity of labor supply. Hence, I also consider a household's utility of the form $U(C,N) = \log C - \kappa \frac{N^{1+\varphi}}{1+\varphi}$, set the inverse Frisch elasticity of labor supply, φ, to 1, as is conventional in the macro literature when using this utility function, and recalibrate κ as previously discussed. Since labor supply is now less elastic, aggregate employment increases by 0.9%; however, firms still spend, on average, 64 pence on employment for each £ of transfer, well above the PE MPH estimated in the micro data. Moreover, the heterogeneous effect is still strong and little affected quantitatively.

[42] The CARES act authorized \$149 billion in Coronavirus Relief Funds through local governments (Congressional Budget Office (CBO)). The Committee for a Responsible Federal Budget estimated \$300 billion loans through the Economic Injury Disaster Loan (EIDL) and \$10 billion of grants to small businesses.

[43] The Coronavirus Job Retention Scheme (CJRS), announced in March 2020, is a wage subsidy scheme whose cost has been estimated by the Office for Budget Responsibility to be £60 billion. Moreover, business grants have been allocated for more than £10 billion. Finally, a relief to the business rates tax payment itself has been put in place.

[44] PPP, for instance, outlays forgivable government-guaranteed loans, mainly targeted at small firms, and makes forgiveness conditional on the usage of the loan for wage bill payments. For more details, see for instance Granja et al. (2020).

Table 8: Steady state effects of permanent cash flow transfers

	Baseline		$\chi = 0.25$
$-\frac{T^l}{Y_{ss}}$ (%)	3.9	1.5	3.9
£ for £ Δ Employment	0.77	0.95	0.36
£ for £ Δ Employment (fixed wage)	0.29	0.37	0.15
%Δ Employment	1.89	0.93	0.98
%Δ Output change	2.93	1.49	1.27
%Δ Consumption change	3.08	1.45	1.33

Notes: $-\frac{T^l}{Y_{ss}}$ defines the total amount transferred to firms as a share of the model-specific equilibrium aggregate output with $\tau = 0$. I assume that the transfer is not wasted on exiting firms. Hence, surviving firms effectively receive $-\tau = \frac{T^l}{1-\pi^e}$. All deviations Δ are relative to equilibrium values when $\tau = 0$. In the first row inside the table, I evaluate the change in employment at equilibrium wages before and after the transfer. In the second row, I evaluate it only using the no-transfer equilibrium wage. The transfer amount in the second column (1.5%) is calibrated to roughly match the expected amount of the furlough scheme in the UK, as a share of annual sales of UK non-financial private sector businesses.

Are large transfers less effective?

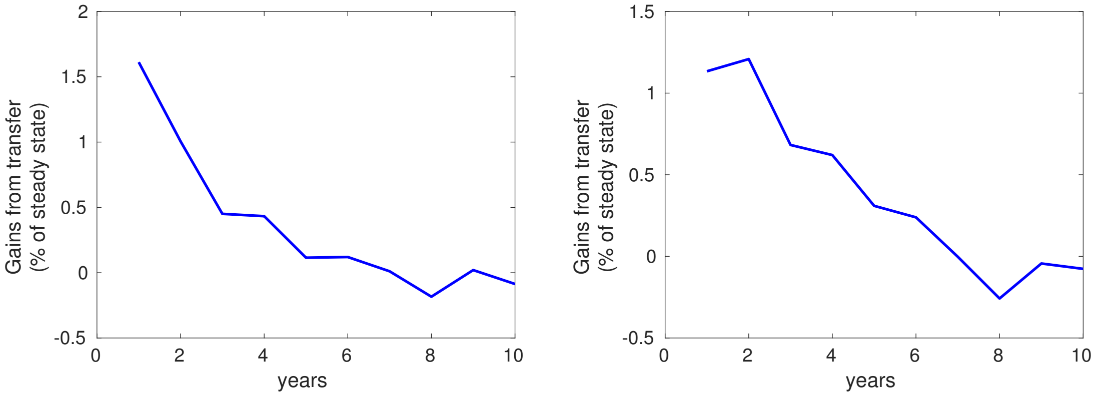
A smaller transfer has a higher pound-for-pound sensitivity of employment, even when keeping the wage constant, as shown in the second column of Table 8. Intuitively, a uniform transfer will be too large for some firms, moving them away from the constrained region and towards an allocation which is characterized by a MPH equal to 0. The larger the transfer, the more likely that some of it will be wasted onto unconstrained firms. On the other hand, a larger transfer naturally boosts employment more.

Fiscal multipliers increase with the MPH

In the last column of Table 8 I consider an economy with a PE average MPH of 0.25, achieved by increasing χ, the capital share of entrants, to 25%. The pound-for-pound sensitivity of aggregate employment to the cash transfer is much lower than when the average MPH is higher. This is also the case when we keep the wage fixed, albeit to a lesser extent. Moreover, the output elasticity drops to more than half its baseline value.

Increasing χ not only lowers the average MPH, but it also makes the covariance between MPH and size positive. The fact that larger firms are more sensitive to cash transfers might make the policy more effective in boosting aggregate employment. As shown for credit tightening, however, this effect is dominated by a lower average sensitivity of employment to cash flow. To further explore the sensitivity of the fiscal multiplier to the presence of large, unconstrained firms, Appendix E.2 explores how large equity issuers slightly reduce the aggregate boost in employment and output via both direct and indirect effects.

Figure 4: Transfer to firms during a recession



(a) Aggregate employment gains

(b) Aggregate output gains

Notes: In the first period, both economies are hit by an unexpected 10% drop in aggregate TFP, which lasts only one year. Aggregate TFP immediately reverts back to 1 in year 2. In the economy with the transfer, in the first period firms also receive an unexpected transitory transfer equal to 3.9% of pre-crisis steady state aggregate output. After the realization of the aggregate shocks in the first period, all agents have perfect foresight. For each variable, I compute the % deviation from the stationary equilibrium with aggregate TFP equal to 1, and then plot the difference between the economy with and without the transfer.

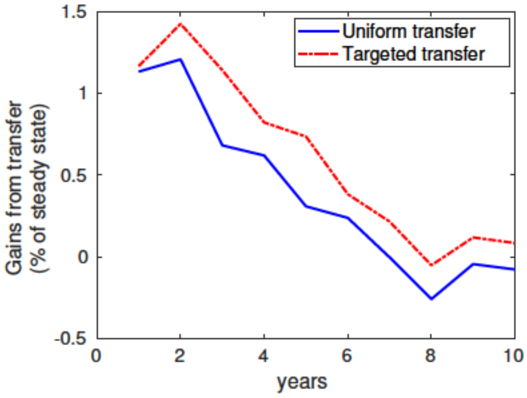
Transitory fiscal transfers during a recession

The results shown so far assume that the fiscal transfer is permanent. These policies, however, are often temporary and implemented during recessions. To illustrate this context, I consider the following experiment. The economy starts at the equilibrium distribution and is hit by an unexpected 10% drop in aggregate TFP, which lasts only one period and immediately reverts to its steady state value. After the shock, all agents have perfect foresight. What happens when an unanticipated and transitory aggregate cash flow transfer, equal to 3.9% of steady state output, is distributed to firms at the same time as the drop in TFP? The aggregate gains brought about by the transfer are shown in Figure 4. Compared to the previous results, looking at a transitory transfer allows us to trace the effects of aggregate variables over time and with different aggregate conditions. Absent policy intervention, aggregate employment falls upon impact by 11.8%. The transfer reduces this drop by 1.6%, roughly one-seventh. The transfer also maintains output higher for the following years, through its effect on capital investment. Although the transfer is purely transitory, its aggregate effects are still seen 6 years after the recession.

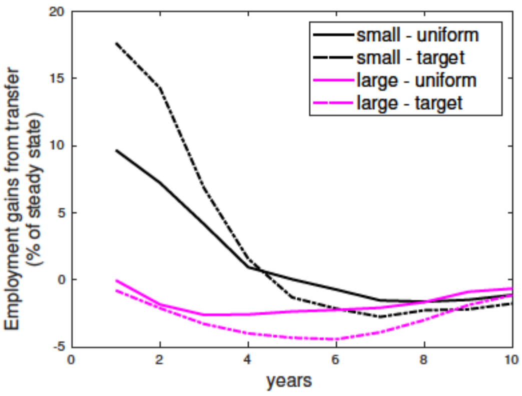
Are targeted transfers more effective?

Motivated by the fact that fiscal policy is often directed at small businesses, I consider a targeted transfer. Only firms whose employment before the TFP shock was below median employment receive the transfer. Its aggregate value is kept at 3.9% of pre-crisis aggregate output. At the firm-level, this doubles the transfer received by small firms from 13% of

Figure 5: The aggregate effects of a targeted transfer



(a) Aggregate output gains



(b) Heterogeneous employment effects

Notes: See notes on Figure 4. The dash-dotted line in both panels depicts a targeted scenario in which only firms with below-median employment receive a lump-sum transfer. In the right panel, small firms are those with employment below the median, while large firms above the 75th percentile. Classification is done in the steady state and is time-invariant.

their average output to 26%. Figure 5a shows that, while a targeted transfer improves aggregate outcomes related to a uniform transfer, the gains are limited. Output gains materialize only after the first period, whereas aggregate consumption improves also upon impact, but only by 0.2% as shown in Appendix E.3. Since the economy is hit by a very large shock, even a targeted transfer reduces the output trough only by less than one-tenth.

Figure 5b sheds light on this finding. Small firms gain from targeting, since they receive a larger cash flow windfall. Nevertheless, employment gains marginally decrease with the size of the transfer. Moreover, large firms lose even more from a targeted transfer, for two reasons. First, some large firms have a non-zero MPH and would have gained from a transfer, which they do not receive under the new scenario. Second, a targeted transfer, by being associated with smaller aggregate employment losses, reduces the aggregate wage by less than a uniform transfer. This general equilibrium effect hurts large firms. Even defining the transfer as a fixed share of each small firm's sales brings about little additional gain, in the order of 0.2% of output (for a given aggregate size of the policy).

Taken together, these results have two main implications. First, while a lump-sum transfer to firms is effective in cushioning employment losses during a TFP-driven recession, its impact has some limits. Indeed, such policy directly influences only the component of aggregate employment that is affected by cash-flow constraints. A drop in TFP also affects frictionless labor demand, which is impacted by the transfer only indirectly. Second, while it is crucial to account for well-identified partial equilibrium sensitivities of employment to cash flow, heterogeneity interacts non-trivially with general equilibrium effects. As a result, targeting of transfer policies is far from trivial and deserves particular attention. This finding seems particularly important in light of recently implemented government interventions targeted at small businesses.

7 Conclusions

The interaction between firm-level financial constraints and employment decisions is important for macroeconomic dynamics, as well as to evaluate the effectiveness of fiscal transfers to firms. In this paper, I first empirically show that financial constraints matter for firms' employment decisions. I exploit the idea that, when financial constraints bind, a firm adjusts its employment in response to cash flow shocks. I use a novel combination of three large data sets in the UK and a new source of variation to estimate this response, which I label the Marginal Propensity to Hire. In particular, I exploit the changes to a UK tax based on a periodically estimated value of the property occupied by the firm. I find that, on average, for every £1 of additional cash flow, 39 pence are spent on employment. Moreover, small and leveraged firms display a greater MPH.

A general equilibrium model of firm dynamics and financial frictions, disciplined by the empirical findings on the MPH, sheds light on the nature of employment - cash flow sensitivities and their heterogeneity. I use the model to show that the MPH can be used to sharpen our understanding of the aggregate effects of financial crises and to evaluate the effectiveness of fiscal policy directed at firms. When financial constraints are endogenously tight, and thus the average MPH is larger, a tightening of credit constraints translates into larger aggregate employment losses; however, such effect is dampened if small firms are more constrained. A similar tradeoff is present with fiscal policy. In addition, the elasticity of aggregate variables to a lump-sum transfer depends on its size. Small firms benefit the most, while large firms can lose from a transfer due to wage effects in general equilibrium. Even targeting the recipients, a transfer is effective only up to a certain extent, since it only operates via firm-level cash-flow constraints. In conclusion, the model results show that not only fiscal policy can have distributional impacts, further intensified by GE indirect effects, but that this heterogeneity is also important to assess the aggregate effects of fiscal policy and financial crises.

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Appendix

A Empirical Appendix

A.1 Data description and construction

This paper uses information primarily from three data sources, which I describe in this section: The Business Structure Database (Office for National Statistics (2017)), the Rating List and Summary Valuations compiled by the Valuation Office Agency and the Financial Analysis Made Easy (FAME) of the Bureau van Dijk.

Quoting the UK Data Service Catalogue description, "The Business Structure Database (BSD) is derived primarily from the Inter-Departmental Business Register (IDBR), which is a live register of data collected by HM Revenue and Customs via VAT and Pay As You Earn (PAYE) records. The IDBR data are complimented with data from ONS business surveys. If a business is liable for VAT and/or has at least one member of staff registered for the PAYE collection tax system, then the business will appear on the IDBR (and hence in the BSD). In 2004, it was estimated that the businesses listed on the IDBR accounted for 99 per cent of economic activity in the UK. Only very small businesses, such as self-employed, were not found on the IDBR."

The BSD is created by the ONS virtual Micro-data Laboratory (VML); every year, a snapshot of the IDBR is taken around April, and the captured point-in-time data are supplied to the VML by the following September. The reporting period is generally the financial year. For example, the 2000 BSD file is produced in September 2000, using data captured from the IDBR in April 2000. The data will typically reflect the financial year of April 1999 to March 2000. Employment information for the vast majority of firms, for instance, is updated on the IDBR using quarterly PAYE information, which typically uses the average of the last four quarters. However, the ONS may, during this time, update the IDBR with data on companies from its own business surveys. I follow the literature, such as Anyadike-Danes et al. (2011), and define the BSD variables with respect to the named year of the snapshot. The data are divided into enterprises and local units. The enterprise is defined as "the smallest combination of legal units that is an organisational unit producing goods or services, which benefits from a certain degree of autonomy in decision-making, especially for the allocation of its current resources". A local unit is "an enterprise or part thereof (e.g.: a workshop, factory, warehouse, office, mine or depot)."; "(...) to qualify as a local unit, a business entity must only consist of one site at a mailing address". The different sources used to update the IDBR might imply a temporary mismatch between enterprise and local units. In contrast, I confirm that employment at local units always sums to their enterprise employment for the regression sample around the time of the tax shock. Similarly, the estimation results are robust to the exclusion of businesses whose employment might be imputed from VAT reported to the HMRC. In fact, the estimated MPH becomes larger, suggesting that potentially infrequent update of the BSD should bias the estimates to zero. For each business, data are available on employment, turnover, foreign ownership, legal status, industrial activity based on Standard Industrial Classification (SIC), year of birth and death, as well as postcodes for both enterprises and local units. Turnover information is available only at the enterprise level. Within the IDBR, every local unit and enterprise is given its own, unique reference number when it enters onto the IDBR which remains unique to that business whilst it remains, in the same form, on the register. Given its confidential nature, the Business Structure Database can be accessed only through the UK Data Service Secure Lab.

Tax liabilities are calculated using information on Rating Lists and Summary Valuations, as provided by the Valuation Office Agency. The VOA compiles and maintains the rating list of rateable values for around 1.9 million non-domestic properties in England and Wales. About 80% of these properties have a summary valuation. I consider information drawn from the 2005 and 2010 rating lists, with summary valuations information for 2010. The data contains information on the adopted rateable value, the address of the property, date information on alteration to the rateable value and its effectiveness, the property category type and description, the size of the property measured in square meters, the adopted pounds per square meter rateable value and the valuation scheme reference number. Part of the tax data is live, which means that any physical change to the property after the revaluation will over-write the existing information. I try to account for this while matching the data by creating two comparable datasets. This will not be an issue in the empirical analysis, since the specific sample considered contains non-updated information at 2010 for all properties. For the tax data, I retain the properties that have non-missing rateable values before and after 2010. This excludes properties that were built, or closed, after the revaluation. For the BSD local unit data, I start by retaining local units in England and Wales, to be in line with the business rates. I then keep local units that did not change postcode sector around the revaluation,[45] and that are live between 2009 and 2011. I also exclude local units that die after 2012 without changing postcode, interpreting this as a property closure too. I break each side of the sample into two groups, depending on whether each full postcode unit has only one property (local unit) or more. I then proceed to match those sample groups. In some cases, one local unit is associated with more properties in the same postcode. Local units are defined as places where eco-

[45] I allow for small changes in the postcode unit, since this allows me to match over postcode sector too at a later stage. This may be coding error, change in the coding of the last letter of a postcode, or genuine relocations "next door". In unreported results, I check that the estimated average MPH is unaffected when dropping these few occurrences.

nomic activity is carried out by one or more persons work; VOA properties, instead, do not require any employee. I therefore create a mapping between the SIC industry code of the local unit and the category type of the property, allowing for groups of properties that are likely to be part of the same local unit.[46] The mapping between industry codes and property types is also used for postcodes with multiple local units and multiple properties, or to check ex post the correctness of the matching.

In order to allow for measurement error of postcode units, I repeat the same strategy at the postcode sector level, adding a small number of additional matches. The final sample consists of roughly 175,000 observations. The sample is then merged with firm-level information from the BSD, using the unique identifier that links local units and enterprises. There are 135,139 firms in the sample. I then exclude central government bodies and local authority establishments, establishments with 0 employees, properties with a rateable value of £0. These restrictions account for 9, 11 and 0.1% of observations respectively. To be in line with rental method for revaluation, as explained in section 2, I keep only the properties reporting a valuation scheme reference number. Moreover, I exclude all properties whose category - i.e.: property type - may be valued with methods other than the rental method.[47] This restricts the sample by a third. I then exclude the properties incurring in material change of circumstances between 1 April 2010 and 2012, around 8% of the sample. Indeed, firms have the possibility to reduce their tax bill by changing the features of the property and then reporting a material change of circumstances at the Valuation Office Agency.[48] This may imply a change in employment due to the complementarity with fixed assets and following a response to a change in the user cost of capital; since, instead, I am interested in the balance sheet channel of cash flow shocks, I exclude this possibility. In the data, it is not possible to observe directly whether a material change of circumstances took place. Nevertheless, I follow the Rating Manual, Volume 2, Section 5, Paragraph 6 and assume that any *effective date* beyond 2010 is deemed to be the date the circumstances arose that required the list to be altered. I also drop all properties incurring in an alteration to its pre-2010 rateable value taking place after 2010. This is typically the result of overdue resolution of appeals or retroactive changes to the tax bill, and accounts for roughly 4% of the sample. Appeals are further discussed in the following section.

[46] For example any property and its car park/ATMs/garages, or a school with its sport ground.

[47] Fish farms and public religious worship halls may be exempted upon request to the local authority. The other valuation methods are: contractors' basis, revenue and expenditure method, fair maintainable receipts, agreed valuation, special treatment (e.g.: football stadia). The relevant information can be found in the Valuation Office Agency Rating Manual, Volume 5. I also exclude all the categories that may be valued through a national, rather than local, scheme.

[48] Material change of circumstances typically involve matters affecting the physical state or physical enjoyment of the hereditament and the category of occupation of hereditament (Rating Manual Volume 2 Section 5). While potentially still working through the balance sheet, the cash flow shock may depend on the marginal product of capital and driven by other reasons such as endogenous location choices.

Table A.1: Descriptive statistics

	Mean	Std. Dev.	25th	Median	75th	Mean (>0)
$\Delta_{2009,10}T$ (% of $Sales_{2008}$)	− 0.05	0.7	−0.2	−0.03	0.06	0.4
$\Delta_{2009,11}Emp$ (% of $Sales_{2008}$)	1.4	15	0	0	0.9	17
$\Delta_{2009,11}Log(Emp)$	0.02	0.32	0	0	0.05	0.38
Emp_{2008}	103	2,054	2	5	11	
$Sales_{2008}$ (Th GBP)	17,364	541,400	121	250	700	
T_{2008} (% of $Sales_{2008}$)	2.5	5.8	0.5	1.2	2.6	

Note: Moments calculated from the sample of 63,242 observations in Table 1. Median and percentile values are averages around the median when there are less than 10 observations taking the median value.

Finally, I drop the establishments that changed enterprise between 2009 and 2011, and the construction sector (UKSIC 41100-43999), given its special nature when it comes to a property tax. The sample now consists of 82,506 establishment-tax observations. The employment variable used in the analysis excludes business owners - thus measuring only the number of employed staff. To protect the results from the effect of the outliers, I trim the dependent variables at the 1st and 99th percentiles. I also drop the upper and lower 0.75 percent of the scaled tax shock. Results are robust to 1 percentile trimming of the tax shock.

When calculating the pound-for-pound MPH, I rescale the employment changes by an annual wage of £21,024. According to the Annual Survey of Hours and Earnings, in April 2010 median gross weekly earnings for all employees were £404, which gives the rescaling wage if multiplied by 52 weeks. It seems sensible to consider both part-time and full-time employees when calculating the wage, especially given the very large number of small firms in the sample. Moreover, small firms typically pay lower wages and employ more part-time employees, as shown in the 2016 Annual Survey of Hours and Earnings; this may lead to overestimation of the pound-for-pound MPH.[49] On the other hand, it may underestimate the MPH since gross earnings slightly underplay firms' labor costs. Gross weekly earnings include regular pay - gross of income tax and employee National insurance contributions -, overtime pay and one-off bonuses, but exclude employer National insurance contributions, employer contributions to pensions schemes, benefits in kind, signing-on fees and stock options not paid through payroll.

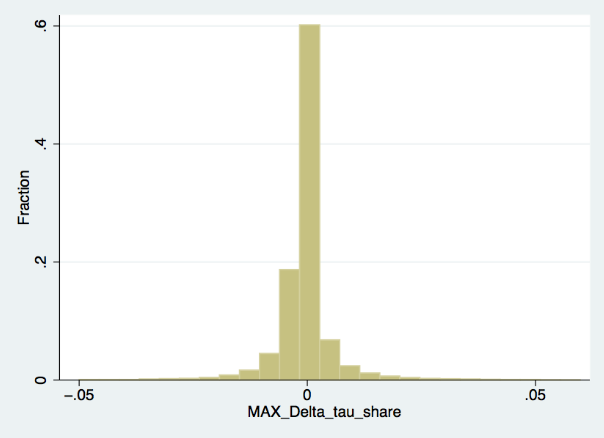
Table A.1 shows the descriptive statistics for the sample used in Table 1, while Figure A.1 the distribution of the scaled tax shocks. Table A.2 shows the sample composition in terms of industry, property type and region. Finally, Table A.3 presents descriptive

[49] The median weekly earnings at micro firms (less than 10 employees) was 64% of the overall median in 2016. Part-time employees at those firms earned even less (35%). At the other extreme of the distribution, full-time employees at large firms earned 29% more than the overall median.

statistics of the business rates and its revaluations by property type.

The matching strategy outlined above, as well as the sample restrictions, affect the representativeness of the regression sample as follows. First, the composition of business rates is broadly unchanged. The share of shops, cafes and restaurants is unchanged at 27%. Offices, in contrast, are under-represented with respect to the overall starting sample by 5 percentage points. The average business rates as well as their change are also in line with the full sample. Second, the geographical composition of the sample is basically unchanged. Only businesses in London drop from 16% to 13% in the regression sample. Indeed, it is conceivable to expect that unique matches will be marginally harder to get in denser areas like London. Third, the industry composition is also broadly in line with the unrestricted sample, barring the mechanic changes due to the exclusion of central government bodies and local authorities. The final dataset slightly over-samples large firms. While median employment is basically unchanged, average employment is five times higher than in the full BSD population. This is due to various sample restrictions that underplay the very small firms, often associated with categories excluded from the business rates. A similar comment applies to firm sales. Interestingly, average employment growth rate is basically the same as for the full sample (1.5%), albeit with a smaller standard deviation.

Figure A.1: The distribution of tax shocks



Note: Distribution of $\Delta_{2009,10}T$ as of column (III) of Table 1.

Table A.2: Industry, property and geographic composition

Observations (%)					
Region		Industry		Property type	
South East	14.2	Wholesale and retail trade	24.2	Offices	12.3
North West	13.7	Accommodation and food service	13.1	Shops	12.1
London	13.1	Human Health, social work	13.0	Factory/warehouse	14.6
East of England	10.5	Other Services	10.6	Shops, cafes and restaurants	27.4
West Midlands	10.4	Manufacturing	9.6		

Note: Shares (%) of total observations by categories. The table shows the 5 most frequent industry section categories, and the 5 most frequent regions in sample. The industry sections shown are codes G, I, Q, C and S. Moments computed using establishment information at 2010. Number of observations: 82,506.

Table A.3: Business rates revaluations by property type

	Offices					
	Mean	Std. Dev.	25th	Median	75th	Mean (>0)
$\Delta_{2009,10}T$ (% of $Sales_{2008}$)	0.03	0.9	−0.1	−0.00	0.1	0.5
T_{2008} (% of $Sales_{2008}$)	3.1	8.5	0.3	1.0	2.7	
	Factory/warehouses					
	Mean	Std. Dev.	p25	Median	p75	Mean (>0)
$\Delta_{2009,10}T$ (% of $Sales_{2008}$)	−0.1	0.6	−0.2	−0.00	0.1	0.3
T_{2008} (% of $Sales_{2008}$)	2.5	6.4	0.4	1.0	2.2	
	Shops					
	Mean	Std. Dev.	p25	Median	p75	Mean (>0)
$\Delta_{2009,10}T$ (% of $Sales_{2008}$)	0.05	0.5	−0.1	−0.00	0.1	0.3
T_{2008} (% of $Sales_{2008}$)	1.7	4.3	0.4	0.8	1.6	

Note: Moments calculated from the sample of 63,242 observations in Table 1. The sub-samples are defined using the dummies for the property type. There are 6,954 office observations, 9,926 factory/warehouses and 7,650 shops. Median and percentile values are averages around the median when there are less than 10 observations taking the median value.

A.2 Robustness of the average MPH

In this section I show various robustness of the main empirical results shown in section 4. First, Table A.4 repeats the same analysis of table 1 but uses the log-difference of employment as the dependent variable. This allows me to express the MPH as a semi-elasticity. Results are robust to different specifications and suggest that a revaluation that increases the tax bill by 1 percentage point of firm sales reduces employment at the firm, on average, by 0.72 per cent.

The analysis done in section 4 constructs tax shocks using tax liabilities calculated by the author. A few important comments are worth making, which will be the object of this section. The tax liability is calculated by multiplying the relevant rateable value by the multiplier. There are two main multipliers, one for Wales and one for England. I refer to section 2 for the description of how multipliers are updated every year. I then make a series of adjustments concerning the multipliers. The City of London authority charged an additional 0.4p for the properties in its area. Since the 1st April 2010, the Greater London Authority introduced a 2p additional levy on the multiplier, for rateable values over £55,000. Small properties, in England only, benefit from a lower multiplier, depending on the rateable value of their property and the sum of all rateable values at the business.[50] The small business multiplier is automatically assumed, according to the rateable value of the property, since 2010 revaluation; the VOA then checks if the conditions of eligibility apply to the ratepayer. In the main analysis, I compute small business multipliers. Column (I) of Table A.5 shows that the results are unchanged if I get rid of the small business multipliers when constructing the tax liabilities.

A number of reliefs are in place, which may affect the business rates liability. The small business rates relief is subject to the same conditions of the small business multiplier, but businesses need to explicitly apply for this to the relevant local authority. The dataset does not have the necessary information to take this into account, since businesses are not matched with all the properties they occupy and, moreover, there is no public information on whether the business rates relief has been granted. Restricting the analysis to the observations that are certainly not affected by the SBRR reduces the sample size by more than half but delivers similar results.

After the 2010 revaluation, a transitional relief was introduced in England only, aimed at phasing in sharp changes in the tax bills. The VOA set out the limits on the percentage

[50] To qualify for the small business multiplier, the ratepayer needed to fulfil the following criteria for the 2005 (2010) rating list: the ratepayer must occupy only one business in England or must occupy one property in England and other additional business properties, such that the main property has a rateable value less than £15,000 (£18,000) and £21,500 (£25,500) in London, each additional business property has a rateable value less than £2,200 (£2,600) and the combined value is less than the threshold.

Table A.4: The average MPH

	$\Delta_{2009,11}Log(Emp)$		
	(I)	(II)	(III)
$\Delta_{2009,10}T$	-0.59^{***}	-0.72^{***}	-0.72^{***}
	(0.17)	(0.17)	(0.18)
Postcode area FE	✓	✓	✓
Industry dummies		✓	✓
Firm controls			✓
Property controls			✓
Observations	63,242	63,242	63,242
R^2	0.00	0.01	0.01

Note: $\Delta_{2009,11}Emp$ is the change in the log of the number of employees at firm i. All notes to Table 1 apply. Standard errors (in parentheses) are clustered at the postcode area level, except for column (V) in which they are clustered at the postcode district level. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

by which the rates bill can increase or decrease every year.[51] The property is considered into the scheme until the true tax liability does not exceed the relieved tax bill. Column (II) shows the marginal propensity to hire calculated out of the first-year cash flow shock induced by the revaluation, after the transitional relief is considered. The coefficient is clearly larger than in the main analysis, because some firms know that they will face a larger tax shock in the future. In column (III), I calculate the 5-year present value of tax shocks. This sums the relieved cumulative tax shocks for the following 5 years, with respect to the pre-revaluation tax liability.[52] The coefficient is still slightly larger than one fifth of the average MPH, suggesting that calculating the tax shocks before any relief effectively underestimates the MPH.

Excluding the financial and insurance activities (section K, UKSIC 2007 codes 64110-66300) and the public administration and defence (section O, codes 84110 - 84300) does not affect the estimates, as shown in Column (IV). The estimated MPH is unchanged if excluding also the real estate activities (section L, codes 68100 - 68320).

Column (V) shows that the results are robust to the exclusion of observations that recorded pending appeals to the business rates. While every firm can appeal for free, it

[51] The scheme was originally devised to last 5 years. Limits to the reductions of tax bills were introduced to partly fund the scheme. Different limits apply for small and large properties, classified as such depending on their rateable value and whether they are in London. Year on year increases were limited to 5, 7.5, 10, 15 and 15 per cent for small properties, 12.5, 17.5, 20, 25 and 25 per cent for large properties. Decreases were limited to 20, 30, 35, 55 and 55 per cent for small properties and 4.6, 6.7, 7, 13 and 13 per cent for large properties.

[52] Note that this is meant to be a calculation made upon revaluation impact by a potential business. The ex-post actual sum of tax changes will be different, since business rates multipliers are adjusted every year in line with RPI. The present value as a share of firm sales has an average of -0.3%, 3.0% of standard deviation and is on average 1.5% conditional on being positive.

Table A.5: Robustness

	$\Delta_{2009,11}Emp$					$(\Delta_{2009,11}Emp - \Delta_{2006,08}Emp)$
	(I)	(II)	(III)	(IV)	(V)	(VI)
$\Delta_{2009,10}T$	-0.38^{***}			-0.39^{***}	-0.44^{***}	-0.54^{**}
	(0.13)			(0.11)	(0.14)	(0.21)
1st year relieved ΔT		-0.57^{***}				
		(0.18)				
5-year relieved ΔT			-0.10^{***}			
			(0.03)			
Observations	63,242	63,242	63,242	62,700	49,753	54,703
R^2	0.01	0.01	0.01	0.01	0.01	0.01

Note: Standard errors (in parentheses) are clustered at the postcode area level. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. Same notes and controls of column (III) of Table 1 apply.

must bear the legal costs and the appeal needs to fall within a limited set of permitted categories. Most importantly, appeals can take several months to be settled, and property occupiers need to keep paying the business rates until any change to the rateable value is legally settled. Even among settled appeals, only a small portion of them were successful.

Finally, in column (VI) I estimate the pound-for-pound sensitivity of the change in net hiring to a cash flow shock. In order to do so, I net the 2009-11 employment change with the 2006-08 employment change. The estimated coefficient is slightly larger than the benchmark, in line with the fact that there is a mild positive correlation between the revaluation and pre-2008 employment changes.

In unreported findings, I check that the results are robust to the anticipation of future choices along the extensive margin, such as establishment closures or material change of circumstances. 634 establishments in the sample are shut down in 2012: excluding these observations leaves the estimated average MPH unchanged. The MPH is even slightly greater at -0.42^{***} when excluding the establishments relocating in 2012. Finally, the coefficient is unchanged when excluding the material change of circumstances taking place in 2012.

A.3 Multiple establishments

The benchmark analysis pursued in this paper retains, for every firm i, the largest (in absolute value) establishment-level tax shock. This has the advantage of using explicitly the property-level and geographic controls to clean potentially endogenous and anticipated effects of the tax shock on employment. On the other hand, firms with multiple estab-

Table A.6: Multiple-establishment firms

	$\Delta_{2009,11}Emp$		
	(I)	(II)	(III)
$\Delta_{2009,10}T$	-0.40^{***}		-0.41^{***}
	(0.11)		(0.11)
Total firm-level tax change		-0.38^{***}	
		(0.11)	
Single establishments only	✓		
Number of firms	55,121	63,242	63,242
R^2	0.01	0.01	0.01

Note: Same notes and controls of column (III) of Table 1 apply. Standard errors (in parentheses) are clustered at the postcode area level. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

lishments will be likely to face an overall tax change that is different from than the one considered in the analysis. The direction of the bias is unclear ex ante, because it depends on the correlation between the different tax shocks faced by each firm i. In this section I show that, in practice, this issue does not affect the estimation of the MPH.

First, I show that, by restricting the sample to the firms with only one establishment between 2009 and 2011, as done in column (I) of Table A.6, the vast majority of observations is kept and the average MPH unchanged. In column (II) I re-introduce multiple-establishment firms and estimate the MPH out of the overall tax shock at the firm level (i.e.: the sum across all establishments). This specification may introduce some noise since the property-level and geographical controls refer to the property associated with the largest firm-level tax shock. The estimated coefficient is very similar, suggesting that the bias introduced by looking only at the largest tax shock (in absolute value) for each firm does not systematically affect the estimation.

I then try to quantify the direction of the bias related with multiple establishments. At this stage, it is useful to recall that businesses have two ways to overturn a tax change: closing the establishment, or physically changing the property, incurring in a material change of circumstances. Both options are excluded by the sampling strategy.[53] Reshuffling workers across different establishments should not be caused by a tax shock, since it does not overturn any tax change, unless a physical change takes place. If the estimated MPH is really measuring the employment responses out of cash flow shocks, we would expect firms with multiple establishments, and whose total tax shock partly cancels out at

[53] Closures and material change of circumstances are ruled out until 2012. In Appendix A.2 I show that the coefficient is not affected by employment responses in anticipation of closures or physical changes taking place after 2012.

the firm level, to respond less. The analysis performed in Table 1 may also be affected by another source of bias: for some firms in the sample it is not possible to match all the establishments with the associated tax change at the property level. I investigate both issues by augmenting specification (1) as follows. First, I add a dummy M that takes 1 if not all firm i establishments are matched with a tax entry. Second, a dummy O which takes 1 if the overall firm tax shock has a different sign than the largest shock $\Delta_{2009,10}T_{j,m}$. Only 0.1% of the firms in the sample have *overall offsetting shocks*. Finally, I interact both dummies with $\Delta_{2009,10}T_{j,m}$.

As shown in column (III), the average MPH is even slightly greater than the benchmark estimate. All the coefficients associated with the additional variables described above are insignificantly different from 0. Only firms with at least one establishment not matched with the property have, on average, a more positive employment growth. Most importantly, firms with offsetting shocks do not display a systematically different response to the tax change, providing an additional test for the presence of the cash flow channel which I try to quantify.

A.4 The *averaged* matching

Mapping a industry SIC code into a category type works better the more precise the category type is. For instance, there is a perfect mapping between SIC 92000 and betting shops. In contrast, this matching strategy fails to deliver unique matches in situations in which generic property types like offices and shops are clustered in a very narrowly defined area.[54]

In order to deal with this issue, I create a separate sample of matches that contain the *average* information for groups of multiple local units and properties sharing the same postcode unit and industry / property type mapping.I match 119,917 groups. To be in line with the results shown in section 4, I adopt the same sampling strategy. I adopt a very conservative approach and exclude any group for which: at least one establishment changed enterprise between 2009 and 2011, or reports zero employees, or is part of a central government body or local authority, or at least one property does not satisfy the sampling conditions explained in section 4. We are left with a bit more than a third of the original groups. Table A.7 shows that the obtained estimates are smaller and less significant than the ones shown in Table 1, but not very different considered the large amount of noise and measurement error introduced by averaging at the group level. Moreover, in principle this strategy compares different properties occupied by the same firm.

[54]For instance, a number of small shops in a train station, or offices at different floors of the same building.

Table A.7: The *averaged* matching

	$\Delta_{2009,11}Emp$	$\Delta_{2009,11}Log(Emp)$
	(I)	(II)
$\Delta_{2009,10}T$	-0.25^{*}	-0.57^{**}
	(0.15)	(0.27)
Number of groups	46,727	46,727
R^2	0.01	0.01

Note: Standard errors (in parentheses) are clustered at the postcode area level. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. Same notes and controls of column (III) of 1 apply.

A.5 Spatial differencing with matching

In this section I create pairs of firm-establishment-properties that share establishment, firm, property and geographic characteristics, and estimate their relative employment response to relative tax shocks. One pair, for example, will consist of two ICT firms, each occupying an office, both located in the postcode district N1.

While being conceptually similar to the benchmark equation estimated in 4, this specification is tighter in that it retains only the firms that can be associated with at least another firm in a pair. Moreover, it allows me to investigate the importance of belonging to different valuation schemes as a source of the variation in tax changes.

For each pair, I compute the difference in any continuous variable between the two observations in the pair. I denote as Δ_d the difference operator. Categorical controls used in the matching strategy (e.g.: industry dummies) will drop from the specification when applying the operator Δ_d. I then estimate the differenced specification below:

$$\Delta_d \Delta_{2009,11} E_{i,j,k,m} = \alpha + \beta \Delta_d \Delta_{2009,10} T_j + \Delta_d \gamma x_{i,2008} + \Delta_d \theta z_{j,2008} + \Delta_d \varepsilon_{i,j,k,m} \qquad (18)$$

I consider two different levels of matching tightness when creating the pairs. In column (Ia) of Table A.8 I match observations with respect to the firm and establishment industry sector, the property type (i.e.: whether the property is an office, a shop or a warehouse/factory) and the postcode area. 59,970 firms are matched, which means that roughly 5% of the original sample is dropped. The coefficient is still very significant but lower than the one estimated in Table 1. Column (Ib) uses the same matching strategy but restricts the sample to pairs in which the two paired observations belong to different valuation schemes. The average MPH is unaffected, suggesting that the variation between valuation schemes is an important driver of the estimated MPH.

Column (IIa) considers a tighter matching strategy at the postcode district level. One

Table A.8: Spatial differencing with matching

	$\Delta_d\Delta_{2009,11}Emp$			
	(Ia)	(Ib)	(IIa)	(IIb)
$\Delta_d\Delta_{2009,10}T$	-0.29^{**}	-0.28^{**}	-0.47^{***}	-0.47^{***}
	(0.11)	(0.12)	(0.16)	(0.17)
Paired by:				
Postcode area	✓	✓		
Postcode district			✓	✓
Industry sector	✓	✓	✓	✓
Property type	✓	✓	✓	✓
Different valuation schemes		✓		✓
Number of pairs	1,776,039	1,694,232	98,007	80,103
Number of firms	59,970	59,828	45,673	42,530
R^2	0.00	0.00	0.00	0.00

Note: Standard errors (in parentheses) are clustered at the firm level. Industry sector refers to the both firm and establishment sector. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

pair in this sample, for example, will consist of two ICT firms, each occupying an office, both located in the postcode district N1. The MPH becomes larger while remaining very significant. By looking at narrower geographical areas we are more likely to control for confounding local demand. The direction of the bias suggests that local demand shocks underplay the MPH by affecting the tax change and employment growth in the same direction. Even in this case the results are robust to the exclusion of pairs belonging to the same valuation scheme.

A.6 Spatial differencing with matching: km distance

In this section I follow the same approach as in section A.5, but I create pairs of establishment-properties that are located within a certain distance, rather than sharing the same postcode area or postcode district. This approach has the advantage of comparing observations that are located nearby but across a postcode area border; on the other hand, it skews the geographical distribution of the sample. As shown in the first three columns, the coefficient becomes larger and more significant as the distance narrows down, which is assuring for the identification strategy. Moreover, as shown by column (IV) of Table A.9, the variation is mainly driven by properties belonging to different valuation schemes. As the distance is further reduced to 1km, however, the coefficient becomes statistically insignificant, although is around the same magnitude of the coefficient in the previous column.

As we narrow down the distance between the two sides of a pair, the geographical

Table A.9: Spatial differencing (km) with matching

Distance	$\leq$ 20km	$\leq$ 10km	$\leq$ 5km	$\leq$ 5km	$\leq$ 1km
	$\Delta_d\Delta_{2009,11}Emp$				
	(I)	(II)	(III)	(IV)	(V)
$\Delta_d\Delta_{2009,10}T$	-0.25^{**}	-0.32^{**}	-0.33^{**}	-0.35^{**}	-0.32
	(0.12)	(0.14)	(0.15)	(0.16)	(0.28)
Different valuation schemes				✓	
Number of pairs	3,269,611	1,247,587	491,777	455,208	67,011
Number of firms	58,734	55,729	49,600	48,038	28,591
R^2	0.00	0.00	0.00	0.00	0.00

Note: Standard errors (in parentheses) are clustered at the firm level. In all specifications, pairs are created when sharing property type, firm and establishment sector, besides the geographical distance. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

composition of the sample becomes dramatically skewed towards areas of high business property density. For instance, the share of observations in the postcode districts W1B-W1W (more central part of West London) goes from 4.8% to 11% and to 36% when the distance is 10, 5 and 1 km respectively. Most importantly, the same is not true for the spatial differencing with matching constructed with postcode geographic controls. The share of observations in the same area is 1.5% in the sample in Table A.8, 2.7% when we built pairs sharing the same postcode area and 4.3% with postcode district.

A.7 Local house price growth

In this section I further show that the estimated MPH is not biased by local shocks. I consider house price growth at the lower layer super output area (LSOA) level, a very granular geographic measure in the UK. The regression sample contains 8,421 LSOAs. The variable of interest, $\Delta_{t,t+k}HP$, is the log-change of median price paid for residential properties in a LSOA. I consider the period 2003-2008, since this is the time frame over which the VOA collected information to implement the 2010 revaluation. Table A.10 shows that there is a mild negative correlation between past house price growth and employment changes, in line with a mild mean reversion documented in section 4.2. This slightly lowers the estimated effect of a change in the business rates. Including the controls employed in the baseline specification increases the MPH. In particular, the inclusion of postcode area dummies makes the coefficient on past house price growth statistically insignificant, as shown in column (IV). Finally, since not all establishments can be matched with house price local data, in the last column I report the benchmark MPH estimate in the sub-sample considered in this table. The coefficient is the same, with and without

Table A.10: House price growth

	$\Delta_{2009,11}Emp$				
	(I)	(II)	(III)	(IV)	(V)
$\Delta_{2003,08}HP$	−0.004	−0.006**	−0.005**	−0.002	
	(0.003)	(0.003)	(0.003)	(0.003)	
$\Delta_{2009,10}T$		−0.27***	−0.31***	−0.34***	−0.34***
		(0.10)	(0.10)	(0.12)	(0.12)
Postcode area FE				✓	✓
Industry dummies			✓	✓	✓
Firm controls			✓	✓	✓
Property controls			✓	✓	✓
Observations	57,530	50,738	50,738	50,738	50,738
R^2	0.01	0.01	0.01	0.01	0.01

Note: Standard errors (in parentheses) are clustered at the firm level. In all specifications, pairs are created when sharing property type, firm and establishment sector, besides the geographical distance. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

controlling for past house price growth. In unreported results I also find that the MPH coefficient is unaffected by the inclusion of quartiles of house price growth. Moreover, the MPH does not systematically vary with local house price growth over the 2003-08 period. Firms in areas which experienced an appreciation in house prices do not display a significantly different MPH.

A.8 Balance sheet data

The balance sheet data used in section 4.3 and for the calibration of the model is taken from FAME (Financial Analysis Made Easy), a database compiled by the Bureau van Dijk. Brav (2009) provide detailed and extensive explanation of the FAME dataset and the legal framework for incorporation at the Companies House. In this appendix I will refer only to the features of the data that specifically refer to the analysis pursued in this paper. A sample of around 1.5 million FAME firms was matched to the Business Structure Database by the UK data service, anonymizing the company registration numbers issued by the Companies House upon registration of the firm. The matching rate was quite high, at 83%. For around 3% of the cases, one BSD firm is associated with more FAME firms; this will happen whenever a demographic change involves reincorporation at the Companies House, but no change in the enterprise definition within the Business Structure Database. Among duplicates, I retain the observations with the longest history of balance sheet data and the largest value for turnover and total assets in 2008, under the assumption that this should allow to pick the consolidated balance sheet of an enterprise group. I then

Table A.11: FAME subsample: descriptive statistics

	Mean	Std. Dev.	Median	Mean (>0)
$\Delta_{2009,10}T$ (% of $Sales_{2008}$)	– 0.02	0.67	−0.04	0.37
$\Delta_{2009,11}Emp$ (% of $Sales_{2008}$)	1.3	14	0	15
$I_{2009-11}$ (% of $Sales_{2008}$)	1.6	18	−0.3	12
$\Delta_{2009,11}Debt$ (% of $Sales_{2008}$)	2.1	25	0.5	15
$\Delta_{2009,11}NetDebt$ (% of $Sales_{2008}$)	0.9	28	0.2	17
Emp_{2008}	214	3,187	6	
$Sales_{2008}$ (Th GBP)	34,397	689,200	410	
$TotalAssets_{2008}$ (Th GBP)	44,717	1,593,099	222	

Note: Moments calculated from the sample of 24,646 observations in Table 4. Median values are averages around the median when there are less than 10 observations taking the median value.

retain the firms reporting a non-missing value for total assets either in 2007 or 2008. In line with Brav (2009), I exclude the following company types: Guarantee, Limited Liability Partnership, Not Companies Act, Other, Public Investment Trust, and Unlimited. For reliability of the balance sheet entries, I also exclude the firms classified by the BSD as sole proprietorships or partnerships in 2008.

Around half of the BSD-VOA sample is matched with balance sheet information from FAME. The vast majority of unmatched firms are set up as legal entities that do not have to report financial information at the Companies House. 96% of the firms in the sample are not quoted. Table A.11 shows some descriptive statistics for the sample.

Depending on the following inclusion criteria, firms need to disclose financial information at different levels of granularity. As of 2017, companies are classified as small if they fulfil two of the following criteria for two consecutive years: annual turnover equal to £6.5 million or less, balance sheet total must not exceed £3.26 million and average number of employees must be 50 or lower. Small companies need to submit an abridged balance sheet and no profit and loss account.[55] The vast majority - around 80% - of the firms in the matched sample fit into this bin. Following the Small Company regulations (SI 2008), an abridged balance sheet consists of the items labelled with a letter or a Roman number in the balance sheet format set out in the regulation. This will guide the variables definition in this paper.

With regard to investment, CAPEX is not part of the compulsory reporting for the vast majority of firms. For these reasons, I use information from the asset side of the balance sheets. Firms can choose whether to report Fixed Assets (item B) or its three components (Intangible assets, tangible assets and investments). Missing values for fixed assets imply

[55] Note that the BSD, reporting information on sales for all enterprises, takes care of this shortcoming.

Table A.12: FAME robustness

	$\widetilde{I}_{2009-11}$	$I^{tang}_{2009-11}$	$I_{2008-11}$	$\Delta_{2008,11}Debt$	$\Delta_{2008,11}NetDebt$	$\Delta_{2009,11}Emp$
	(I)	(II)	(III)	(IV)	(V)	(VI)
$\Delta_{2009,10}T$	-0.26	-0.14	-0.22	-0.42	-0.51	-0.37^{**}
	(0.29)	(0.24)	(0.36)	(0.41)	(0.46)	(0.19)
Observations	23,227	22,797	24,686	24,659	24,659	23,532
R^2	0.02	0.02	0.01	0.01	0.01	0.02

Note: Standard errors (in parentheses) are clustered at the postcode area level. Controls are the same as in Table 4. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

that no line for this category was reported in the original accounting documents. Given the reporting requirements, I interpret a missing entry for fixed assets as a 0, for non-missing observations of total assets in the same year.[56] In column (I) of Table A.12 I show the response to the tax shocks when investment is calculated using only the non-missing information on fixed assets. Not imputing a zero entry clearly reduces the sub-sample but does not affect the coefficient much. Column (II) defines, instead, investment as the difference in tangible assets plus depreciation.

I define debt as current liabilities plus long-term debt. The use of current liabilities instead of short-term debt in current liabilities is motivated by the fact that the latter is not part of the compulsory items in the abridged balance sheet. It should be borne in mind that this might overestimate firms' stock of debt.[57] Net debt is defined as debt minus *Bank deposits*, which is the FAME definition for cash at bank and in hand.

While all balance sheets cover a 12-month period, the month in which they are reported is not the same for all firms, and ranges from July to end of year. This may imply that the dependent variables are computed with respect to a reference value that is already affected by the news of a future tax shock.[58] To account for this, I repeat the same analysis as in Table 4, but over the period 2008-11, as shown in columns (III)-(V).

Finally, FAME data also allow me to control for firms' capital intensity directly, defined as the ratio of firm fixed assets over sales in 2008. First, this controls for possible confounding factors related to real estate intensity, on top of the industry dummies included in the main regressions. Second, it implicitly controls for the property ownership

[56] A non-missing observation for total assets implies that a balance sheet had been compiled. Inspecting the original accounts documents, it seems that firms do not report fixed assets in their balance sheet when not owning any, rather than explicitly adding a line in the accounts with £0.

[57] Current liabilities are typically made of Bank Loans and overdrafts, trade creditors and other creditors. The latter term includes debt in corporation tax, dividends, social securities and VAT, besides accruals and deferred income.

[58] Draft revaluations were published on 30 September 2009. Firms reporting their 2009 balance sheet for the period 1 January - 31 December may already account for the revaluation in the 2009 values.

Table A.13: Additional placebo tests and dynamics

	$\Delta_{2006,09}Emp$	$\Delta_{2007,09}Emp$	$\Delta_{2008,09}Emp$	$\Delta_{2009,10}Emp$	$\Delta_{2009,11}Emp$
	(I)	(II)	(III)	(IV)	(V)
$\Delta_{2009,10}T$	0.25	0.09	-0.00	-0.27^{***}	-0.39^{***}
	(0.25)	(0.17)	(0.10)	(0.08)	(0.11)
Observations	54,445	58,252	62,339	62,776	63,242
R^2	0.01	0.01	0.01	0.01	0.01

	$\Delta_{2009,12}Emp$		$\Delta_{2009,13}Emp$	
	(VI)	(VII)	(VIII)	(IX)
$\Delta_{2009,10}T$	0.15	-0.39	0.19	-0.60^{*}
	(0.18)	(0.25)	(0.26)	(0.32)
Observations	59,188	24,201	55,665	24,102
R^2	0.01	0.03	0.02	0.04

Note: Standard errors (in parentheses) are clustered at the postcode area level. Same notes and controls of column (III) of Table 1 apply. Columns (VII) and (IX) use the FAME-matched sample as in Table 4. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

status, since renters typically have a lower stock of fixed assets. This analysis is further expanded in section A.10. As shown in column (VI), the MPH coefficient is not affected.

A.9 Placebo tests

In this section I expand on the discussion on placebo tests presented in Section 4.2. In Table A.13, I re-estimate equation (1) for different horizons of employment changes. Results are robust to restricting the sample such that each year has the same sample size, as well as to estimating a fixed-effects panel regression. There is never a statistically significant association between the tax change and employment changes before 2009, therefore dismissing concerns about reverse causality, simultaneity, and anticipation.

I also investigate how the employment response evolves over time. First, the baseline results focus on the period 2009-11, given the timing of the data. Draft revaluations were announced on 30 September 2009 but businesses had to start paying the new bill in April 2010, which is also when employment is captured from the business register. Using $\Delta_{2009,10}Emp$ as the dependent variable, I find a smaller sensitivity of 27 pence to the £, still significant at the 1% level. This coefficient is mainly picking up a news effect, as well as the response to early payments. The MPH is greater in 2011, however, suggesting that employment responds more as the business needs to pay the new tax bill in full. Estimating an employment response beyond 2011 delivers noisy results. The point

Table A.14: Additional placebo tests and dynamics: balance sheet

	$I_{2006-08}$	$\Delta_{2006,08}NetDebt$	$\Delta_{2006,08}Cash$	$I_{2009-12}$	$\Delta_{2009,12}NetDebt$
	(I)	(II)	(III)	(IV)	(V)
$\Delta_{2009,10}T$	−0.41	0.32	−0.28	−0.39	−0.30
	(0.31)	(0.56)	(0.26)	(0.31)	(0.61)
Observations	21,246	21,305	21,289	24,091	24,088
R^2	0.03	0.01	0.01	0.01	0.01

Note: Standard errors (in parentheses) are clustered at the postcode area level. Controls are the same as in Table 4. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

estimates for 2012 and 2013 are positive, albeit close to 0, in the full sample, as shown in columns (VI) and (VIII). However, they remain negative and large when considering the sample of firms with balance sheet data from FAME – columns (VII) and (IX). Longer-run estimates may be noisier as more firms may adjust quasi-fixed factors of production, thus confounding the effects; in contrast, 2009-11 seems a reasonably short horizon to treat the tax change as a cash flow shock.

Table A.14 shows a placebo test on investment, cash holdings and net debt. Past investment does not respond to future tax changes. In case of reverse causality, we might expect to find a positive coefficient indicating that part of the tax change is due to firms' investment – in their property – before the revaluation. In contrast, the estimated coefficient is negative and insignificantly different from 0. Firms' experiencing increases in the business rates mildly worsen their net debt position and cut their cash holdings, as shown in column (II) and (III). These responses, however, are insignificantly different from 0. If the tax changes were anticipated, instead, we would expect firms experiencing negative cash flow shocks to precautionarily raise cash ahead of the revaluation. In column (IV) and (V), I also explore investment and net debt changes over a longer horizon than what reported in Section 4.3. Investment between 2009 and 2012 is lower the higher the tax change: the sensitivity of 39 pence to the £ is higher than what estimated for the shorter horizon, 2009-11, in Table 4. On average, firms are still reducing their debt, net of cash, in 2012, when faced with a negative cash flow shock. All these responses, however, remain statistically insignificant.

A.10 Renters and owners

Although the business rates are paid by the occupiers of the property, it may be argued that, at least in the long-run, some of the tax incidence will be borne by property own-

Table A.15: Renters and owners

	$\Delta_{2009,11}Emp$		
	(I)	(II)	(III)
$\Delta_{2009,10}T$ x renters	-0.41^{*}	-0.41^{***}	-0.46^{**}
	(0.22)	(0.19)	(0.20)
$\Delta_{2009,10}T$ x owners	-0.40	-0.36	0.03
	(0.25)	(0.42)	(0.48)
Renters	-0.005^{**}	-0.009^{***}	-0.008^{***}
	(0.002)	(0.002)	(0.002)
Observations	24,646	24,646	24,646
R^2	0.02	0.02	0.02

Note: Standard errors (in parentheses) are clustered at the postcode area level. Controls are the same as in Table 4. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

ers.[59] In addition, there are other possible reasons for which renters and owners may respond differently to the revaluation. First, if the value of the property correlates with the estimated rateable value, this could impact the owners through the collateral channel presented by Chaney et al. (2012) among others. Second, given the correlation between estimated rateable values and the self-reported business rents used when creating the valuation schemes, renters may be better able to anticipate the revaluation; note, however, that any deviation from their expectations will be likely to cause sharper responses, exactly in form of unexpected changes. Finally, renters may be more sensitive to the shock if this also comes together with a change in the rent they pay, thus resulting in a underestimation of the effective cash flow shock at the firm.

In order to investigate whether there are systematic differences between renters and owners in terms of MPH, I follow Chaney et al. (2012) and group firms according to the fixed assets they own. Balance sheet reporting requirements, as explained previously, make this analysis drastically more difficult than with Compustat data using by Chaney and co-authors. I consider two definitions of renters. In the first column of Table A.15, I classify as renters those properties whose fixed assets in both 2007 and 2008 were less than £6,000. This cutoff is chosen so that around a fourth of observations are defined as renters. A uniform cutoff, besides arbitrary, is also probably not a good indicator of the ownership status of a property. Another alternative is to look at the price to rent ratio, or, conversely, at the rental yields. Bracke (2015) finds an average ratio of 19 for a matched dataset of residential properties in central London. The CBRE UK all sector average prime yields averaged around 5% in 2007, thus implying a ratio of price to annual rent of around 20. In column (II) and (III) I experiment with two cutoffs: a price-rent ratio

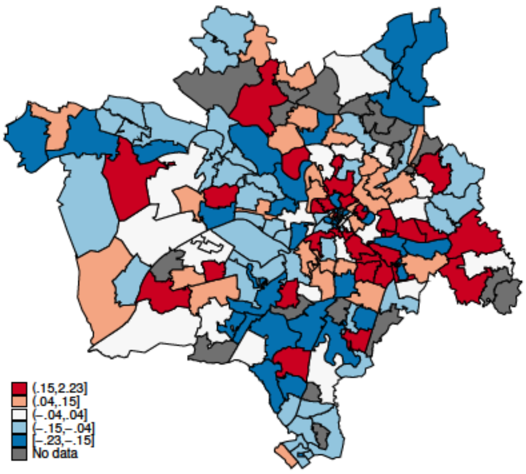
[59]For an analysis on this issue see Bond et al. (1996) and a 2015 report by Regeneris consulting.

of 15 and 5 respectively, where the ratio is computed by dividing firm fixed assets by the rateable value.[60] The implied share of renters is 42% and 61% respectively.

B Additional maps

Figure A.2 repeats the analysis of Figure 1, but showing the most frequent change.

Figure A.2: Business rates revaluation: Most frequent growth rate in tax liability for large offices in Manchester



Notes: Maps plot postcode sectors (e.g.: M1 1). Sample of offices in postcode area M, whose size is above the 75th of offices distribution (i.e.: 178 m^2). Properties undergoing material change of circumstances before 2012 are excluded, as well as properties without a valuation scheme and whose 2005 rating list has been altered after 2010. For each property, I compute the percentage growth rate in the tax liability due to the revaluation, rounded at the integer. The map shows the mode of this quantity at the postcode sector.

C Derivation of the financial friction

This section derives the enforcement constraint shown in equation 4. As mentioned in section 5.1, exiting firms are forbidden to borrow, so I will focus on firms that have already learnt they will survive to the next period. The decision to default arises after the realization of revenues, but before repaying the intra-period loan. At this stage, the firm has total liabilities $l_t + b_{t+1}$. The firm also holds liquidity given by its revenues minus all the payments that were not financed through the intra-period loan. Hence, we can see from the budget constraint that firm liquidity is equal to the intra-period loan l_t. Since the liquidity can be easily diverted, the only asset available for liquidation by the lender is physical capital k_{t+1}.

[60] A cutoff of 5 is aimed at including potentially high-yielding properties, like industrials or London-based. This, however, implies a yield of 20%, hence a very conservative approach.

Let us assume that there are two different creditors, and that the inter-period creditor is senior to the intra-period creditor. If the firm defaults, the lender acquires the right to liquidate the firm's capital. The recovery value of firm's capital, however, could be k_{t+1} or 0. At the moment of contracting the loan, neither the lender nor the firm know the recovery value. With probability ϕ, the collateral has full value by the end of the period. With probability $1-\phi$, it has no value at the end of the period, but full value at the beginning of the following period. Whether collateral has value at the end of period t is only discovered if liquidation is triggered at that point. If the intra-period creditor triggers liquidation and k_{t+1} has no value in period t, then she gets nothing. The collateral will have again full value at the beginning of the next period, and $k_{t+1} \geq b_{t+1}$ ensures that the inter-period creditor gets the loan back. If k_{t+1} has instead full value, the inter-period creditor is senior and gets b_{t+1}, so the intra-period creditor gets $k_{t+1} - b_{t+1}$.

In order to derive the renegotiation outcome, I follow Jermann and Quadrini (2012) and assume that the firm has all the bargaining power in the renegotiation and the lender gets only the threat value. A defaulting firm can offer $\phi\,(k_{t+1} - b_{t+1})$ to the intra-period lender in order to dissuade her from triggering liquidation. In this case both lenders are indifferent between liquidating the firm or not.

From the borrower perspective, enforcement requires that the value of not defaulting is not smaller than the expected value of defaulting:

$$\beta \sum_{i=1}^{N_z} \pi^z_{ji} V_0(k_{t+1}, b_{t+1}, z_{i,t+1}) \geq l_t + \beta \sum_{i=1}^{N_z} \pi^z_{ji} V_0(k_{t+1}, b_{t+1}, z_{i,t+1}) - \phi(k_{t+1} - b_{t+1}) \quad (19)$$

from which we derive: $l_t \leq \phi(k_{t+1} - b_{t+1})$.

D Numerical method and calibration

As discussed in section 5.4, I solve the model by reformulating the firm problem such that each firm's value is measured in units of marginal utility. In steady state, I start with a guess for the price p. Then I solve the combined problem with value function iteration as discussed below, obtain the stationary distribution by iteration, update the price such that the goods market clears, and iterate until convergence (i.e.: the absolute difference between current and implied price is less than 0.05%). The AR(1) process for the log of idiosyncratic productivity is discretized using Tauchen and Hussey (1991) method over 7 grid points. Following Khan and Thomas (2013) , I specify the value function over $V(k, \frac{b}{k}, z)$; using $\frac{b}{k}$ allows me to restrict the knot points to the feasible set. I set a grid for the states and more refined grids for the choices, and use linear interpolation for the mapping. For capital, I use a convex grid of 60 points for k_t and 180 points for k_{t+1}; the convexity enables me to define the capital endowment of entrants precisely. I use also 55 points for current net leverage ratio, and 165 points for its choice. The majority of firms in the simulations borrow or have a mildly negative net leverage ratio; hence, I define the grid as being concave when b is negative, and linear otherwise. This also accounts for the potential kink introduced around zero leverage by the tax on interest rate.

The marginal propensity to hire is computed as explained in section 5.5. In order to identify whether a firm has $\mu_t > 0$ and $\xi_t > 0$, I proceed as follows. For the first Lagrange multiplier, I compute the slackness of the collateral constraint; labor decisions is defined in the numerical solution such that there is exactly no slack if the constraint is binding. To assess whether the non-negativity of dividends binds, I use the envelope condition and define $\xi_t = \frac{V_k(k_t,\frac{b_t}{k_t},z_{j,t})}{p_t\left(\nu z_{j,t}k_t^{\nu-1}(n^*)^{\alpha}+1-\delta_k-R(b_t)\frac{b_t}{k_t}\right)}$, where n^* is the optimal choice of labor, and $V_k(k_t,\frac{b_t}{k_t},z_{j,t})$ is the derivative of the value function with respect to capital, calculated numerically using the numerical solution of the model. I confirm the accuracy of the analytical MPH by numerically evaluating the MPH out of a change in the net financial asset b, using the policy functions that solve the model. I obtain the same results.

At the calibration stage, the moments are computed using the invariant distribution $\lambda^*(S)$. The average MPH is computed restricting the stationary distribution to non-exiting firms only.

The remaining empirical moments are computed as follows. I consider the BSD-VOA-FAME sample used in Table 4. The net leverage ratio is computed as the ratio between the firm-level average net debt in 2007 and 2008 and the firm-level average total assets between 2007 and 2008. Using one of the two years only gives very similar results. The net leverage ratios are winsorized between -1 and 1. The log of TFP is estimated for each firm i as follows: $log(TFP_{i,t}) = log(Sales_{i,t}) - \alpha log(Employees_{i,t}) - \nu log(FixedAssets_{i,t-1})$ where α and ν are the calibrated values in the model. Fixed assets are chosen to be one period in advance to be in line with the model, since in the data they are recorded at the end of the year. This implies that the TFP growth can be computed only between 2007 and 2008 and between 2008 and 2009, since balance sheet data start in 2006. Using contemporaneous fixed assets changes the autocorrelation marginally, to -0.21.

The standard deviation of employment and sales growth rates are computed with the larger BSD-VOA sample, used to estimate the MPH in Table 1. The reported moments refer to growth rates between 2005 and 2006, for a set of firms that remain alive throughout 2012. Using the FAME-BSD-VOA sample delivers very similar values for the reported moments.

In the model, I draw a sample of 200,000 firms from the invariant distribution, and simulate it for 50 periods, discarding the first 40 periods. I retain the firms that are alive for all the last 10 periods, to be in line with the data sample from which the targeted moments will be calculated. Two biases may arise: aging and selection. Both the model and the data suffer from the aging bias: as we go on over time in the sample, surviving firms are older and thus the moments will be affected.[61] To overcome this issue, I compute the cross-sectional moments in the first year of the sample. Selection bias, defined as the surviving firms being ex ante - in the first year of the sample - different from the whole sample may exist in the data, while it is not present in the model given the random nature of exit.

The share of net savers is defined as the fraction of firms in the restricted simulated panel that have negative end-of-period net debt (i.e.: $b_{t+1} < 0$).In the same way, net leverage ratios used to compute the moments are end-of-period. They are defined as net debt b over total assets, which is given by k plus financial savings $|b < 0|$. Growth rates are also computed using the sample of surviving firms. This introduces a slight aging bias, since they must be calculated for firms of at least 2 years of age. Similarly, autocorrelations introduce a minimum age of 4 years.

To be in line with the empirical counterpart, Figures 3a and 3b consider last period size and net leverage ratios. Consider the simulated panel of surviving firms used to compute the moments in Table 7. Figure 3a shows the correlation between the MPH in the second year of the panel and labor n chosen in the first year. Net leverage ratios in figure 3a are the beginning-of-period 2 values - hence chosen in period 1. Looking at the second year of the panel introduces a slight aging bias, since firms are restricted to be at least 2 years of age. Nevertheless, the average MPH is only mildly affected (0.38). Moreover, this strategy has the advantage that the correlations are not affected by the normalization on the pre-determined debt for new entrants.

The transition paths after unexpected shocks are solved using a shooting algorithm. I set a time path equal to 30 periods, to ensure that the economy converges back to the pre-shock stationary distribution. Results are unaffected if considering 40 periods. I use backward iteration to obtain policy functions, and then forward iteration on the distribution to compute aggregate variables. I start with a guess for the price path, solve the path backward and forward as discussed, assuming that the economy is hit by an unexpected shock in the first period, and then update the price path such that markets clear in each period. For the update of the price paths, as well as the update of steady state prices described above, I use a dampening parameter, and stop when the previous and the implied price paths are reasonably close (i.e.: the maximum absolute difference between current and implied price is less than 0.35% along the full path.).

[61] Note, however, that standard deviation of growth rates remains fairly constant over time in the data sample.

E Model: additional results

E.1 Equity issuance and balance sheet propensities

This section extends the model to allow for equity issuance, although subject to a cost. First, I show that, for large enough costs, the properties of the MPH are preserved. Second, this corroborates the reliability of the analytical MPH used in the main analysis.[62] Third, this allows me to estimate the model counterpart of investment and debt propensities to cash flow estimated in the data.

I proceed as follows. First, I find the general equilibrium stationary distribution and prices for each of the models considered, under $\tau = 0$. Then, keeping prices fixed, I solve the model for 10 levels of a lump-sum tax τ, equal to 10% of each decile of the equilibrium output stationary distribution for a model with $\tau = 0$. Then I simulate a panel of 200,000 firms, drawn from the invariant distribution at $\tau = 0$. After 50 years, I hit each firm with an unexpected change in τ; the size of the shock is firm-specific and is chosen to be 10% of their sales 2 years before.[63] The shock is assumed to be permanent. For each firm, I define a treatment path, which feeds in the tax shock, and a control path, which keeps $\tau = 0$. This allows me to define firm-level responses for a given path of idiosyncratic productivity z. Propensities are calculated at the firm-level as the difference between the treatment and the control variable, divided by the size of the shock.

I consider two equity issuance cost functions. The benchmark follows Bond and Söderbom (2013), defining the cost as convex and such that the marginal cost is increasing in issued equity relative to the firm's stock of capital:

$$\Xi(d_t) = 1(d_t < 0)\left(\frac{\vartheta}{2}\right)\left(\frac{d_t}{k_t}\right)^2 k_t \tag{20}$$

In the last column of Table A.16 I also explore the possibility of a linear cost, as in Michaels et al. (2018): $\Xi(d_t) = \eta d_t 1(d_t < 0)$.

I follow the corporate finance literature and re-write the recursive problem so that firms maximize the present discounted expected value of after-fee dividends:

$$V(k_t, b_t, z_{j,t}) = \max_{d_t, k_{t+1}, b_{t+1}, n_t} \left\{ p_t\left[d_t - \Xi(d_t)\right] + \beta \sum_{i=1}^{N_z} \pi^z_{ji} V_0(k_{t+1}, b_{t+1}, z_{i,t+1}) \right\}$$

[62] The accuracy of the analytical MPH has been also checked by comparing it with the numerical counterpart evaluated out of changes to b. At stationary distribution, the resulting average MPH is 0.39 as found for the analytical counterpart.

[63] This approach makes the analysis more similar to the data, compared to a uniform lump-sum shock for all firms. Firms keep treating the shock as lump-sum, although its size effectively depends on past sales.

Table A.16: Propensities with equity issuance

	$\vartheta = 50$	$\vartheta = 4$	$\vartheta = 1$	$\eta = 0.05$
MPH	0.27	0.16	0.10	0.04
MPI	1.52	0.69	0.33	0.20
MPB	0.87	0.34	0.17	0.20
Equity issuers	73%	77%	73%	50%
Median equity payout	3%	14%	23%	33%
Positive MPH	69%	55%	40%	21%
Corr(MPH,size)	-0.41	-0.20	-0.13	-0.02
Corr(MPH,leverage)	0.61	0.47	0.39	0.07

Notes: Equity payout is defined as a fraction of output. Leverage is the beginning-of-period net leverage ratio, computed as explained in the main text.

subject to constraints (5) - (8). Table A.16 shows the average propensities with different equity issuance costs.[64] In the first column, I consider a very large cost to mimic an economy that approaches the case explored in the main text in which equity issuance is forbidden. The parameters for the following two columns are taken from Bond and Söderbom (2013), and Michaels et al. (2018)) for the last. MPI denotes the average change in capital following a cash flow shock, while MPB in debt.

First, we notice that the average MPH is lower than when equity issuance is forbidden. Even in presence of large and convex equity issuance costs, some firms have been able to save themselves out of the constraint by pursuing small equity issuances in the past, and using them to finance capital investment. The possibility to issue equity, moreover, also lowers the firm-level MPHs. Indeed, the new firm-level MPH is lower than the analytical counterpart without equity issuance the more (negative) dividends absorb the cash flow shock.

The share of firms issuing equity is quite large, but most of them issue a very small amount of equity. This is apparent with a convex issuance cost that disincentivize large issuances. The large share of equity issuers is also related to the fact that there is no tax incentive on debt, but only a disincentive on savings.

The correlation between MPH and size is similar to the baseline model, and slightly weaker when looking at net leverage ratios. Even when the equity cost is a function of the payout ratio, small firms may be so disrupted that they prefer to issue more equity and lower their employment response. The same reasoning applies to leveraged firms; first, they are constrained in inter-temporal borrowing so equity issuance may be their only

[64] Average of the firm-level responses on the first year of the tax shock. Sample of firms that did not exit between 2 years before the shock - that defines the scaling sales - and the year of the shock.

option. Second, they may issue equity to finance capital investment and, in the following periods, be in a better position to both pay the tax - through larger wealth - and borrow more - through additional collateral.

As equity issuance costs become less binding, the average MPH falls, and the correlation with size weakens, as well as with net leverage ratios. Turning to the other firms' choices, firms display much larger sensitivities of adjusting capital and debt. Productive and constrained firms typically cut capital following a negative cash flow shock; by keeping the debt to capital ratio constant, they also decrease their stock of debt. Less productive firms, especially when small, may have enough room to increase their leverage ratio further. Since the shock is permanent, they may have the incentive to hang on for the first period and finance - either through equity issuance, or inter-temporal debt - capital expenditures, which in the following periods expands their wealth and ability to pay the tax. For this reason, 4% of firms display a negative MPI when $\vartheta = 4$. This share increases to 12% with linear equity issuance costs. In this model, firms' responses are very dispersed, and the cost does not seem to bind much. The average MPH decreases, pushed both by the extensive and the intensive margin. Moreover, the correlation with size is nearly 0.

E.2 Equity issuers

In this section, I consider how the main quantitative results of the paper are affected by the inclusion of firms that can freely issue equity, and whose MPH is therefore zero. For simplicity, I assume that equity issuers do not face any financial friction, and therefore we can characterize their optimal choice in closed form as follows:

$$
\begin{aligned}
k_u^*(z_j) &= \left(\frac{1-\beta(1-\delta_k)}{\nu\beta(1-\pi^e)\left(\frac{\alpha}{w}\right)^{\frac{\alpha}{1-\alpha}} \sum_{i=1}^{N_z} \pi_{ji}^z z_i^{\frac{1}{1-\alpha}}} \right)^{\frac{1-\alpha}{-1+\alpha+\nu}} && (21) \\
n_u^*(k, z_j) &= \left(\frac{\alpha z_j k^\nu}{w} \right)^{\frac{1}{1-\alpha}} && (22)
\end{aligned}
$$

They exit at the same rate as the population, and are replaced by an equal share of firms with capital equal to a χ fraction of aggregate capital. Aggregate capital satisfies:

$$
\widetilde{K} = (1-\Psi_e) \int_S k\lambda(d[k \text{ x } b \text{ x } z_j]) + \Psi_e \left((1-\pi^e) \sum_{j=1}^{N_z} k_u^*(z_j) H(z_j) + \pi^e \chi \widetilde{K} \right) \qquad (23)
$$

where λ is the distribution of non-issuers, computed as in the baseline model but now taking into account that the aggregate stock of capital depends on equity issuers too. Ψ_e denotes the share of equity issuers. The distribution of issuers is governed by the ergodic distribution of idiosyncratic productivity $H(z_i)$. Aggregate output and aggregate investment are defined as follows:

$$
\begin{aligned}
Y =&(1-\Psi_e)\int_S \left[(1-\pi^e) z_j k^\nu \left(N\left(k,b,z_j\right)\right)^\alpha\right]\lambda(d[k \text{ x } b \text{ x } z_j]) \\
&+\Psi_e(1-\pi^e)\sum_{j=1}^{N_z}\left[(1-\pi^e) z_j\left(n_u^*(k_u^*,z_j)\right)^\alpha k_u^{*\nu}+\pi^e z_j\left(n_u^*(\chi\widetilde{K},z_j)\right)^\alpha\left(\chi\widetilde{K}\right)^\nu\right]H(z_j)
\end{aligned}
$$

$$
\begin{aligned}
I =&(1-\Psi_e)\left[(1-\pi^e)K\left(k,b,z_j\right)+\pi^e\chi\widetilde{K}-(1-\delta_k)k\right]\lambda(d[k \text{ x } b \text{ x } z_j]) \\
&+\Psi_e\sum_{j=1}^{N_z}\left[(1-\pi^e)k_u^*(z_j)+\pi^e\chi\widetilde{K}-(1-\delta_k)\left((1-\pi^e)k_u^*(z_j)+\pi^e\chi\widetilde{K}\right)\right]H(z_j)
\end{aligned}
$$

where N and K are the labor and capital policy functions for non-issuers, as described for the baseline model. Equity issuers do not hold any net debt b. As a result, aggregate net exports in the output market clearing condition are multiplied by $(1-\Psi_e)$.

I consider two economies. In the first, I calibrate the share of equity issuers to the fraction of publicly quoted firms in the sample, 4%. General equilibrium effects change the equilibrium distribution, but the average MPH among non-equity issuers is basically unaffected, whereas it falls to 0.37 when considering the economy as a whole. The covariance between MPH and size also drops, but only slightly.

In a second experiment, I assume that equity issuers always keep the maximum level of productivity. They do not face any financial friction, and the assumptions on entry and exit are unchanged. I calibrate this share to 0.6% of all firms. Looking at the population of UK firms in 2010, publicly listed firms accounted for 0.25% of all employers. On the other hand, a larger number of businesses are likely to be able to tap on equity-like financing, and grow large. UK businesses employing more than 250 employees represent 0.6% of all employers, as reported by Business Population Estimates. In this economy, equity issuers grow very large. In equilibrium, this affects the wage, and also indirectly increases the startup capital of entrants. Even with such an extreme experiment, however, the average MPH of non-equity-issuers falls only slightly to 0.36. The presence of very large unconstrained firms not only lowers the MPH of firms with more than 25 employees, but also that of smaller firms, via the aforementioned general equilibrium effects.

Table A.17: Steady state effects of permanent cash flow transfers: equity issuers

	baseline	equity issuers	productive issuers
Average MPH	0.39	0.39	0.36
£ for £ Δ Employment	0.77	0.64	0.50
£ for £ Δ Employment (fixed wage)	0.29	0.23	0.16
%Δ Employment	1.89	1.48	1.02
%Δ Output change	2.93	2.41	1.92
%Δ Consumption change	3.08	2.65	2.09

Notes: The column "equity issuers" considers the experiment with 4% of firms allowed to freely issue equity. In the last column, 0.6% of firms can issue equity and are always very productive. In the first row, I report the average partial-equilibrium MPH among firms not issuing equity. For all economies, the aggregate value of the transfer is 3.9% of aggregate output. Exiting firms do not receive the transfer, while equity issuers do. All deviations Δ are relative to equilibrium values when $\tau = 0$. In the first row inside the table, I evaluate the change in employment at equilibrium wages before and after the transfer. In the second row, I evaluate it only using the no-transfer equilibrium wage.

To illustrate the role played by the startup capital, I also consider the case in which equity issuers never exit. This affects their optimal capital choice. Moreover, it implies that aggregate output and aggregate investment are, respectively:

$$\begin{aligned} Y =& (1-\Psi_e)\int_S \left[(1-\pi^e) z_j k^\nu \left(N\left(k,b,z_j\right)\right)^\alpha\right] \lambda(d[k \text{ x } b \text{ x } z_j]) \\ &+ \Psi_e \sum_{j=1}^{N_z} z_j \left(n_u^*(k_u^*, z_j)\right)^\alpha (k_u^*(z_j))^\nu H(z_j) \end{aligned}$$

$$I = (1-\Psi_e)\left[(1-\pi^e) K\left(k,b,z_j\right) + \pi^e \chi \widetilde{K} - (1-\delta_k)k\right] \lambda(d[k \text{ x } b \text{ x } z_j]) + \Psi_e \sum_{j=1}^{N_z} \delta_k k_u^*(z_j) H(z_j)$$

whereas aggregate capital is $\widetilde{K} = (1-\Psi_e)\int_S k\lambda(d[k \text{ x } b \text{ x } z_j]) + \Psi_e \sum_{j=1}^{N_z} k_u^*(z_j)H(z_j)$.

In this model, equity issuers grow even larger, thus having an additional effect on the wage. The feedback loop on startup capital, however, is absent. The latter effect prevails, implying that the average MPH of non-equity issuers is basically unchanged at 0.39 in the first experiment and at 0.38 in the second.

Table A.17 shows the effects of a uniform transfer in the two economies, with issuers also exiting with probability π^e. In the first experiment, the pound-for-pound employment sensitivity to the fiscal transfer decreases. The presence of equity issuers affects the effectiveness of fiscal transfer in two opposite ways. On the one hand, equity issuers lose from the transfer: their partial-equilibrium MPH is zero, but the transfer increases the wage, hurting their labor demand. Moreover, also the remaining firms in the economy have a smaller MPH, due to GE effects on startup capital. On the other hand, constrained firms receive a larger transfer, as a share of their average output, because equity issuance has increased the level of aggregate output. The first effects prevail, slightly reducing the effectiveness of the transfer.

The presence of very large, very productive equity issuers further decreases the aggregate effects of the fiscal transfer. This is particularly noticeable for employment, whose increase is only 55% of what experienced in the baseline model. Output elasticity, instead, drops by one third.

When issuers do not exit, the effectiveness of the fiscal transfer is not very different from what shown in Table A.17, due to counteracting effects. On the one hand, equity issuers are on average even larger, because none of them is newly born, which implies they become even more important for general equilibrium adjustments. On the other hand, this version of the model shuts down the GE feedback effect via the startup capital of new entrants. Moreover, for consistency I maintain that all issuers receive the transfer. Since none of them exits, this in fact slightly lowers the ratio of transfer to average output of non-issuers.

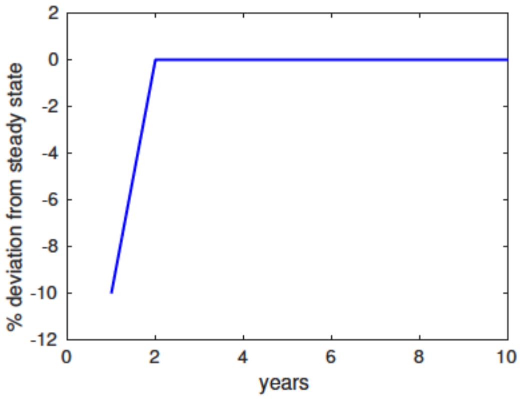
E.3 Policy experiment: additional results

Figure A.3 shows the dynamics of aggregate output, employment and consumption following the purely transitory aggregate TFP shock considered in section 6.4. The solid line refers to an economy without any policy intervention. Aggregate employment falls by 11.8% upon impact, and subsequently overshoots, driven by investment dynamics. Cash-flow constrained firms cut investment upon impact. Unconstrained firms, however, are not affected for given prices, since the aggregate TFP shock is purely transitory. Moreover, higher borrowing drives down aggregate net exports upon impact and up immediately after, affecting wages and the firms' discount factors. The net effect implies an investment boom for some firms, which prevails in the aggregate. The dashed and dash-dotted lines refer to an economy which experiences a transitory uniform and targeted transfer, respectively, as described in the main text.

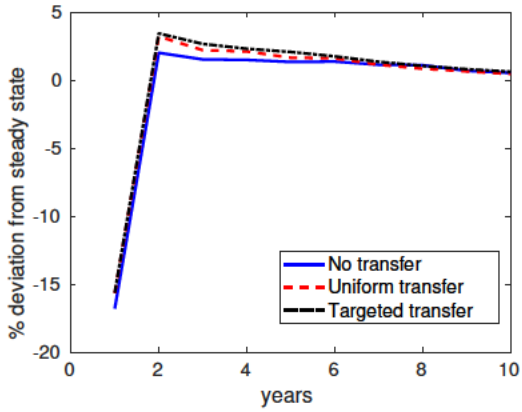
E.4 Sensitivity of aggregate employment to ϕ

In this section I derive Equation (17) presented in Section 6.3. With a slight abuse of notation, I sort the firms in the economy by their constraint status and define $\underline{c}$ as the cutoff below which all firms are constrained. Considering a measure 1 of firms, aggregate

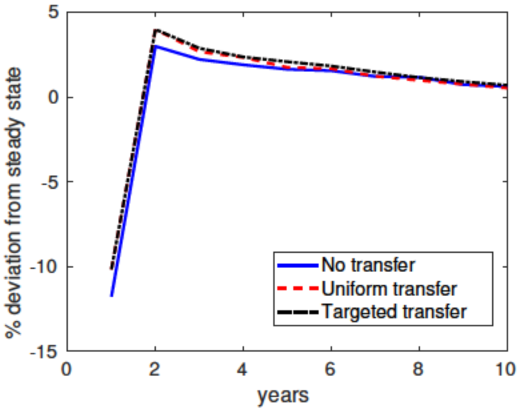
Figure A.3: Transitory transfers to firms during a purely transitory recession



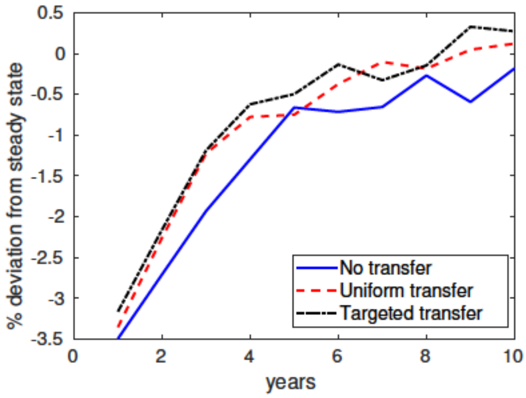
(a) Aggregate TFP



(b) Aggregate output



(c) Aggregate employment



(d) Aggregate consumption

Notes: See notes on Figure 4. The dash-dotted line depicts a targeted scenario in which only firms with below-median employment receive a lump-sum transfer.

employment is:

$$N = \int_{0}^{\underline{c}} n_i^c di + \int_{\underline{c}}^{1} n_i^u di$$

Then by the means of the Leibniz rule we get:

$$\frac{\partial N}{\partial \phi} = \int_{0}^{\underline{c}} \frac{\partial n_i^c}{\partial \phi} di + \int_{\underline{c}}^{1} \frac{\partial n_i^u}{\partial \phi} di + \frac{\partial \underline{c}}{\partial \phi} \left[n^c(\underline{c}) - n^u(\underline{c})\right]$$

The economy can be classified in three groups: already constrained firms with a positive partial-equilibrium MPH, firms becoming constrained due to the change in ϕ and unconstrained firms with a zero MPH. We decompose each employment response in two parts: (i) how employment changes for a given wage, (ii) and how changes in ϕ affect the wage and, in turn, employment.

$$\frac{\partial N}{\partial \phi} = \int_0^{\underline{c}} \left(\left. \frac{\partial n_i^c}{\partial \phi} \right|_w + \frac{\partial n_i^c}{\partial w} \frac{\partial w}{\partial \phi} \right) di + \int_{\underline{c}}^1 \left(\left. \frac{\partial n_i^u}{\partial \phi} \right|_w + \frac{\partial n_i^u}{\partial w} \frac{\partial w}{\partial \phi} \right) di + \frac{\partial \underline{c}}{\partial \phi} \left[n^c(\underline{c}) - n^u(\underline{c}) \right]$$

For unconstrained firms, it holds that $\left. \frac{\partial n_i^u}{\partial \phi} \right|_w = 0$. In order to shed light on the constrained firms' responses, we can exploit the binding financial constraints. I combine the non-negativity of dividends and collateral constraint to get: $y - wn\left(1 + \frac{1}{\phi}\right) = 0$. Then differentiating this by ϕ we get:

$$\left(\left. \frac{\partial n_i^c}{\partial \phi} \right|_w + \frac{\partial n_i^c}{\partial w} \frac{\partial w}{\partial \phi} \right) \left(MPL - w - \frac{w}{\phi} \right) - n_i^c \frac{\partial w}{\partial \phi} \left(1 + \frac{1}{\phi} \right) + \frac{w n_i^c}{\phi^2} = 0$$

Using the MPH formula, we get:

$$\left(\left. \frac{\partial n_i^c}{\partial \phi} \right|_w + \frac{\partial n_i^c}{\partial w} \frac{\partial w}{\partial \phi} \right) = \frac{\text{MPH}_i}{w} \left(\frac{w n_i^c}{\phi^2} - n_i^c \frac{\partial w}{\partial \phi} \left(1 + \frac{1}{\phi} \right) \right)$$

We substitute back into the previous equation for aggregate employment:

$$\frac{\partial N}{\partial \phi} = \left(\frac{1}{\phi^2} - \frac{1}{w} \frac{\partial w}{\partial \phi} \left(1 + \frac{1}{\phi} \right) \right) \int_0^{\underline{c}} \text{MPH}_i n_i^c di + \int_{\underline{c}}^1 \left(\frac{\partial n_i^u}{\partial w} \frac{\partial w}{\partial \phi} \right) di + \frac{\partial \underline{c}}{\partial \phi} \left[n^c(\underline{c}) - n^u(\underline{c}) \right]$$

Then we make use of the fact that unconstrained firms have a zero MPH, and note that the first integral is then equal to the product of average MPH and average size plus the covariance between MPH and firm size, which gives Equation (17).