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UNCONVENTIONAL MONETARY POLICY AND PRODUCTIVITY: EVIDENCE ON THE RISK-SEEKING CHANNEL FROM US CORPORATE BOND MARKETS

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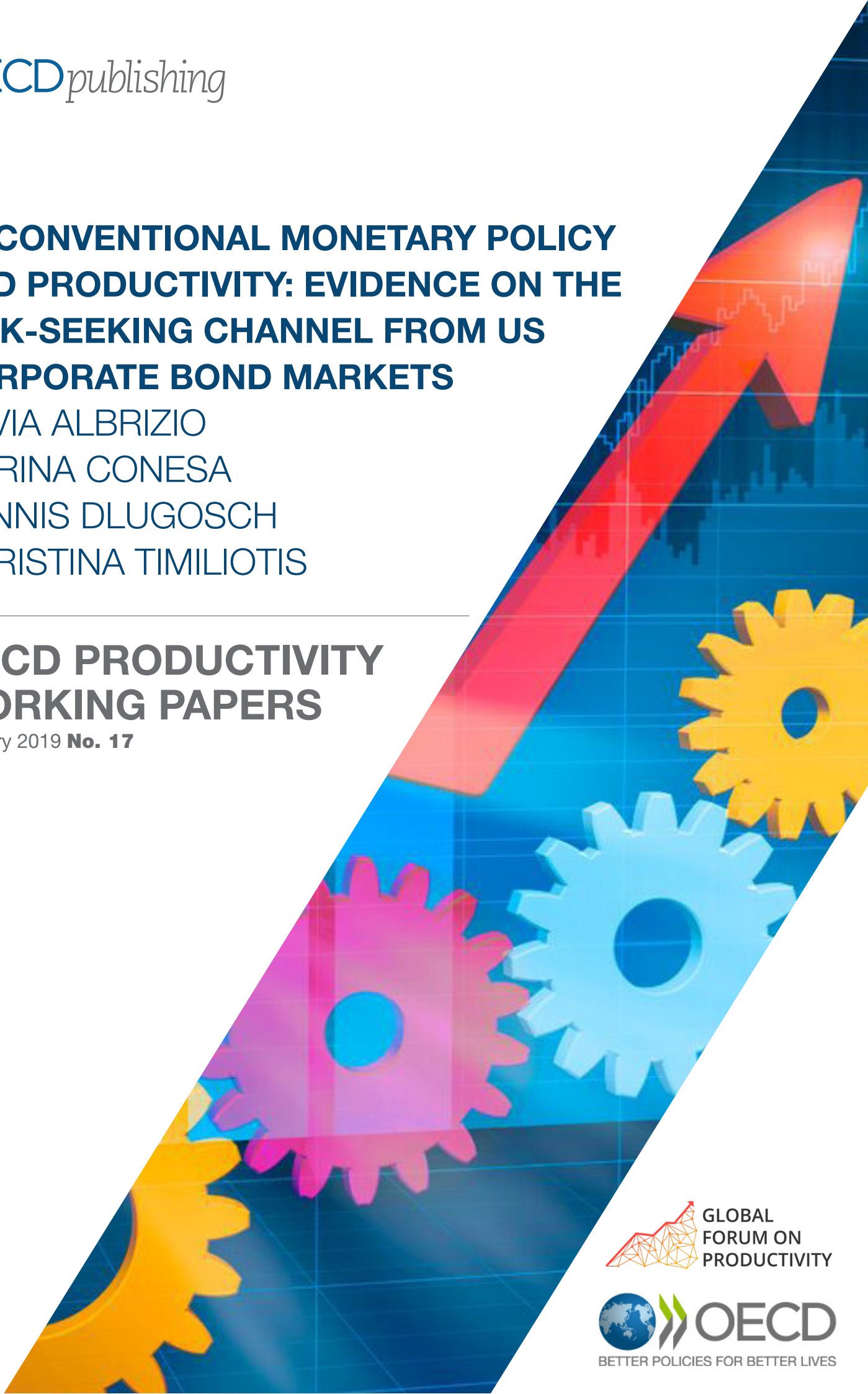

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ABSTRACT/RÉSUMÉ

Unconventional monetary policy and productivity: Evidence on the risk-seeking channel from US corporate bond markets

We examine the relationship between lax monetary policy, access to high-yield bond markets and productivity in the US between 2008 and 2016. Using monetary policy surprises, obtained from changes in interest rates futures in narrow windows around FOMC announcements, we isolate the increased access to high-yield bond markets relative to investment-grade bond markets that is due to unconventional monetary policy (UMP). We find that through the risk-taking channel, UMP has increased investors' appetite for high-yield US corporate bonds, thereby increasing access to high-yield bond markets for firms with a higher risk profile. Since the relationship between credit ratings and firm-level productivity is U-shaped, the aggregate effect on productivity is a priori unclear. Turning to the real economy, we thus analyse whether this additional access to finance had an effect on aggregate productivity by altering the reallocation of resources across firms. Our results show that unconventional monetary policy induced less investment in tangible capital by high-productive firms. However, before drawing conclusions on the net effects of UMP on aggregate productivity, we discuss a number of issues that this paper could not deal with due to data limitations, including prominently whether this apparent misallocation may have been offset by a shift in the composition of investments towards more intangible investment

JEL classification: D24, E52, G21, G32, G33, J63, O16 , O47.

Keywords: Unconventional monetary policy, productivity, capital reallocation, United States, bond markets.

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Politique monétaire non conventionnelle et productivité : observation du canal de la prise de risque sur les marchés des obligations d'entreprises aux États-Unis

Nous examinons la relation entre une politique monétaire laxiste, l'accès aux marchés obligataires à haut rendement et la productivité aux États-Unis entre 2008 et 2016. À partir des effets de surprise de la politique monétaire, calculés comme correspondant aux variations de taux sur les contrats à terme de taux d'intérêt sur les courts laps de temps entourant les dates des annonces du Comité de politique monétaire de la Réserve fédérale (FOMC), nous mettons en évidence un accès aux marchés obligataires à haut rendement élargi par rapport à l'accès aux marchés d'obligations de qualité d'investissement, qui est dû à la politique monétaire non conventionnelle. Nous constatons en effet que par le canal de la prise de risque, la politique monétaire non conventionnelle a accru l'appétence des investisseurs pour les marchés d'obligations d'entreprises à haut rendement aux États-Unis, permettant ainsi aux entreprises à profil plus risqué d'accéder plus largement aux marchés obligataires à haut rendement. Étant donné le profil en U de la courbe entre la note de crédit et la productivité au niveau des entreprises, l'effet global sur la productivité est a priori peu évident. Nous attachant ensuite aux effets sur l'économie réelle, nous examinons si cet élargissement de l'accès au financement a eu un effet sur la productivité globale par un redéploiement des ressources entre les entreprises. Nos résultats montrent que la politique monétaire non conventionnelle a induit moins d'investissements dans les actifs corporels de la part des entreprises très productives. Cela étant, avant de tirer des conclusions sur l'impact net de la politique monétaire non conventionnelle sur la productivité globale, nous examinons un certain nombre de questions que le présent article n'a pu aborder, faute de données disponibles, au premier rang desquelles la question de savoir si cette mauvaise affectation apparente des ressources peut avoir été compensée par un changement de composition de l'investissement au profit d'investissements plus importants dans les actifs incorporels.

Classification JEL : D24, E52, G21, G32, G33, J63, O16, O47

Mots-clés : Politique monétaire non conventionnelle, productivité, réaffectation des ressources, États-Unis, marchés obligataires.

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Unconventional Monetary Policy and productivity: Evidence on the risk-seeking channel from US corporate bond markets

By Silvia Albrizio, Marina Conesa, Dennis Dlugosch and Christina Timiliotis[1]

1. Introduction

1. The productivity slowdown the US has experienced since mid-2000s has triggered an intense debate among policymakers on the underlying causes without reaching a unique consensus (Gordon, 2012; Summers, 2016, Byrne et al., 2016). Within this debate, policymakers and academics' attention has only recently been drawn to the unintended consequences that macroeconomic policies might have had on productivity by meddling with the resource and "creative destruction" process of market economies (Obstfeld, 2018; Borio, 2018; Adalet McGowan et al., 2017a; 2017b).

2. Monetary policy constitutes an obvious candidate in this context given the relatively lax stance adopted by many advanced economies in this regard since the early 2000s, and notably following the financial crisis. As the world faced its worst economic crisis since the Great Depression, major central banks including the Fed, indeed introduced record-low short-term interest rates in an effort to promote economic growth. Conventional monetary policies became limited in their effectiveness, however, as short-term interest rates approached the zero lower bound. The Fed and other major central banks thus reverted to the use of unconventional monetary policies, including a series of large-scale asset purchases. Taken together, these measures significantly contributed to flattening the yield curve, and are likely to have fuelled investors' risk-taking behaviour (Borio and Zhu, 2008; Lhuissier and Szczerbowicz, 2017).

3. One of the channels through which investors' risk-taking could have materialized is the search-for-yield. This behaviour could unfold in a situation where investors have sticky return targets, but are unable to meet these due to low interest rates. This would then raise their incentive to take on more risk in order to meet future obligations. Examples of investors to which this applies notably include institutional investors, such as pension funds and insurance companies.

4. High-yield bonds, as opposed to government bonds, provide one way to boost the expected return profile at the cost of being more risky. Figure 1 shows that the demand for corporate bonds of this type has drastically increased over the past decade In particular, this increase in the supply of high-yield corporate bonds coincided with the scale-up of quantitative easing by the Fed and possibly opened up the bond market to firms with a high risk profile that may not have received financing otherwise. Implications on the real economy and on aggregate productivity of this increase in

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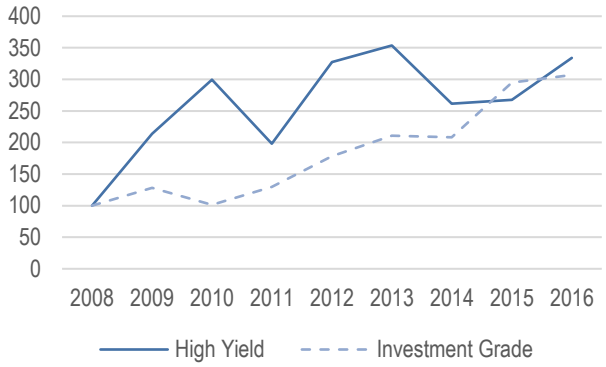
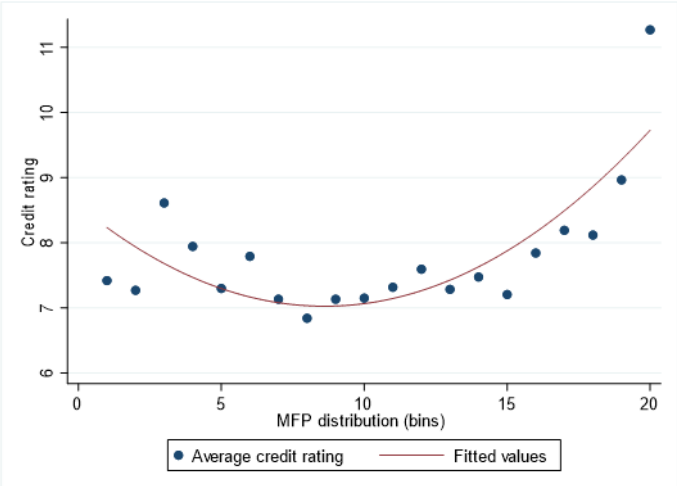
corporate bond issuance are a priori unclear, insofar as the relationship between credit ratings and productivity is non-linear, as shown by Figure 2, and several recent contributions to the literature (see for instance Aghion et al., 2018; Bakhtiari, 2017). Accordingly, the same low credit rating could mask two different types of high-leveraged firms: (i) low-productive companies with low profits, repayment capacity and investment ("zombies"), or (ii) high-productive firms with unproven operating histories, high borrowing and investment ("gazelles"). In sum, credit ratings thus cannot help to understand whether the increase in access to high-yield bond markets due to the risk-taking channel of monetary policy eventually facilitates or impedes a growth-improving reallocation of resources.

Figure 1. US corporate bond issuance: investment grade and high yield (2008=100)



Note: Data refer to non-convertible bonds of non-financial companies.
Source: Dealogic

Figure 2. Corporate bond ratings and the distribution of productivity



Note: Credit ratings are defined on a range from 21=AAA to 1=CC. We consider average credit ratings and multifactor-productivity performance by firm over the period 2008-16.The construction of MFP values is based on the Solow measure (see Gal, 2013). Data refers to consolidated data for US non-financial firms, only.
Source: Calculations based on Thomson Reuters Worldscope and Dealogic.

5. This paper sheds light on the empirical relationship between unconventional monetary policy and capital reallocation in the US using a two-stage approach. First, we assess to what extent the recent growth in supply of high-yield bonds relative to investment-grade bonds can be attributed to monetary policy shocks. Second, we test if the increased access to high-yield bond markets induced by expansionary monetary policy negatively weighed on capital reallocation, by allocating capital to low instead of high-productive firms. Given that the misallocation of resources has been associated with important losses in aggregate productivity (Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009), this finding would bear implications for the productivity slowdown debate.

6. The analysis is developed mirroring these two steps. Following the approach pioneered by Gertler and Karadi (2015), we identify shocks to monetary policy using surprises in interest rate futures on Treasury bonds. Surprises are computed as changes in interest rates futures in narrow windows around Federal Open Market Committees (FOMC) meetings, and are used to instrument the indicators of monetary policy (short and long interest rates of government bonds). Using a monthly structural VAR framework, we then identify the variation in the ratio of high-yield over investment grade gross bond issuance that can be attributed to monetary policy. Since higher demand for HY relative to IG bonds is expected to drive up the prices for HY bonds and decrease their yields, we define risk-taking as a simultaneous increase in the relative high-yield bond issuance and decrease in the spread. Contrary to conventional monetary policy which mainly acts on short term interest rates, UMPs are introduced with the ultimate aim of driving down longer term interest rates (Krishnamurthy and Vissing-Jorgensen, 2011). Our approach thus identifies shocks to unconventional monetary policies (UMP) by using interest rates on Treasury bonds with long maturities as monetary policy indicators.

7. Following the identification of UMP shocks, we use the estimated relative policy-induced increase in high-yield bond issuance (HY/IG) to assess its effect on reallocation. In line with canonical models of firm dynamics, we measure reallocation as the covariance between firm productivity and growth, captured by capital accumulation (see Foster et al., 2016; Decker et al., 2016). The intuition behind this model is that firms with a higher productivity should be able to attract more (financial) resources and grow faster. To test for the potentially distortionary effect of HY/IG shocks on resource allocation, we then augment this framework with an interaction between productivity and the relative change in high-yield bond issuance due to UMP shocks. Results show that unconventional monetary policy have favoured investment in tangible capital in the least productive firms, allowing them to accumulate fixed capital and grow disproportionally more than more productive ones. We further show that this heterogeneous effect on investment might result from the intrinsically higher propensity to issue HY bonds of less productive firms, pointing towards a potential crowding-out effect. A priori, the main finding from the reallocation model would point to a misallocation of resources. However, before drawing conclusions on the net effects on aggregate productivity, further research is needed to explore a number of issues that this paper could not deal with due to data limitations, including prominently whether this apparent misallocation may have been offset by the use of HY bond proceeds to finance productive intangible investment or other uses of proceeds in the most productive firms.

8. The remainder of this paper is organized as follows. Section 2 provides a brief overview of the evolution of corporate bond markets in the US since the 2000s and their relation to monetary policy. Section 3 further explains the monetary policy-productivity

channel explored in the paper and surveys the related literature; section 4 discusses our dataset; section 5 illustrates our empirical strategy; section 6 presents and discusses the empirical findings; and section 7 concludes.

2. The evolution of corporate bond markets in the US and its relationship with (unconventional) monetary policy

9. The extraordinary turmoil that hit global financial markets during the great financial crisis and the subsequently sluggish pace of economic recovery forced central banks around the world, including the FED, to take a number of *unconventional* steps to alleviate financial distress and support economic activity. Once the target federal funds rate was lowered to its effective zero lower bound towards the end of 2008 (Figure 3, Panel A), limiting the scope for further conventional monetary policy, the FED began to increase its monetary basis by purchasing large quantities of government debt securities in the secondary market (Figure 3, Panel B).[2] Both in terms of scale and prominence, this step was considered unprecedented (Gilchrist and Zakrajsek, 2013).

10. The above mentioned large-scale asset purchase program (LSAP), which made headlines under the name of "Quantitative Easing", involved the purchasing of (i) debt obligations of the government-sponsored housing agencies (GSEs), (ii) mortgage-backed securities (MBS) issued by those agencies, and (iii) coupon securities issued by the Treasury. Contrary to conventional monetary policy tools, these programs were targeted at long-term assets, with a view to lowering long-term interest rates, which had remained largely unaffected. Besides the launch of the three LSAP programs over the period 2008-12 (QE1, QE2, QE3), the FED later also introduced the Maturity Extension Program (MEP) that further extended the average maturity of its holdings of securities, again, with the aim of putting further downward pressure on long-term interest rates (see Fawley and Neely, 2013, for a more detailed description of these programs).

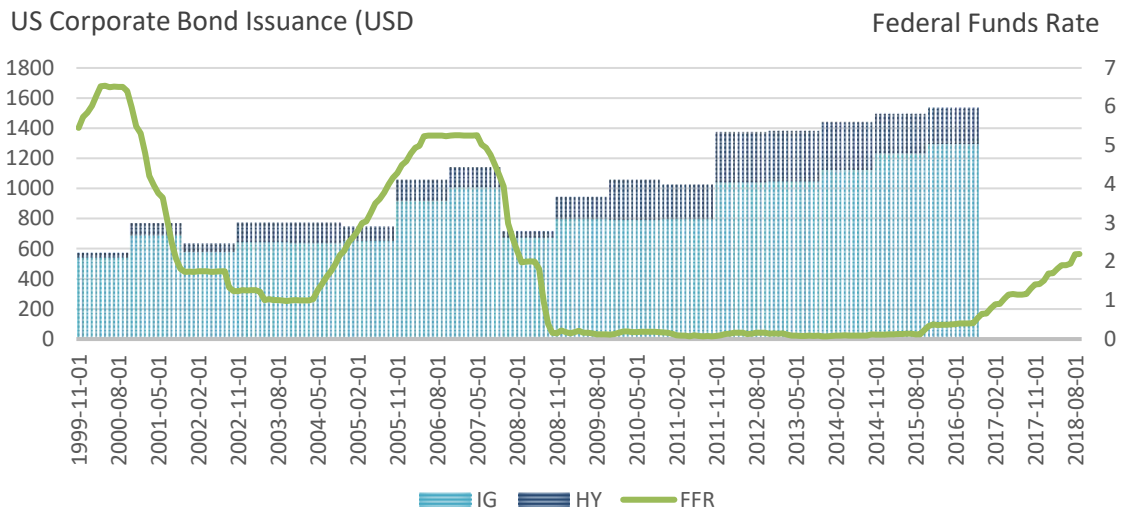
11. Further to historically low interest rates, debt security markets synchronously endured a steady retrenchment in bank lending. Many banks struggled to cope with the legacy of the crisis, weakened by trading losses and credit provisions. On top of this, stricter prudential regulations and higher capital requirement, as well as a more prudent stance towards risky borrowers, trimmed their lending capacity. Together, these circumstances contributed to creating an environment that boosted the demand for corporate debt securities, promising relatively higher returns, thereby boosting the attractiveness of market debt as a further financing option for non-financial corporations.

12. While the deepening of bond markets is per se beneficial for firms, considering that it increases funding diversification and lengthens debt maturity, the post-crisis surge in bond finance has been accompanied by a decrease in credit quality, as evidenced by the rise in the share of high-yield corporate bonds (cf. Figure 1). The real effects of this development have not yet been gauged, but there are good reasons to believe that debt markets may have become more fragile by favouring firms with low growth potential, thus exposing bond holders to greater risks.

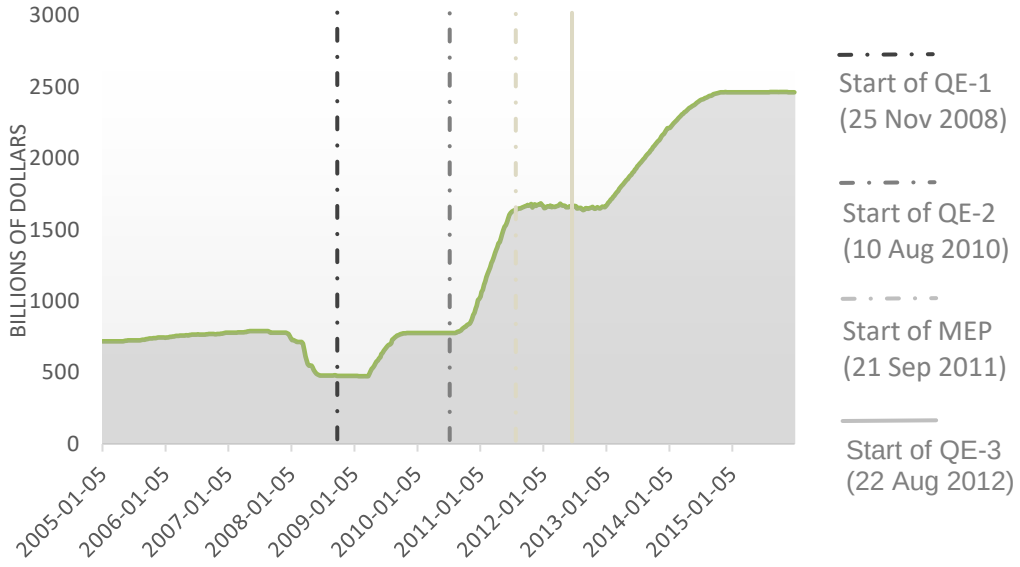
[2] Unconventional monetary policy tools further include *forward guidance* – the verbal assurance of central banks on their intended monetary policy actions.

Figure 3. Unconventional monetary policy and the corporate bond market

Panel A: The inverse relation between corporate bond issuance and the Federal Funds Rate



Panel B: US Treasury Securities held by the Federal Reserve (all maturities)



Note: Federal Funds Rate data are based on monthly, not seasonally adjusted data. Corporate bond issuance data cover non-convertible high-yield and investment grade bonds (Panel A). Total face value of US Treasury securities held by the Federal Reserve (Panel B).
Source: Federal Reserve Bank of St. Louis; Securities Industry and Financial Markets Association (SIFMA) based on Thomson Reuters

3. Related literature and the economics behind the risk-seeking channel

13. Given the complexity of the transmission channel analyzed hereafter, which involves monetary policy, financial instruments and resource reallocation, the paper relates to several strands of literature. To our best knowledge, no single paper so far assessed all three factors in conjunction.

3.1. The broader finance-productivity link

14. This paper adds to a body of research investigating the role of financial factors on productivity. Empirical evidence generally suggests that financial frictions tend to reduce aggregate productivity and innovative activity (Buera et al., 2011; Duval et al. 2017; Heil, 2017; Gopinath et al. 2018; Demmou et al, 2018), including economy's churn rates, i.e. the sum of births and deaths of enterprises, one critical indicator of a well-functioning reallocation process (Adalet McGowan et al. 2017a, 2017b; Andrews and Petroulakis, 2017). Our paper also relates to the literature on the effects of differences in capital structures on firm-level investment and innovation where the empirical evidence shows that in countries which rely more on debt- than equity financing, the level of innovation tends to be significantly lower (Kortum and Lerner, 1998; Brown et al., 2009; Hsu et al., 2014; Acharya and Xu, 2017).

3.2. The real economy effects of unconventional monetary policy

15. The contribution of Foley-Fisher et al. (2016) is closest to our paper in terms of combining the risk-taking channel of unconventional monetary policy and its effects on firm-level investment. Contrary to us, their analysis is confined to a specific part of the unconventional monetary policy program of the Fed, namely the Maturity Extension Program (MEP). Supported by evidence showing that the riskiness of newly issued corporate bonds increased significantly during the MEP program, the authors confirm that expansionary monetary policy was accompanied by an increase in risk-taking. Moreover, the authors show that the MEP boosted investment for financially constrained firms, although no connection is made between these results and their effects on allocative efficiency and productivity. Another main distinction constitutes the fact that Foley-Fisher et al. (2016) capture monetary policy through a dummy variable for when the program occurred as opposed to our framework, which also captures differences in the strength of the monetary policy stimulus.

16. As for the relation between unconventional monetary policy and financial instruments, we compare to Lhuissier et al. (2018). Using a similar proxy SVAR framework, the authors show that expansionary monetary policy incentivizes firms to raise capital through corporate bonds rather than bank loans. Contrary to our study, however, their empirical framework rests on aggregate data. Constrained by this limitation, no implication is thus derived with regards to the effect of this change in firms' capital structures on allocative efficiency and firm-level productivity.

3.3. The economics of the risk-seeking channel

17. Expansionary unconventional monetary policies, by lowering interest rates across the entire yield curve, may affect the risk perception and the risk-tolerance of investors and induce them to bear a higher degree of risk in their portfolios. This risk-taking behavior tends to be enhanced in an environment where not only current but also future returns are very low due to unconventional monetary policy. Borio and Zhu (2008) suggest that there are at least three ways through which the risk-taking channel of monetary policy may operate: via credit expansion due to the increased valuation of collateralized assets; via the decreased attitude towards risk due to the compression of risk premia fostered by the central bank communication; and via the search for yield, as narrowly defined, due to the incentives created by the structure of some economic contracts in the financial industry.

18. In this respect, the compensation scheme of professional money managers, whose premium depends on whether the nominal returns of their portfolios are higher than a predetermined specific threshold (Rajan, 2006), creates a motive to take on more risk, particularly in a low interest environment. Similar incentives could be brought about by remuneration scheme of pension funds or insurance companies, which have to meet sticky nominal return targets in order to be able to meet future obligations. Bekaert et al. (2013) provide evidence of a time-varying risk appetite by decomposing the VIX index, which consists of a weighted average of implied volatilities of S&P 500 index options, into risk aversion and uncertainty. They show in a monthly VAR that shocks to monetary policy significantly decrease risk aversion. Ceteris paribus, with lower attitudes towards risk, investors take on more risk.

19. The literature provides ample empirical evidence for the risk-taking channel of monetary policy. Jimenez et al. (2014) use data from the Spanish credit registry to show that lower overnight interest rates lead banks to increase loan grants to ex ante riskier borrowers. Ioannidou et al. (2014) exploit the fact that in the dollarized economy of Bolivia monetary policy is exogenous to show that expansionary monetary policy increases loans grants to firms with ex ante lower credit ratings. Similarly, Morais et al. (2015) show that accommodative foreign monetary policy induces foreign banks to grant more loans to Mexican firms with ex post higher default risk, thereby suggesting that risk-taking also operates internationally. Moreover, Hau and Lai (2016) exploit differences of local tightness of monetary policy in the Euro area due to differences in local inflation and show that in countries with lower real rates, investors significantly favor to invest in ex ante riskier equity mutual funds.

4. Data

20. The analysis focuses on the corporate bond market in the United States from 2008 to 2016 to study the effects of unconventional monetary policy on primary corporate bond markets and the real economy. Our sample consists of listed non-financial companies. It is constructed using two major datasets: Dealogic, which provides data on bond deals, and Worldscope, which contains annual balance sheet data.

4.1. Bond issuance data

21. Data on corporate bond deals are sourced from Dealogic, which provides information on gross issuance in primary corporate bond markets broken down by credit rating. The database provides information on each deal such as maturity date, years to maturity, yield to maturity, rating, coupon rate, use of proceeds, etc. Additionally, it includes sufficient information on the bond issuer and its parent company such that we can identify the set of non-financial companies domiciled in the US issuing a bond. As the focus of our study lies in analyzing the effects of US unconventional monetary policy on corporate bond markets, this step is crucial as it allows to narrow down the set of firms which are most impacted. By considering the nationality, the detailed business class and the sector of both the issuer and the parent companies, we are able to identify the relevant productive unit.[3] This is a fundamental step as, although the analysis focuses on non-financial companies, some non-financial parent companies may issue bond via

[3] Annex A provides a more detailed description of the selection criteria and the steps followed to clean the database. The final sample includes corporate bond deals issued in US, according to Dealogic deal nationality, by listed non-financial firms belonging to the sectors listed in Annex A Table A2.

financial vehicles. Without considering this information, one could, for instance, wrongfully include an issuer who is a US financial vehicle with a foreign non-financial parent corporation, or exclude a US-based non-financial parent corporation that obtained resources through the issuance of a foreign-based or US-based financial vehicle. A closer look at the data reveals that in about 6% of the cases non-financial private corporations rely on domestic and foreign financial vehicles for their bond issuance operations.[4]

22. As we intend to examine the risk-seeking channel induced by unconventional monetary policy, we separate all corporate bond issuance in two broad credit rating groups, high-yield and investment-grade bonds. Relative to their investment grade counterparts, high-yield bonds offer greater coupon payments in order to compensate investors for the higher risk of default. Typically, companies issuing HY bonds are highly leveraged or are experiencing financial difficulties, though young and small companies may also fall into this category as investors require higher returns in order to be compensated for more volatile future cash-flows or for the uncertainty over their business model due to a lack of good past performance. Once this selection is made, we aggregate firm-level bond issuance by month and broad credit ratings in order to perform the proxy-SVAR at the monthly level.

4.2. Balance-sheet data

23. Balance-sheet information and multifactor productivity are based on consolidated firm-level data from Thomson Reuters' Worldscope – a database which provides data on all publicly traded firms in 75 countries starting in 1985. The main advantage of Worldscope lies in its potential to draw from a rich set of firm-level controls and its reliability, as listed companies mandatorily have to report a variety of firm characteristics in their balance sheets, many of which are also publicly disclosed in the form of Securities Exchange Commission (SEC) filings. Against this background, Worldscope has been used frequently to study firm-level investment (e.g. Kang and Piao, 2015; Dlugosch and Kozluk, 2017).

24. A main disadvantage of Worldscope is that it is constrained to listed firms and thus excludes by design firms not traded on stock exchanges. In the context of our analysis, one could argue that the restriction to publicly listed firms may be problematic as firms entering the bond market do not per se need to be listed on a stock exchange. In reality, the overwhelming majority of corporations issuing bonds however are either publicly listed or the subsidiary of a listed firm. Thus, our sample of non-financial companies with a rating and public listing represents 94.10% of the average yearly total bond issuance over the 2008-2016 period.

25. Since the focus is on the US, this disadvantage is further diminished, given that the majority of US firms seek access to external funds through market-based financing as opposed to bank-based financing and thus, the majority of firms are actually publicly

[4] To name one example, the parent company Ford Motor Co which is based in US issues bonds both through issuers based in US such as Ford Motor Credit Co LLC and issuers based outside US as Ford Motor Credit Canada Ltd or Ford Credit Australia Ltd.

traded firms (Cihak et al., 2013; Demirguc-Kunt and Maksimovic, 2002).[5] In sum, most US firms in Dealogic are thus contained in the Worldscope database.

26. Issues arising from the underrepresentation of certain firm types and industries could nevertheless emerge as the changing nature of investment behaviour of firms with greater access to capital due to bond issuance could spread to the whole universe of firms in the US, including very young or small, or more generally non-listed firms. In the absence of available balance-sheet data for those, however, this paper only captures dynamics within the sample of listed firms.

4.3. Matching

27. While the core of the analysis does not require the matching of the two datasets per se, we extend the discussion of our results to investigate the link between firm and bond characteristics (see section 5.3 and 5.4). In particular, we assess firms' propensities to issue high-yield bonds based on their productivity performance, and investigate whether the use of proceeds from bond issuance differs across firms with different productivity profiles. Since Worldscope and Dealogic operate with different company code identifiers, we use the bond's ISIN to single out a common identifier at the firm-level.[6] In cases where this proves impossible, we manually merge the two dataset by names. After cleaning and filtering both datasets, we are able to match 95% of observations in Dealogic with Worldscope records. In all cases, this relates to the status of the firm issuing the bond, which had not yet been publicly listed and therefore could not be covered by Worldscope. Dealogic data are aggregated at the yearly level to pair them with the firm's balance sheet data.

4.4. Productivity measurement

28. To calculate firm-level multi-factor productivity we use a Solow residual approach, where MFP is measured as the residual of a standard Cobb-Douglas production function. Along the lines of Gal (2013), data on value added are externally imputed as the sum of factor incomes going to employees, (wL, i.e. average labour cost times the number of employees), and to capital owners (rK, i.e. the rate of return times the capital stock). While the number of employees and information on the capital stock (measured as the deflated book value of fixed tangible assets) can be sourced from Worldscope, data on the cost of employees by firm are not available, and thus obtained as industry-average from the OECD STAN database. All monetary variables are deflated using 2-digit US-specific industry deflators constructed from OECD STAN and national accounts. As usual, measuring productivity comes with a number of caveats, most notably, the unobserved quality and utilisation of inputs, as well as unobserved differences in market power (Gal, 2013).

[5] A number of explanations have been offered as to why access to corporate bond market tends to be linked with listings, including management's prior experience with public securities; stricter corporate governance requirements making the form less prone to debt-related moral hazard concerns in the eyes of investors; and the absence of additional costs for producing financial statements in accordance with regulatory rules and requirements (OECD, 2015a).

[6] ISIN: International Securities Identification Number (https://www.isin.org/isin/). CUSIP: Committee on Uniform Securities Identification Procedures (https://www.cusip.com/cusip/about-cgs-identifiers.htm)

5. Empirical approach

5.1. The proxy SVAR framework

29. We use a vector autoregression (VAR) framework with macroeconomic and financial variables to study the effect of monetary policy on issuance of corporate bonds in primary markets. The main empirical challenge lies in identifying the monetary policy shock. Standard practice relies on timing restrictions in order to obtain monetary policy shocks which are orthogonal to other shocks in the VAR. However, in a VAR setup that simultaneously employs macroeconomic and financial variables this procedure appears less appropriate as it would imply that financial variables react to monetary policy only with a lag which seems implausible (Gertler and Karadi, 2015). Therefore we make use of recent advancements in the literature on the identification of monetary policy and use a proxy SVAR approach.

30. In particular, we follow Mertens and Ravn (2013) and Gertler and Karadi (2015) who show that identification of a shock within a VAR can be achieved through a proxy variable, i.e. information external to the VAR. As long as the proxy is correlated with the shock we seek to identify but orthogonal to other shocks we can use instrumental variable regressions to uncover the impact of a monetary policy shock on any other variable.

31. In order to illustrate the underlying mechanics of the proxy SVAR, consider the following simple example of a reduced-form VAR representation with two variables and one lag [7]:

$$\begin{pmatrix} y_{1,t} \\ y_{2,t} \end{pmatrix} = \begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix} \begin{pmatrix} y_{1,t-1} \\ y_{2,t-1} \end{pmatrix} + \begin{pmatrix} u_{1,t} \\ u_{2,t} \end{pmatrix} \quad \textbf{(1)}$$

where y_1 can be any economic or financial variable, y_2 is an indicator for monetary policy, b_{ij} reduced-form coefficients and $u_1$and u_2 reduced-form shocks. We can write the reduced-form shocks as a function of the structural shocks, $e_1$and e_2:

$$\begin{pmatrix} u_{1,t} \\ u_{2,t} \end{pmatrix} = \begin{pmatrix} s_{11} & s_{12} \\ s_{21} & s_{22} \end{pmatrix} \begin{pmatrix} e_{1,t} \\ e_{2,t} \end{pmatrix} \quad \textbf{(2)}$$

32. In order to identify the monetary policy shock, we need to find estimates of the structural coefficients s_{12} and s_{22}. The proxy SVAR approach provides us with these estimates if we can find a further variable external to the VAR which fulfills two conditions. First, the instrument needs to be correlated with the structural monetary policy shock, e_2, but simultaneously uncorrelated to the other shock e_1. We can then use instrumental variable regressions to obtain an estimates of the ratio of $\frac{s_{22}}{s_{12}}$:

$$u_{1,t} = \frac{s_{22}}{s_{12}} \widehat{u_{2,t}} + w_t \quad \textbf{(3)}$$

[7] The generalisation to more than two variables and more than one lag is straightforward and does not change any of the above conclusions, see Gertler and Karadi (2015).

where $w_t$is a white noise error term. Intuitively, the first-stage of the instrumental variable approach forms the prediction $\widehat{u_{2,t}}$ which can be interpreted as movements in monetary policy not anticipated through variation in other variables, i.e. surprises in monetary policy. The coefficient s_{12} can be calculated algebraically from the reduced-form variance-covariance matrix without further identifying restrictions. Eventually we obtain an estimate of s_{22}, the structural coefficient of interest.

33. Following the approach of Gertler and Karadi (2015) we use high-frequency surprises in interest rates around Fed announcements as instruments to identify the monetary policy shock. Since we do not have access to intra-day data, in line with Hansson and Stein (2015), we calculate surprises in daily windows around Fed announcements. The underlying identifying assumption is thus that no other factors besides monetary policy affect interest rates within this window. As a last step, we need to mensualize the high-frequency surprises around Fed announcements to match the monthly frequency of the VAR. Here, we follow Gertler and Karadi (2015) and create monthly average surprises by cumulating all FOMC day surprises, then take monthly averages of this series and get monthly average surprises through a further first-difference transformation. This procedure also takes into account that not all FOMC meetings take place on the same day within a month.

34. Our identification strategy relies on the assumption that the external instruments are uncorrelated with all other shocks than the monetary policy shock. However, two potential confounding factors could potentially impede causal inference. First, some important economic releases occur on the same day as the FOMC announcement and therefore could be picked accidently up by our instrumental variable regressions. Second, the Fed might have knowledge that market participants do not have, and, as a consequence, FOMC announcements could also trigger reactions by investors unrelated to the conduct of monetary policy. Using intra-daily data, e.g. minute-by-minute data, in narrow windows around the FOMC announcements could potentially, alleviate these concerns. However, in the lack of access to intra-daily data, following previous research, we use daily changes in interest rates around FOMC announcements (e.g. Hansson and Stein 2015; Lhuissier and Szczerbowicz, 2017) to identify shocks to monetary policy. Further, since we focus on long-term interest rates, Hansson and Stein (2015) argue that since market participants only react to changes in monetary policy with a lag, daily changes are preferable.

35. As we seek to analyze the impact of expansionary monetary policy on primary and secondary bond markets, we use a monthly VAR consisting of the following vector of variables:

$$[\log IP_t, \log CPI_t, i_t, \frac{HY_t}{IG_t}, r_{hy,t} - r_{ig,t}] \quad \textbf{(4)}$$

where IP stands for industrial production, CPI for inflation, i_t for a monetary policy indicator (a government bond rate), $\frac{HY_t}{IG_t}$ for the ratio of total high-yield issuance of US domestic non-financial corporate bonds over total investment-grade issuance of US domestic non-financial corporate bonds and $r_{hy,t} - r_{ig,t}$ for the spread between yields on non-financial HY corporate bonds and non-financial IG corporate bonds. An increase in the HY-IG spread indicates that prices for HY bonds decreased relative to IG bonds, and vice versa.

36. Using the proxy SVAR, we test whether expansionary unconventional monetary policy increases investors' appetite for risk in corporate bond markets. A significant increase in $\frac{HY_t}{IG_t}$ would show that issuance of high-yield corporate bonds reacts stronger to expansionary unconventional monetary policy than investment-grade corporate bonds, indicating an increase in riskiness of the composition of new US domestic non-financial corporate bonds. In order to check whether the risk-seeking behavior is actually driven by a change in risk appetites of investors, we further look at the HY-IG spread. An increase in relative high-yield bond issuance ($\frac{HY_t}{IG_t}$) and a simultaneous decrease in the spread ($r_{hy,t} - r_{ig,t}$) would provide evidence for greater investors' demand of HY corporate bonds, as the increased demand for HY bonds relative to IG bonds would drive up the prices for HY bonds and decrease their yields.

37. Last, we experiment with a slightly different VAR specification where we substitute $r_{hy,t} - r_{ig,t}$ with the excess bond premium spread instead, EBP_t, as in Gertler and Karadi (2015). The Gilchrist and Zakrajasek (2012) excess bond premium spread is an indicator for refinancing conditions on secondary corporate bond markets cleaned for bond defaults and as such a proxy for refinancing conditions absent financial frictions induced by the fear of default. By contrasting results from a VAR specification with yield spreads and with the excess bond premium, we can analyse the mechanism through which monetary policy induces risk-taking, i.e. through a reduction of yields or through lower (perceived) default risk.

5.2. VAR Estimation and the choice of the monetary policy indicator and instrument

38. We derive the structural coefficients of a monetary policy shock in two steps. First, we estimate the reduced-form VAR equation by equation with OLS and save the innovations from the reduced-form regressions. For each variable in the VAR but the monetary policy indicator, we run an instrumental variable regression of the innovation of the variable we want to examine, e.g. high-yield bond issuance relative to investment-grade bond issuance, on the innovation of the monetary policy indicator. In this instrumental variable regression, the first stage isolates movements in the monetary policy indicator solely due to surprises in interest rate futures and thus disentangles the surprise component from other confounding factors. Second, the estimated coefficients are used to obtain the structural coefficient estimates that are used to study the impulse response functions. These two steps allow to compute a time series of the part of $\frac{HY_t}{IG_t}$ induced by UMP, which can be included in the firm-level reallocation model.

39. Since our focus is on the period of unconventional monetary policy in the US, we seek to run the instrumental variable regressions over the same period. In line with Lhuissier and Szczerbowicz (2017), we choose a starting point for our structural analysis shortly before the announcement of the Fed of the first QE program, i.e. 2008M10. Since we have longer time series for all variables in the VAR, we experiment with two estimation windows for the estimation of the reduced-from coefficients. First, we estimate the reduced-form on the same time period as in the structural analysis, i.e.

starting in 2008M10.[8] Second, as a robustness check, we use the full time series available in Dealogic from 1993M1 to estimate the reduced-form.

40. In addition to the dates of FOMC announcements, we extend the set of important dates with a list of further Fed communications from Rogers et al. (2014). This list includes speeches by B. Bernanke with further information on the future conduct of monetary policy. The additional dates added to the list of FOMC announcement dates are 25/11/2008 (Fed announces purchases of MBS and Agency bonds), 01/12/2008 (Bernanke states Treasuries may be purchased), 27/08/2010 (Bernanke Speech at Jackson Hole), 15/10/2010 (Bernanke Speech at Boston Fed), 26/08/2011 (Bernanke Speech at Jackson Hole), 31/08/2012 (Bernanke Speech at Jackson Hole) and 22/05/2013 (Bernanke Testimony). However, results also hold if we do not add these further dates.

41. We use a generic four-lag VAR to determine the optimal combination of monetary policy indicator and instrument. As we focus on unconventional monetary policy in the US and consistent with the view that QE should flatten the yield curve, we restrict the set of potential monetary policy indicators to long-term Treasury bonds. In order to avoid running into a problem with weak instrument, we estimate a reduced-form VAR for different indicators of monetary policy, i.e. for Treasury bonds with different long maturities, and then check the statistical properties of the results of the first-stage of the instrumental variable regression, i.e. the regression of the innovation in the monetary policy indicator on the instrument. Since we do not have access to intraday data for US long-term government bonds, we follow Hansson and Stein (2015) and compute daily surprises[9] around Fed announcements.

5.3. Monetary policy shocks and capital reallocation

42. In the second step, we use our estimate of the evolution in the $\frac{HY_t}{IG_t}$ ratio due to monetary policy to study allocative efficiency on capital markets, i.e. whether more productive firms increase their investment by larger amounts as compared to less productive firms. We obtain a time series of the $\frac{HY_t}{IG_t}$ ratio that is solely due to surprises in monetary policy by:

$$\frac{HY_t^{MP}}{IG_t^{MP}} = s^{\frac{HY}{IG}} \times \widehat{u_t^{MP}} + w_t \qquad \textbf{(5)}$$

where $\frac{HY_t^{MP}}{IG_t^{MP}}$ is the new time series of $\frac{HY_t}{IG_t}$ ratio due to monetary policy, $\widehat{u_t^{MP}}$ the variation in the reduced-form innovation of the monetary policy indicator which is solely driven by the surprises and thus orthogonal to the other shocks in the VAR, and $s^{\frac{HY}{IG}}$ the

[8] To make sure the lags in the VAR do not move the estimation window beyond the 2008M10 starting point and thus potentially excluding relevant FOMC announcements, we choose a starting point for the reduced-form estimation such that incorporating all lags, the first data point of the innovations corresponds to 2008M10.

[9] Specifically, we compute the surprises around a Fed announcement as $surprise_t = r_{t+1} - r_{t-1}$, where r is the yield on a government bond.

structural coefficient we obtained from the instrumental variable regressions and from information of the reduced-from variance-covariance matrix. Since the firm-level model relies on balance-sheet data which usually comes at an annual frequency, we aggregate the estimated monthly time series of $\frac{HY_t^{MP}}{IG_t^{MP}}$ by summing all values within a year.[10] For matters of simplicity, we will refer to the ratio $\frac{HY_t^{MP}}{IG_t^{MP}}$ as "HY shock" for the rest of the analysis.

43. To test for potential distortionary effects of UMP-driven changes in the HY shock on resource allocation, we augment the canonical model of firm dynamics (see Foster et al., 2016; Decker et al., 2016) with the HY shock, obtained from the proxy SVAR. The basic idea behind these models is that conditional on firm size, firms with a higher productivity should attract more (financial) resources and grow faster. As a result, highly productive firms would tend to grow at the expense of unproductive firms. In equilibrium more productive firms should be characterised by higher market shares, a concept known as allocative efficiency (Andrews and Cingano, 2014). An economy where allocative efficiency is distorted would imply that resources get trapped in unproductive firms therefore impeding the growth of productive firms and putting downward pressure on aggregate productivity growth. If monetary policy induced HY bond issuance had an influence on the capital reallocation dynamics, it would thus be captured by the interaction between the HY shock and lagged multi-factor productivity.

44. We embed our empirical framework in an otherwise standard Tobin's Q investment model. The Tobin Q model implies that firms should invest if the market value of a marginal unit of capital exceeds its replacement costs. Following the literature, Tobin's Q is calculated as the sum of market value of assets and debt divided by total assets. All information regarding potential investment projects is summarized in Q, as the Q quantifies the increase in the discounted firms' profits and thus the increase in total firm value if a firm buys an additional unit of capital. However, the Q model relies on certain assumptions and may not well control for firm-level investment demand when asset prices are subdued due to deviations from fundamental value, i.e. in times of fire sales. Further, firms might have incentives to invest aside internal investment demand, e.g. through taxes, which are not captured by the Q model.

45. The resulting baseline specification is as follows:

$$\frac{I_{i,j,t}}{K_{i,j,t-1}} = \alpha + \beta_0 \times Q_{ij,t-1} + \beta_1 \times MFP_{ij,t-1} + \beta_2 \times MFP_{i,j,t-1} \times HYshock_t + \sum_l \gamma_l x_{i,j,t} + \delta_j + \delta_t + \epsilon_{it} \quad \textbf{(6)}$$

where $\frac{I_{i,j,t}}{K_{i,j,t-1}}$ denotes tangible investment of firm *i* in sector *j* at time *t* scaled by the tangible capital stock in period *t-1*, MFP_i is the index of multi-factor productivity of firm *i*, and $x_{i,j,t}$ stands for other firm-level characteristics. Our baseline specification includes Tobin's Q and controls for firm-specific demand-effects, measured by contemporaneous sales over lagged capital (see IMF, 2015 for comparison). To diminish

[10] Results are qualitatively similar if we aggregate the monthly values by taking their yearly mean.

concerns of reverse simultaneity, we use lagged values of MFP and Tobin's Q. To check for robustness, we also augment the baseline specification with a broader set of control variables in order to alleviate concerns with omitted variable bias.

46. Allocative efficiency would imply that β_1, the sign of the estimated coefficient of $MFP_{ij,t-1}$, is positive, so as to reflect that more productive firms attract more resources. The expected sign of the interaction between productivity and additional HY corporate bond issuance due to monetary policy, β_2, on the other hand, is a priori ambiguous, given that the relationship between productivity and credit ratings tends to follow an inverse U-shape (see Figure 2). The main point of our analysis it to establish whether low, or high productive firms effectively benefit from an increased demand in HY bonds relative to IG bonds and as such shed light on the impact of unconventional monetary policy on allocative efficiency. A positive and significant β_2 coefficient would suggest that search for yield induced by monetary policy benefits mostly highly productive firms, thereby pointing to an increase in allocative efficiency. The reverse would be suggested by a negative and significant coefficient, though with caveats that will be discussed later.

47. In the baseline specification, we control for unobserved shocks common to all firms and sector-specific shocks through the use of year and sector fixed effects (δ_j and δ_t). These could emanate from sector-specific regulations affecting the overall attractiveness to invest in one particular sector, or from cyclical influences, pertaining to the whole economy at a specific point in time. We also experiment with a more lenient approach that allows us to further incorporate the HY shock as a standalone variable, by using sector fixed effects only. To the extent that patterns of resource allocation tend to reflect factor adjustments within sectors (see Foster et al., 1996), the most challenging fixed effects structure we can employ in this analysis includes industry, year and industry-year fixed effects.

48. We assess the sensitivity of our results in a number of ways. First, we try to reduce the possibility that the coefficient estimates could suffer from omitted variable bias. In particular, we augment our regression baseline to account for a firm's age and size, as measured by number of employees. Similarly, omitted variables bias could arise due to the possible influence of confounding macroeconomic factors. Our baseline specification at most captures shifts at the industry, year or industry-year level. Macroeconomic shifts pertaining to the whole economy, however, are not taken into consideration, and could bias the effect of UMP (captured by HY shocks) on capital accumulation. To address this concern, we further add an interaction between GDP (as a catch-all variable) and MFP to our regressions.

49. Expansionary unconventional monetary policy might not only affect the amount of bond issuance but could also affect the likelihood to actually issue a corporate bond. Therefore our model should account for the selection bias resulting from firms who start to issue bonds due to expansionary monetary policy. Thus, we use a two-stage Heckman regression model (Heckman, 1979), in which the first stage assesses firms' propensity to issue high-yield bonds and use this information in a second stage regression, which is equivalent to the baseline specification to correct for the selection bias.

6. Results

6.1. Did expansionary monetary policy increase demand-driven risk-seeking behaviour in corporate bond markets?

50. Table 1 shows the results of the first-stage regressions for two different monetary policy indicators, the 5Y and 10Y real rate. Column 1 of Panel A and B depict that both mensualized daily surprises in 3Y real rates and 5Y real rates tend to be highly correlated with a 5Y real rate monetary policy indicator. Further, we find similar results for the 10Y real rate in column 2 of Panel A and B. The following columns then show that these results are robust to changes in the VAR specification and different estimations windows. Specifically, column 3 and 4 of Panel A and B include a different measure of the spread between high-yield and investment-grade bonds. Lastly, column 5 and 6 show that the results change little when we estimate the reduced-form VAR over the full period.

51. In order to choose the optimal combination we opt for a decision criterion that relies on the F-test of the joint model. Stock, Wright and Yogo (2002) recommend a threshold of 10 for the F-statistic of the first-stage regression such that problems with weak instruments do not impede the credibility of our results. Then, in line with Gertler and Karadi (2015) and Lhuissier and Szczerbowicz (2017), we choose the combination of monetary policy indicator and instrument with the highest F-statistic for our preferred VAR specification, i.e. the model from column 1 in Panel B. In the following, we will thus use the 5Y real rate as a monetary policy indicator and instrument it with the changes in 3Y real rates.

Table 1. Structural identification: First-stage results

Panel A: T5Y Real

	T5Y Real	T10Y Real	T5Y Real	T10Y Real	T5Y Real	T10Y Real
	(1)	(2)	(3)	(4)	(5)	(6)
IV: T5Y Real	0.685***	0.599***	0.678***	0.571***	0.737***	0.662***
	(0.025)	(0.023)	(0.031)	(0.025)	(0.027)	(0.024)
Observations	99	99	96	96	99	99
R-squared	0.213	0.205	0.191	0.181	0.233	0.238
F-test model	19.06	15.56	14.86	13	20.19	18.54
Rf. VAR estimation period	08-16	08-16	08-16	08-16	93-16	93-16
(HY-IG) yield spread	Y	Y	N	N	Y	Y
GZ Excess bond spread	N	N	Y	Y	N	N

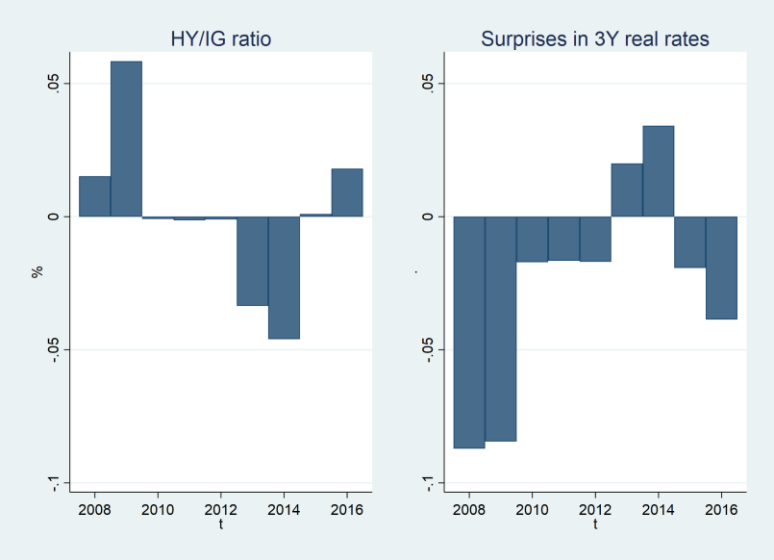
Panel B: T3Y Real

	T5Y Real	T10Y Real	T5Y Real	T10Y Real	T5Y Real	T10Y Real
	(1)	(2)	(3)	(4)	(5)	(6)
IV: T3Y Real	0.661***	0.537***	0.678***	0.525***	0.704***	0.583***
	(0.023)	(0.021)	(0.026)	(0.021)	(0.026)	(0.024)
Observations	99	99	96	96	99	99
R-squared	0.201	0.166	0.194	0.155	0.215	0.187
F-test model	19.09	13.42	17.82	13.22	18.95	14.31
Rf. VAR estimation period	08-16	08-16	08-16	08-16	93-16	93-16
(HY-IG) yield spread	Y	Y	N	N	Y	Y
GZ Excess bond spread	N	N	Y	Y	N	N

Note: This table presents first-stage results of the instrumental variable regressions of reduced form VAR innovations on reduced form VAR innovations in different monetary policy indicators. We use mensualized daily surprises of interest rates around FOMC announcements and some important Fed speeches as an instrument for reduced form VAR innovations in different monetary policy indicators. The VAR consists of five variables, an indicator for monetary policy, industrial production, CPI, a corporate bond spread indicator and the ratio of new HY issuance over new IG issuance and is estimated with 4 lags. We use monthly data from October 2008 to December 2016, and up to August 2016 for VAR specifications with GZ's excess bond spread which covers a shorter time span. Robust standard errors in parentheses. ***/**/* denotes significance at the 1%/5%/10% level.

52. Figure 4 shows the resulting time series of the HY shock and the yearly averages of monetary policy surprises. The negative correlation implies that as positive surprises indicate a more contractionary stance of monetary policy relative to expectations, we would expect HY shock to fall as investors have less incentive to take on risk and thus likely have a higher demand for IG relative to HY bonds leading to the fall in their ratio. Further, the time series of the HY shock shows that in the beginning of the period of unconventional monetary policy, as monetary policy gets increasingly expansionary, HY bond issuance was more pronounced relative to IG bonds.

Figure 4. The ratio of HY/IG due to monetary policy shock



Note: This graph shows the HY/IG ratio due to monetary policy shocks and the shocks as estimated by the proxy SVAR. We construct the HY/IG ratio due to monetary policy shocks by multiplying the estimated second-stage coefficient of the instrumental variable regression with the monetary policy indicator predicted by the surprises. The monetary policy indicator is the 5Y real rate, its instrument the mensualized daily surprise around FOMC announcements and some speeches of the 3Y real rate. The graph on surprises in 3Y real rates shows average monthly surprises within a year.

53. We then proceed to estimating the structural coefficients for all variables in the VAR and analyse their propagation using impulse-response functions. Figure 5 shows impulse responses for two different VAR specifications. Both models include the 5Y real rate as indicator of unconventional monetary policy, CPI and industrial production, the HY shock and a spread measure. Whereas model 1 includes the spread in yields between HY and IG bonds, model 2 uses the excess bond premium index. All panels in Figure 5 depict the impulse responses of an endogenous variable to a negative surprise in 5Y real rates which we interpret as an expansionary monetary policy shock. For each graph, the solid black line shows the median response, the dashed lines the 90% confidence bands. We compute the impulse responses using a wild bootstrap with 2,000 repetitions (Gertler and Karadi (2015).

54. Panels A.1 and A.2 of Figure 5 show the response of the $\frac{HY_t}{IG_t}$ ratio due to an expansionary monetary policy corresponding to a fall in 5Y real rates of around 18 basis points. The $\frac{HY_t}{IG_t}$ ratio increases by around 10 percentage points after an expansionary monetary policy shock, indicating a higher degree of riskiness of new corporate bond issuances. In the second month after the expansionary monetary policy shock, the ratio actually decreases potentially pointing to a lagged reaction of IG but not HY bonds. Effects in the first two periods for both model specifications are significant at the 95% level. However, the cumulated effect after the first two periods shows a significant increase in the $\frac{HY_t}{IG_t}$ ratio of around 5 percentage points. With the median value of the $\frac{HY_t}{IG_t}$ ratio at approximately 60%, this increase corresponds to an increase in the ratio of around 8%. After the first two periods, the responses revert back to zero within 7-12 months.

55. Turning to the spread between HY and IG bond yields, Panel B.1 of Figure 5 shows a decrease in the spread of around 13 basis points. This decrease implies that prices of HY bonds have risen stronger than IG bonds putting downward pressures on the yield spread. This points towards an increased risk appetite of investors. The response of the spread slowly converges back to 0 over the next three years. The combination of increasing quantities and decreasing yields in the high-yield bond market relative to the investment grade segment supports the risk taking hypothesis due to unconventional monetary policy expansion.

56. Panel B.2 of Figure 5 shows the VAR specification with the excess bond premium index as used in Gertler and Karadi (2015). After an expansionary monetary policy shock, this index falls by a small amount; however the response is significant at the 90% level only after three quarters.[11] What is relevant in our set-up is that the relative high-bond issuance is stable considering the more generalized index of refinancing costs absent of default risk. Further, the fact that the spread between yields on high-yield and investment-grade corporate bonds decreases significantly but not the default free excess bond premium spread suggests that unconventional monetary policy affects primary corporate bond markets through a reduction in perceived default risk rather than a decrease in refinancing conditions.

57. Figure B.1 in the appendix shows impulse-response functions for the other variables in the VAR. Panel B shows the response for CPI of the VAR specification including the spread between HY and IG yields to an expansionary monetary policy shock. Consistent with standard economic theory, prices rise significantly by around 0.9% and remain rather elevated through the whole 36 months considered for the impulse response function. Output slightly decreases in the first period but then steadily rises up to month 12 then converging back to zero. However, similar to Gertler and Karadi (2015), the responses of industrial production are not significant at the 90% level.

58. In conclusion, we find qualitatively similar results for both VAR specifications considered. Importantly the $\frac{HY_t}{IG_t}$ ratio shows a significant increase in the first period. Further, if we estimate the reduced-form VAR for the full time period for which we have data, i.e. for 1993M01-2016M12 instead of 2008M06-2016M12, we obtain similar results (Annex Figure B.2.).[12]

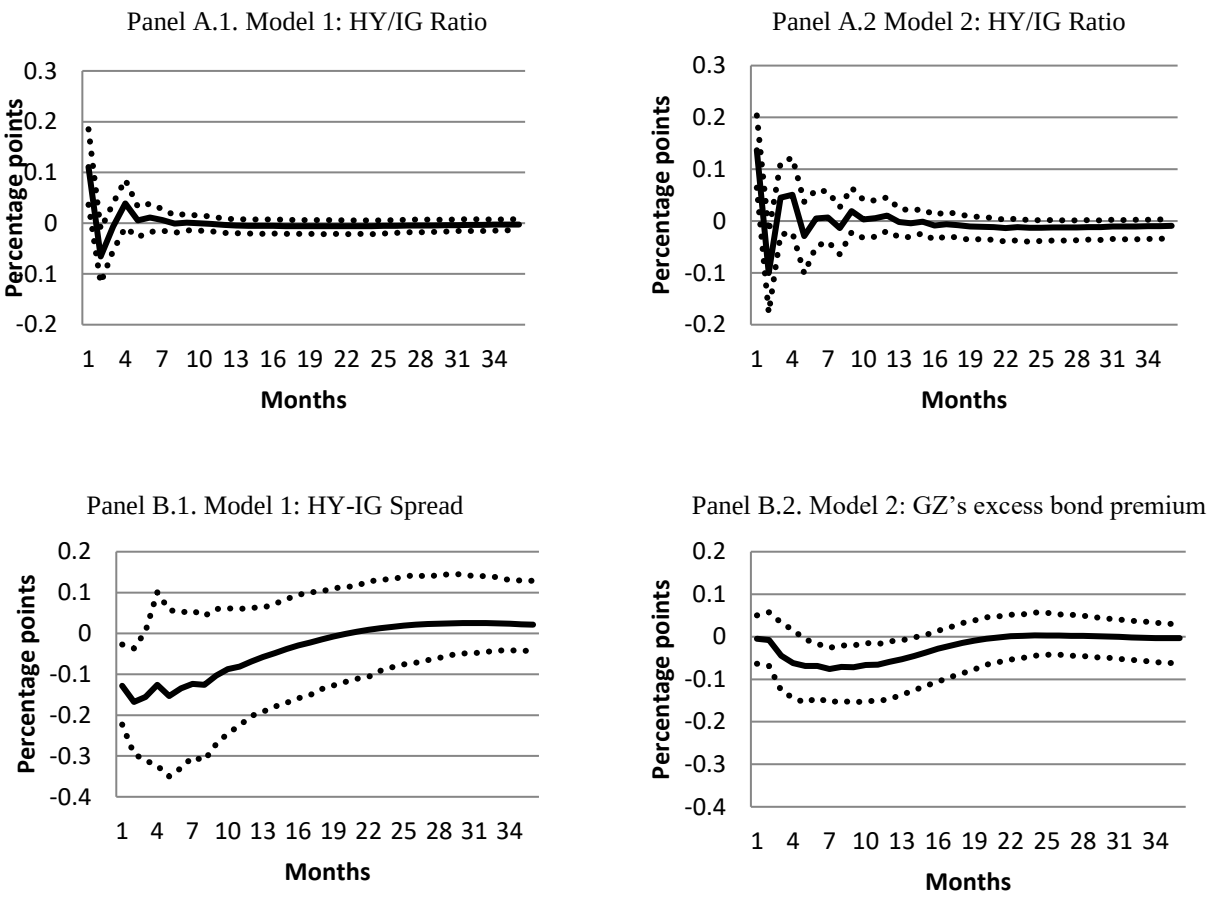
59. We find qualitatively similar results when we compare our analysis to Lhuissier and Szczerbowics (2017) who also study the effect of expansionary unconventional monetary policy on US corporate bond issuance in a proxy SVAR framework. However, they focus more on capital structure decisions, i.e. on the choice between corporate bond issuance and bank loans, but do not break down corporate bond issuance by credit rating and as thus remain silent on risk-taking of investors on corporate bond markets. They also find that expansionary monetary policy increased bond issuance, though they only measure total issuance. They find significant responses for output and the excess bond

[11] Gertler and Karadi (2015) find a negative and statistically significant effect on the EBP already at impact, however, a direct comparison is no straightforward as they focused conventional monetary policy using a 1Y nominal government bond with estimations done for a longer time period.

[12] In particular, the $\frac{HY_t}{IG_t}$ ratio and the spread between yields between HY and IG bonds are statistically significant and with the expected sign further underlining the robustness of our results.

premium index with 68% confidence bands which do not contradict our findings of no statistical significance based on more conservative confidence intervals.

Figure 5. Risk-seeking in corporate bond markets after an unconventional expansionary monetary policy shock



Note: This figure depicts the impulse response functions of a one-unit standard deviation expansionary surprise in monetary policy. We identify the monetary policy shock using an instrumental variable approach. The IRF are shown for VAR specifications with the 5Y real rates as policy indicator and mensualized daily surprises in 3Y real rates as instruments. Both VAR models include the logarithm of industrial production and CPI as further variables. The reduced-form VAR is estimated over the 2008M06-2016M12 period. We obtain the IRFs using a wild bootstrap with 2,000 repetitions. The solid black line shows median responses. The dashed lines the lower and upper bounds of a 90% confidence band.

6.2. Did monetary policy shocks distort the capital reallocation process?

60. Table 2 displays the baseline estimates of equation 6 in which we analyse the effects of unconventional monetary policy shocks on capital reallocation by allowing for changes to the HY shocks to directly affect firm-level investment. As the HY shock relies on aggregate data, the inclusion of year fixed effects comes at a cost of dropping the HY shock (column 2). The main variable of interest the interaction between lagged MFP and HY shock. Column 3 further incorporates sector-year fixed-effects controlling for sector-level confounding variables. To control for potential error correlation within firms, robust standard errors are clustered in this dimension in all specifications.

61. In line with the hypothesis that more productive firms should grow faster than less productive firms, a higher productivity is positively associated with firm-level investment across all specifications, suggesting that more productive firms are able to attract relatively more capital. Put differently, capital reallocation within the same industry overall is productivity-enhancing. Moreover, Tobin's Q and firm-level demand-effects also display the expected positive and significant association, suggesting that the framework model accurately captures both firm-level investment decisions and capital reallocation dynamics.[13]

Table 2. Reallocation - Baseline results

Dependent variable: capital expenditures

	1	2	3
L.MFP	0.1117***	0.1107***	0.1160***
	(0.0102)	(0.0103)	(0.0104)
L.MFP#HY shock	-0.4641***	-0.4654***	-1.2294***
	(0.0915)	(0.0923)	(0.2763)
HY shock	-1.5932***		
	(0.1383)		
L.Q1	0.0067***	0.0069***	0.0066***
	(0.0021)	(0.0021)	(0.0021)
Sales/Capital	0.0042***	0.0042***	0.0041***
	(0.0004)	(0.0004)	(0.0004)
Observations	21,632	21,632	21,626
R-squared	0.1458	0.1481	0.1580
Adj. R2	0.144	0.146	0.146
Industry FE	Yes	Yes	Yes
Year FE	No	Yes	Yes
Industry-Year FE	No	No	Yes
Level of clustering	Firm	Firm	Firm

Note: This table reports the baseline results where capital expenditures over lagged fixed assets are regressed on lagged values of firm-level multi-factor productivity (Panel A) or the marginal revenue product of capital (Panel B), their respective interaction with the HY shock obtained from the first part of the analysis, the firm's lagged market value (measured using Tobin's Q) and a measure of aggregate demand. Industry refers to 2-digit level detail according to NACE Rev. 2, covering the non-farm non-financial business sector (industry codes 10-83, excluding 64-66), year to the period 2008-13. Robust standard errors are reported in parenthesis. *** denotes statistical significance at the 1% level, ** significance at the 5% level, and * and the 10% level.
Source: Calculations based on Thomson Reuters Worldscope and Dealogic.

62. The negative and significant coefficient of the interaction between MFP and the HY shock indicates that expansionary unconventional monetary-policy may have diminished allocative efficiency of the economy by increasing risk-seeking in the bond market, and this is robust to different specification of the fixed effects structure. While high productive firms thus generally seem to invest more than their low productive peers, this effect is mitigated by the changes in the composition of the riskiness of

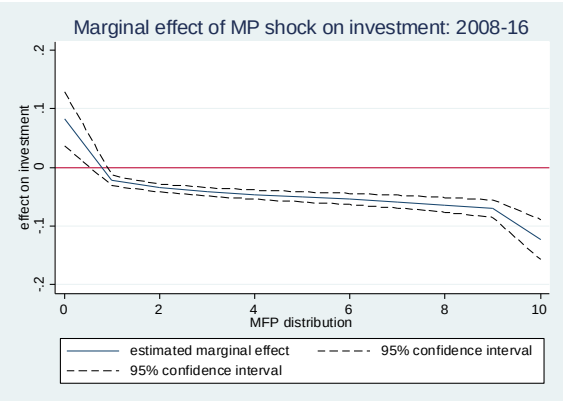
[13] Corporate bond issuance at the sector-level could deviate from aggregate trends. Thus, the results from the reallocation model might solely come from specific sectors and not necessarily generalize to the whole economy. In order to show the robustness of our results, we drop iteratively the five sectors with the largest increases in bond issuance over the 2008-2016 period and re-estimate all reallocation models. Results hold robust.

corporate bonds. The changes to the HY shock itself are associated with an overall decline in investment (column 1), though the total effect of changes in the HY shock must be considered in relation with its interaction term (see below). Overall, estimation results suggest that the changes in the composition of riskiness of corporate bond issuance due to the risk-seeking channel of monetary policy transmission may constrain the growth of more productive firms, in turn reducing aggregate MFP via lower allocative efficiency.

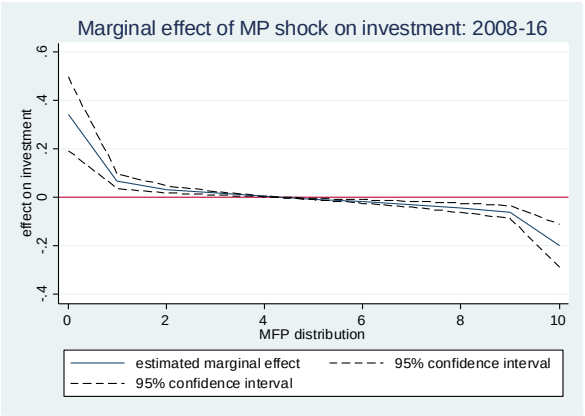
63. To get a sense of the overall direction and magnitude implied by the coefficient estimates, Figure 6 displays the findings graphically. Panel A represent the marginal effects obtained from column I (Table 2), whereas Panel B is based on estimates of column III (Table 2), in which the standalone effect of HY shocks is absorbed by year fixed effects. If interpreted causally, the results suggest that a one standard deviation increase of the HY shock would lead to a 2 percentage point increase in capital expenditures for firms at the 25th percentile of the MFP distribution, and a 2 percentage point decrease for firms at the 75th percentile. Low productive firms therefore increase their investment following a HY shock, while high productive firms reduce their investment.

Figure 6. Marginal effects of increased bond issuance due to monetary policy surprises on firm-level capital expenditures

Panel A: Total effect



Panel B: Differential effect



Note: This graph shows the marginal effects of a one standard deviation increase in the HY shocks that were obtained in the first part of this paper for different centiles of the MFP distribution. Panel A reflects the marginal effect calculated based on Table 2, column 1, while Panel B represents the marginal effects calculated from Table 2, column 3 (sector, year, and sector-year fixed effects).
Source: Calculations based on Thomson Reuters Worldscope and Dealogic.

Crowding out effects

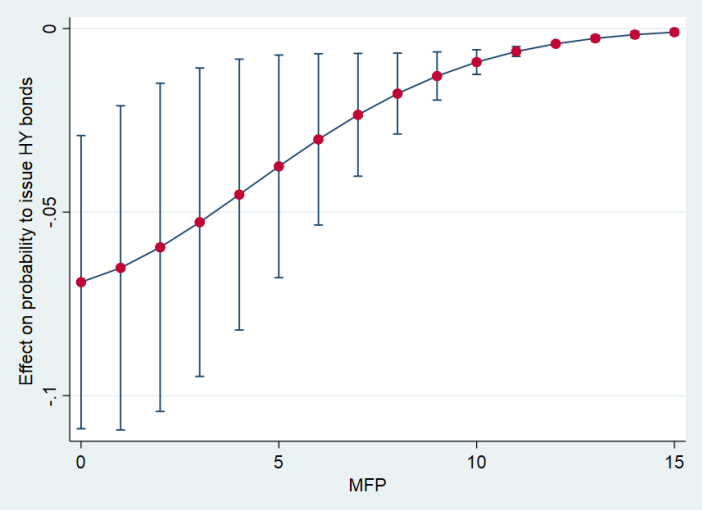
64. One explanation for the observed differences in investment following a shift in the composition of riskiness on corporate bond markets could be the presence of crowding-out effects. These effects could occur if the share of HY bonds issued in a reaction to expansionary monetary policy was mostly associated with low productive firms that rely more on corporate bond markets to fund new projects. As a result, these firms would be able to acquire the financial means to increase capital spending on goods and services that were previously out of reach. In turn, the increased demand for these goods and services would drive up their price. All other firms would thus face higher

procurement costs, possibly forcing them to refrain from their purchase. In this case, one would observe a relative decline in investment for firms that are not issuing bonds.

65. Without firm-level data on procurement costs, we cannot directly test this hypothesis, however we can check the underlying premise, i.e. whether low productive firms have a higher likelihood to issue bonds. To that end, we use probit models to analyse whether firms' propensity to issue bonds differs by the level of MFP. If low productive firms on average tend to issue more bonds, we can provide tentative empirical evidence pointing towards a crowding-out mechanism. We test this conjecture using a reduced-form probit regression, where the variable of outcome is defined as a dummy capturing if a firm has issued any bond in year *t*, and whether this bond was categorized as high-yield or investment-grade. All other control variables are identical to the set of control variables used in our baseline estimation.

66. In line with our conjecturing, Table 3 shows that high MFP firms have a significantly lower propensity to issue corporate bonds in general, but that these effects are particularly pronounced for HY bonds (see column 2). Moreover, the non-linear marginal effects obtained from this probit regression displayed in Figure 7 suggest that a one percent increase in MFP significantly reduces the probability of issuing a HY bond, especially at low levels of MFP. We interpret these results as evidence that the subsample of firms which gained access to capital markets due to investors' increasing risk-seeking behaviour were indeed mainly low productive firms, supporting the idea that a crowding-out effect may have taken place.

Figure 7. Marginal effects of increasing MFP on the propensity to issue HY bonds



Note: This graph shows the marginal effect of increasing MFP by one percent on the likelihood to issue HY bonds for different starting points contained in our sample. Results are based on the probit regression displayed in Table 3. The red point represents the point estimate, while the ranges report 95% confidence intervals.
Source: Calculations based on Thomson Reuters Worldscope and Dealogic

Table 3. Crowding-out effects

The effect of firm-level characteristics on the propensity to issue bonds

Issuance dummy	All bonds	HY bonds	IG bonds
L.MFP	-0.191***	-0.198***	-0.142***
	(0.0348)	(0.0434)	(0.0405)
L.Q1	-0.0285***	-0.0178**	-0.0484***
	(0.00769)	(0.00811)	(0.0121)
Sales/Capital	-0.00158	-0.000206	-0.00323**
	(0.00107)	(0.00130)	(0.00162)
Observations	21,642	21,642	21,414
Issuance dummy	All bonds	HY bonds	IG bonds
L.MFP	-0.191***	-0.198***	-0.142***
	(0.0348)	(0.0434)	(0.0405)
L.Q1	-0.0285***	-0.0178**	-0.0484***
	(0.00769)	(0.00811)	(0.0121)
Sales/Capital	-0.00158	-0.000206	-0.00323**
	(0.00107)	(0.00130)	(0.00162)
Observations	21,642	21,642	21,414

Note: Estimates from probit regression. Values are marginal effects. The coefficient corresponds to the impact of a change in the explanatory variable on the probability to issue bonds at the mean of the independent variable. Industry refers to 2-digit level detail according to NACE Rev. 2, covering the non-farm non-financial business sector (industry codes 10-83, excluding 64-66); year to the period 2008-13. All regressions include year and industry fixed effects. Robust standard errors are reported in parenthesis. *** denotes statistical significance at the 1% level, ** significance at the 5% level, and * and the 10% level.
Source: Calculations based on Thomson Reuters Worldscope and Dealogic.

6.3. Robustness checks

67. To diminish endogeneity concerns, we perform several robustness tests. First, we account for a potential selection bias, which could affect our baseline estimates if the propensity to issue bonds was correlated with the effect of changes in the HY shock on investment. For instance, changes in the HY shock may affect not only the amount of investment of already issuing firms, but also the propensity of other firms to issue bonds in order to exploit the higher appetite for risk of investors.

68. To address this possibility, we run a two-step Heckman selection procedure to our baseline model. This consists in estimating first a firm's propensity to issue high-yield bonds based on the same set of explanatory variables as in our baseline specification, and subsequently using the obtained correction factor (the so-called Mill's ratio) in the second stage estimation of the baseline specification. We find the first stage results to be credible (see right column of Table 4)[14] corroborating the results obtained from the probit model in section 5.2, and second stage results to hold robust to adding the correction factor. Therefore, selection bias is not likely to be a serious issue influencing the interpretation of our results.

[14] Credible estimates of a Heckman selection model require at least one variable to appear with a non-zero coefficient in the selection equation and not in the equation of interest (Caldera-Sànchez and Andrews, 2011).

69. Next, we address concerns related to omitted variable by augmenting the baseline equation with additional firm-level characteristics, notably firm age and size (Table 5, Panel A). The existing literature treats both as potential determinants of firm-level investment, not least since they are considered reliable predictors of firm-level credit constraints (Gala and Julio, 2016). The inclusion of these controls comes at the cost of losing significance for Tobin's Q, which is strongly correlated with firm size. However, the interaction term between HY shocks and MFP remains unaffected.

70. Endogeneity bias could also arise due to the confounding macroeconomic factors, such as if the identification of the first stage HY shock was not purely exogenous, hence capturing broader cyclical effects. The fixed effect structure controls for omitted variable bias that could induce shifts at the industry or year level, but does not control for omitted factors at the more aggregate level. To account for this, we include an additional interaction term between the output gap (a catch-all variable) and MFP. Except for the most demanding fixed-effect structure, the results displayed in Table 5 (Panel B), however, are robust to this change.

71. Lastly, the interaction of MFP and the HY shock could pick up confounding firm-level factors. For instance, changes to the HY shock could also change the sensitivity of firm-level investment to underlying firm-level fundamentals like Tobin's Q or sales. Including interactions of the HY shock with Tobin's Q and firms' sales is a way to test the robustness of the MFP interaction to these possible firm-level effects. Table 5 (Panel C) shows that the interaction of the HY shock and MFP remains robust to this extended specification.[15]

[15] The interaction of Tobin's Q is significant and negative implying that changes in the corporate bond market risk reduce the sensitivity of investment to Tobin's Q. The interaction with firm-level sales is not significant.

Table 4. Robustness I: A Heckman selection model

Second stage		First stage	
Dependent variable: Capital expenditures		**Dependent variable: Issuing HY bonds**	
L.MFP	0.115***	L.MFP	-0.155***
	(0.011)		(0.036)
L.MFP#HY shock	-0.385***	L.MFP#HY shock	0.603***
	(0.083)		0.232
L.Q1	0.008***	L.Q1	-0.032***
	(0.002)		(0.011)
Sales/Capital	0.004***	Sales/Capital	-0.003**
	(0.000)		(0.001)
Dummy HY Issuance	0.811***		
	(0.058)		
Observations	18789	Observations	18789

Note: This table presents first and second stage results of a Heckman selection model, where the first stage measures firms' propensity to issue HY bonds and the second stage models firm-level investment choices. Both regressions account for industry and year fixed-effects as well as age controls. Industry refers to 2-digit level detail according to NACE Rev. 2, covering the non-farm non-financial business sector (industry codes 10-83, excluding 64-66), year to the period 2008-13. All regressions are clustered at the firm level. Robust standard errors are reported in parenthesis. *** denotes statistical significance at the 1% level, ** significance at the 5% level, and * and the 10% level.
Source: Calculations based on Dealogic and Thomson Reuters Worldscope.

Table 5. Robustness: controlling for confounding factors

Panel A: Controlling for age and size effects

Dependent variable: capital expenditures	I	II	III
Fixed effects	Industry	Industry; Year	Industry; Year; Industry-Year
L.MFP	0.0955***	0.0950***	0.1002***
	(0.0098)	(0.0098)	(0.0099)
HY shock	-2.1442***		
	(0.1418)		
L.MFP#HY shock	-0.4921***	-0.5009***	-1.2501***
	(0.0898)	(0.0905)	(0.2740)
L.Q1	0.0032	0.0034	0.0032
	(0.0022)	(0.0022)	(0.0021)
Sales/Capital	0.0041***	0.0041***	0.0041***
	(0.0004)	(0.0004)	(0.0004)
L. Employees(log)	-0.0201***	-0.0202***	-0.0202***
	(0.0029)	(0.0029)	(0.0029)
Age	-0.0123***	-0.0124***	-0.0121***
	(0.0010)	(0.0010)	(0.0010)

Observations	21,632	21,632	21,626
R-squared	0.1662	0.1685	0.1777
Adj. R2	0.164	0.166	0.166

Panel B: Controlling for macroeconomic cycles with the output gap

	I	II	III
Fixed effects	Industry	Industry; Year	Industry; Year; Industry-Year
L.MFP	0.1117***	0.1078***	0.1196***
	(0.0128)	(0.0126)	(0.0231)
HY shock	-1.5885***		
	(0.1381)		
L.MFP#HY shock	-0.4650***	-0.4713***	-1.2244***
	(0.0937)	(0.0943)	(0.2814)
L.MFP#Output gap	0.0006	-0.0002	0.0018
	(0.0023)	(0.0022)	(0.0066)
L.Q1	0.0070***	0.0071***	0.0069***
	(0.0021)	(0.0021)	(0.0021)
Sales/Capital	0.0046***	0.0046***	0.0045***
	(0.0004)	(0.0004)	(0.0004)
Observations	21,632	21,632	21,626
R-squared	0.1453	0.1476	0.1576
Adj. R2	0.143	0.145	0.145

Panel C: Controlling for confounding firm-level factors

Dependent variable: capital expenditures	I	II	III
Fixed effects	Industry	Industry; Year	Industry; Year;
L.MFP	0.1088***	0.1078***	0.1115***
	(0.0103)	(0.0104)	(0.0105)
HY shock	-0.9935***		
	(0.1680)		
L.MFP#HY shock	-0.2016**	-0.2038**	-0.6851**
	(0.0887)	(0.0894)	(0.2845)
L.Q1	0.0092***	0.0093***	0.0086***
	(0.0023)	(0.0023)	(0.0023)
L.Q1#HY shock	-0.2598***	-0.2599***	-0.2146***
	(0.0667)	(0.0671)	(0.0668)
Sales/Capital	0.0046***	0.0046***	0.0046***
	(0.0004)	(0.0004)	(0.0004)
Sales/Capital# HY shock	-0.0153	-0.0155	-0.0119
	(0.0107)	(0.0107)	(0.0113)
Observations	21,632	21,632	21,626
R-squared	0.1500	0.1523	0.1604
Adj. R2	0.148	0.150	0.148

Note: This table reports robustness checks of the baseline regression, where Panel A further controls for age and size effects; Panel B accounts for possible confounding macroeconomic effects by interacting MFP with the output gap; and Panel C tests if the HY shock could still pick up confounding firm-level factors by accounting for its interaction with all other variables. Industry refers to 2-digit level detail according to NACE Rev. 2, covering the non-farm non-financial business sector (industry codes 10-83, excluding 64-66), year to the period 2008-13. All regressions are clustered at the firm level. Robust standard errors are reported in parenthesis. *** denotes statistical significance at the 1% level, ** significance at the 5% level, and * and the 10% level.
Source: Calculations based on Dealogic and Worldscope.

6.4. Discussion and implications for further research

72. Our results provide evidence that expansionary monetary policy changes the composition of risk in primary corporate bond markets through a risk-taking channel. Specifically, proxy SVAR results imply that HY bond issuance increases relative to IG bond issuance. At the same time, the spread between HY bond yields and IG bond yields decreases which points towards an increased appetite for risk of investors. Using the estimated changes in the HY shock due to shocks to unconventional monetary policy interacted with MFP in an otherwise standard firm-level reallocation model, we provide evidence that this change in the composition of risk in corporate bond markets tends to be associated with less allocative efficiency, i.e. capital does not seem to flow towards its most productive use as strongly as in the absence of UMP shocks. The firm-level results are robust to different fixed effect structures, the inclusion of age and firm size as additional controls, interactions of the HY shock with other variables and accounting for selection bias induced by UMP shocks themselves.

73. We discuss three such possibilities: (i) using proceeds for non-productive purposes, (ii) using proceeds for intangible investment, and (iii) using proceeds to build cash-holdings. However, it is important to bear in mind that our analysis focusses on a specific segment of the financial markets, namely the market for corporate bonds, and a specific firm-level outcome, namely investment in tangible capital. Therefore, a potential mechanism underlying our results is that firms which issue bonds actually use the proceeds for a different purpose than investment in tangible capital.

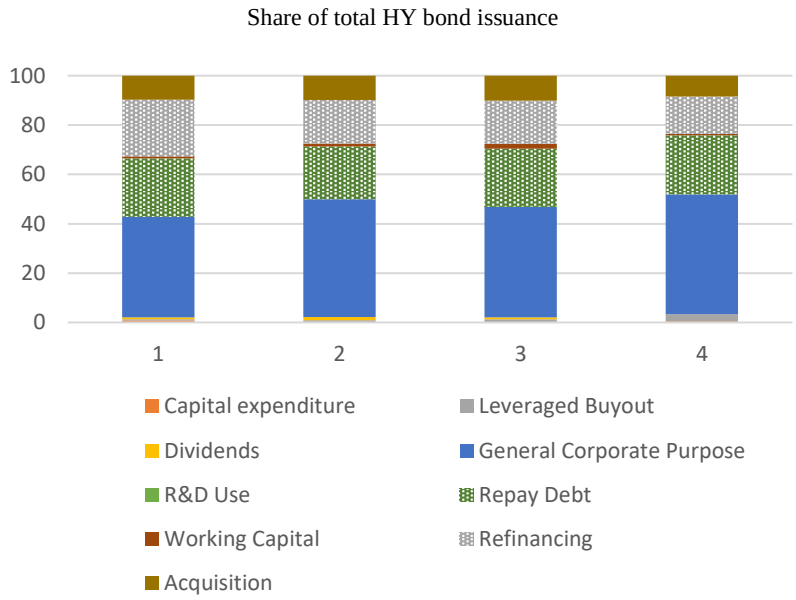
Use of proceeds

74. With a view to better understanding this heterogeneous effect of HY shocks on investment behaviour across firms with different levels of MFP, we inspect the firms' use of proceeds, by exploiting the idea that inherent firm-characteristics could interact with firm-level preferences for particular uses of bond revenues. One possibility is that low MFP firms have a higher propensity to divert corporate bond proceeds to productive investments than their high-productive peers, who use the capital to pay dividends to their investors, or re-finance outstanding debt at a lower rate of interest, at the expense of capital investments. For instance, Çelik et al. (2015) show that the global share of funds raised through bond issuance that are allocated to investment fell sharply since 2008, alongside with an increase in the share of funds used for debt reduction and refinancing purposes.

75. The Dealogic database provides some background information on the use of the proceeds from HY bond income by firms. However, after matching the Dealogic and Worldscope database Figure 8 displays no meaningful difference in the share of bonds attributed to the various categories of uses across quartiles of MFP. This may not be surprising as the data comes with a number of caveats.

- firms are not obliged to disclose the exact use of their proceeds, and more granular data would be warranted to accurately disentangle the different categories firms can chose from;
- the category "general corporate purposes" potentially contains a variety of uses and could disguise important heterogeneities across firms' uses of proceeds from bond issuance;
- for the purpose of Dealogic, firms can attribute each bond to several categories without providing information on its predominant use.

Figure 8. The use of HY corporate bonds by MFP quartile



Note: This graph represents the share of the total HY bond issuance used for various purposes as indicated by the issuer in the Dealogic database over the period 2008-16. Where bonds are attributed to more than one purpose, each category is weighted equally. Within the available categories for the use of proceeds, we considered the following ones: capital expenditures (investment), dividend payments to investors, research and development (R&D), working capital, acquisitions and leveraged buyouts, general corporate purposes, the repayment of debt and refinancing purposes.
Source: Calculations based on Thomson Reuters Worldscope and Dealogic.

Intangible capital

76. Proceeds could be used to invest in intangible capital, which are not included in our analysis due to data limitations. In many countries, growth of intangible capital has now surpassed that of tangible investment (Corrado and Hulten, 2010; Corrado et al. 2012, 2016). Recent evidence (Crouzet and Eberly, 2018a, 2018b; Gutiérrez and Philippon, 2017b) points to a growing role of intangibles– such as R&D, design and new business processes – in explaining weak fixed capital accumulation over the past two decades. This change is also reflected in the changing capital composition of firms (Corrado, Hulten and Sichel, 2005).

77. Intangibles are commonly considered a key driver of productivity (Andrews and De Serres, 2012; Andrews and Criscuolo, 2013), especially since their contribution to MFP growth appears to be stronger than for tangible assets (OECD, 2015b). This is

related to the non-rivalrous nature of intangibles: costs incurred at the initial stage of developing certain types of knowledge are not re-incurred when that knowledge is used again (Andrews and Criscuolo, 2013). Moreover, intangible investment can lead to increasing returns to scale, as well as create knowledge that spills over into other parts of the economy (OECD, 2015b).

78. Against this background, it is possible that the additional access to finance granted by unconventional monetary policy may have induced firms, especially those at the upper range of the productivity distribution, to partially substitute their tangible capital investment for more productive intangible assets. This could then explain why low productive firms that have less scope for absorbing intangible assets increase tangible investment in reaction to UMP-induced HY shocks, while high productive firms replace tangible for intangible capital. Whether such a "capital substitution effect" occurred and was sizable enough to offset the decline in tangible investment, however, remains speculative so long as data constraints limit further analysis.

Cash holdings

79. Another hypothesis is that high MFP firms may have reacted to HY shocks by piling up more cash. Considering the economic uncertainty characterising the crisis years, precautionary motives may have led firms to increase their cash holdings to ensure greater flexibility. This would be beneficial if firms either face uncertainty about future transactions, or tight credit constraints (Sànchez and Yurdagul, 2013). For instance, firms spending significant amounts of resources on innovation may find it harder to borrow at any point in time, in which case cash holdings are a necessary backup solution. In this regard, it is no coincidence that the rise of intangible assets has been identified as the fundamental driver of the upwards trend in US corporate cash holdings over the past decades (Falato and Sim, 2013).

80. A simple test of whether expansionary unconventional monetary policy drove the increase in cash holdings is to replace the left hand side variable of our baseline equation, capital expenditures, with a variable of cash holdings. However, the results show no sign of correlation between HY shocks and the cash holdings variable (Table 6).

Table 6. Testing for the use of proceeds with balance-sheet data

Dependent variable: **Cash**	Industry FE	Industry, Year FE	Industry, Year, Industry-Year FE
L.MFP	0.2920*	0.2918*	0.2903**
	(0.1702)	(0.1710)	(0.1468)
HY shock	25.4529		
	(19.6851)		
L.MFP#HY shock	-3.0234	-3.0511	-10.8141
	(2.2568)	(2.3035)	(7.6959)
L.Q1	-0.0332**	-0.0333**	-0.0307**
	(0.0166)	(0.0164)	(0.0123)
Sales/Capital	0.0070*	0.0071*	0.0063**
	(0.0036)	(0.0037)	(0.0029)
Observations	15,723	15,723	15,714
R-squared	0.0218	0.0220	0.0889
Adj. R2	0.0188	0.0187	0.0708

Note: The dependent variable, cash holdings, is scaled by total assets. Industry refers to 2-digit level detail according to NACE Rev. 2, covering the non-farm non-financial business sector (industry codes 10-83, excluding 64-66); year to the period of 2008-13. All regressions are clustered at the firm level. Robust standard errors are reported in parenthesis. *** denotes statistical significance at the 1% level, ** significance at the 5% level, and * and the 10% level.
Source: Calculations based on Thomson Reuters Worldscope and Dealogic.

81. Taken together, we thus find no evidence that the use of proceeds is driving the decline in investment observed for high productive firms in Figure 6. In view of the data constraints faced in this analysis, however, further research is warranted to explore the estimated heterogeneity across the productivity distribution in response to a rise in HY bond issuance due to UMPs. In particular, investment in intangible capital seems to be a promising avenue for further research. Thus without further empirical evidence on the effect of shifts in the composition of risk in corporate bond markets due to expansionary unconventional monetary policy on investment in intangibles, we refrain from extrapolating our firm-level investment results to an aggregate level. This is because the investment in intangibles might on aggregate balance the negative effects on allocative efficiency found for investment in tangible capital.

7. Conclusion and policy implications

7.1. Conclusion

82. The aim of this paper is to shed light on the relationship between expansionary monetary policy, access to high-yield bond markets and productivity in the US between 2008 and 2016.

83. Our first contribution is to provide empirical evidence that expansionary unconventional monetary policy induces a shift in the composition of risk on corporate bond markets by increasing the issuance of HY bonds relative to IG bonds. We further show that this shift in risk results from higher investor demand for HY bonds, i.e. through a risk-taking channel activated by monetary policy. Our estimates point toward reductions in the perceived default risk as the main driver of this additional appetite for risk of institutional investors. The subsequent investors´ search for yield in the high-yield segment of the bond market contributes to increase the access to finance of riskier firms.

84. The second contribution of this work is to assess the effect of the higher HY bond issuance induced by monetary policy on the efficiency of capital reallocation. We therefore examine whether more productive firms succeed in attracting more capital than less productive firms, suggesting a deterioration in allocative efficiency. Our results show that risk-taking induced by monetary policy easing disproportionally favoured investment in tangible assets in low productive firms. We provide tentative evidence that this finding could potentially result from a crowding-out effect. However, due to data limitations our analysis is confined to one segment of the financial market (the bond market) and one specific firm-level outcome (tangible investment). We therefore discuss whether firms might allocate the proceeds of bond issuance to different purposes, most notably investment in intangible capital. If so, results might mask a “capital substitution effect”, where the additional access to finance granted by unconventional monetary policy may have incentivized the most productive firms to partially substitute their tangible capital investment for intangibles. In the event of such a substitution, productivity gains from intangible investment may have offset, in the aggregate, the productivity losses due to the decline in tangible investment. In the absence of further

analysis exploring this angle, however, the discussion remains speculative for the time being.

85. Alternatively, we also assess whether high productive firms may have used corporate bond proceeds for reasons other than productive investment (e.g. paying dividends to their investors or building up cash holdings), thereby reducing the overall amount of capital invested. However, we do not find any evidence supporting this hypothesis, with the data at hand. Further research using more granular data on the use of proceeds would be needed to disentangle this and additional mechanisms such as debt refinancing and financial structure.

7.2. Policy implications

86. Our results suggest that, while UMP interventions have been key for dragging the US economy out of the Great Financial Crisis, their ex post assessment points to side effects that need to be taken into account in future monetary and financial policy conduct.

87. First of all, UMPs have increased access to the corporate bond market for risky firms as well as investors' appetite for risk, changing the risk structure of this market. Together with the well-documented substitution of bank loans with corporate bond issuance (see Lhuissier et al., 2018) induced by the tighter regulatory environment after the crisis, this change has shifted financial market risk from banks to holders of corporate bonds, mainly large institutional investors like pension funds, insurance companies, and a wide range of hedge funds and other managed accounts. In other words, risk has moved from a currently highly regulated to a probably less regulated segment of the US financial market. With signs that the overall level of riskiness has increased since the crisis, this move could foreshadow further financial turbulences in the future. Therefore, financial market monitoring could benefit from supplementing traditional financial indicators, which largely focus on banks, with additional indicators for instance sourced from balance sheets of institutional investors.

88. Second, the changes in access to and appetite for risky financial instruments triggered by UMPs can have consequences for the real economy via their effects on the allocation of capital and aggregate productivity growth. While more work is needed to firmly establish the overall direction of these effects, the preliminary evidence produced in this paper points to a tendency to misallocate tangible investment towards less productive uses, with potentially negative consequences for aggregate productivity. To an extent, this matches the short-term aim of monetary policy to sustain firms and economic activity during the recession, but undoing the effects of the resulting misallocation on productivity in the longer-term may prove difficult, pointing to the need for policy to address this potential trade off. Further research should ascertain whether our preliminary results are robust to covering a wider set of financial instruments and to adopting a broader definition of capital including intangibles. However, if our results prove robust, they would suggest the need to flank extraordinary monetary policy expansions with measures in financial, product and labour markets that enhance the ability of the economy to efficiently allocate capital.

89. Finally, our analysis only focused on one country and UMP episodes, but it would be interesting to verify whether similar evidence would result from extending it to more countries and different types of monetary policies, including periods of both unconventional and conventional monetary easing.

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Annex A. Data

Table A.1. Summary statistic

	Observations	Mean	Standard deviation	5%	25%	50%	75%	95%
MFP	18789	9.303	1.547	5.875	8.656	9.516	10.295	11.296
HY/IG ratio	21632	0.003	0.031	-0.046	-0.001	-0.001	0.015	0.058
Capital expenditures	21632	0.374	0.680	0.001	0.096	0.191	0.373	1.214
Tobin's Q	18965	1.579	5.795	0.000	0.007	0.066	0.417	7.135
Sales/Capital	21632	17.798	34.792	0.110	2.387	6.459	15.467	80.812
Employees	21611	6.494	2.634	1.792	4.605	6.731	8.517	10.588
Age	21632	12.161	6.121	2.000	7.000	13.000	17.000	21.000
Cash/Capital	15654	0.314	5.467	0.001	0.028	0.098	0.229	0.705

Note: This table reports the number of observations, mean, standard deviation, and various percentiles of the variables used in our analysis. Variables are winsorized at the 1% level to reduce the effects of outliers. The data description in the section 3 provides more detail on the variable constructions.
Source: Based on Thomson Reuters Worldscope and Dealogic.

Cleaning and matching

Filtering and Cleaning

1. Dealogic data are clean according to the following filters. First, based on the Deal Nationality, we retain all the deals issued in US that are classified either as high yield or investment grade. Second, we retain deals for which either the parent or the issuer is a non-financial private company in US, namely either (i) the parent and the issuer are private US non-financial companies, (ii) the parent is a US financial private company while the issuer is a non-financial private company or vice-versa, (iii) the parent is non-US but the issuer is a US non-financial private company, or (iv) the parent is a US non-financial private company and the issuer is a non-US private financial company. Third, to identify only manufacturing and non-financial services companies, whether this are parent or issuer, we applied an additional filter on the sectors based on the SIG code (Specific Industry Group code) transformed into two-digit SIC code (Standard Industry Classification code) (see Table A2). Regarding the rating categories, we scored them into numerical values from 1 to 21 (AAA being the highest quality rating and CC the lowest) and we cleaned for unrealistic data in the cases where a rating between AAA and BBB- was associated with corporate bond high yield and where a rating between BB+ and CC was associated with corporate bond investment grade. Finally, we consider the following categories of the variable use of proceeds which provides the intended use of the capital raised: capital expenditures (investment), dividend payments to investors, research and development (R&D), working capital, acquisitions and leveraged buyouts, general corporate purposes, the repayment of debt and refinancing purposes.

2. Worldscope data are cleaned and benchmarked using a number of common procedures before the data are used for economic analysis (cf. Kozluk and Dlugosch, 2017 ; etc). To begin with, we correct for reporting errors by dropping values below zero where the variable cannot take on zero values from an accounting perspective (as would be the case for total assets), and winsorize all variables at the 1% and 99% level to eliminate outliers that could bias the estimation results. We then apply a number of filters to clean for double listings and non-company accounts. Lastly, all monetary variables

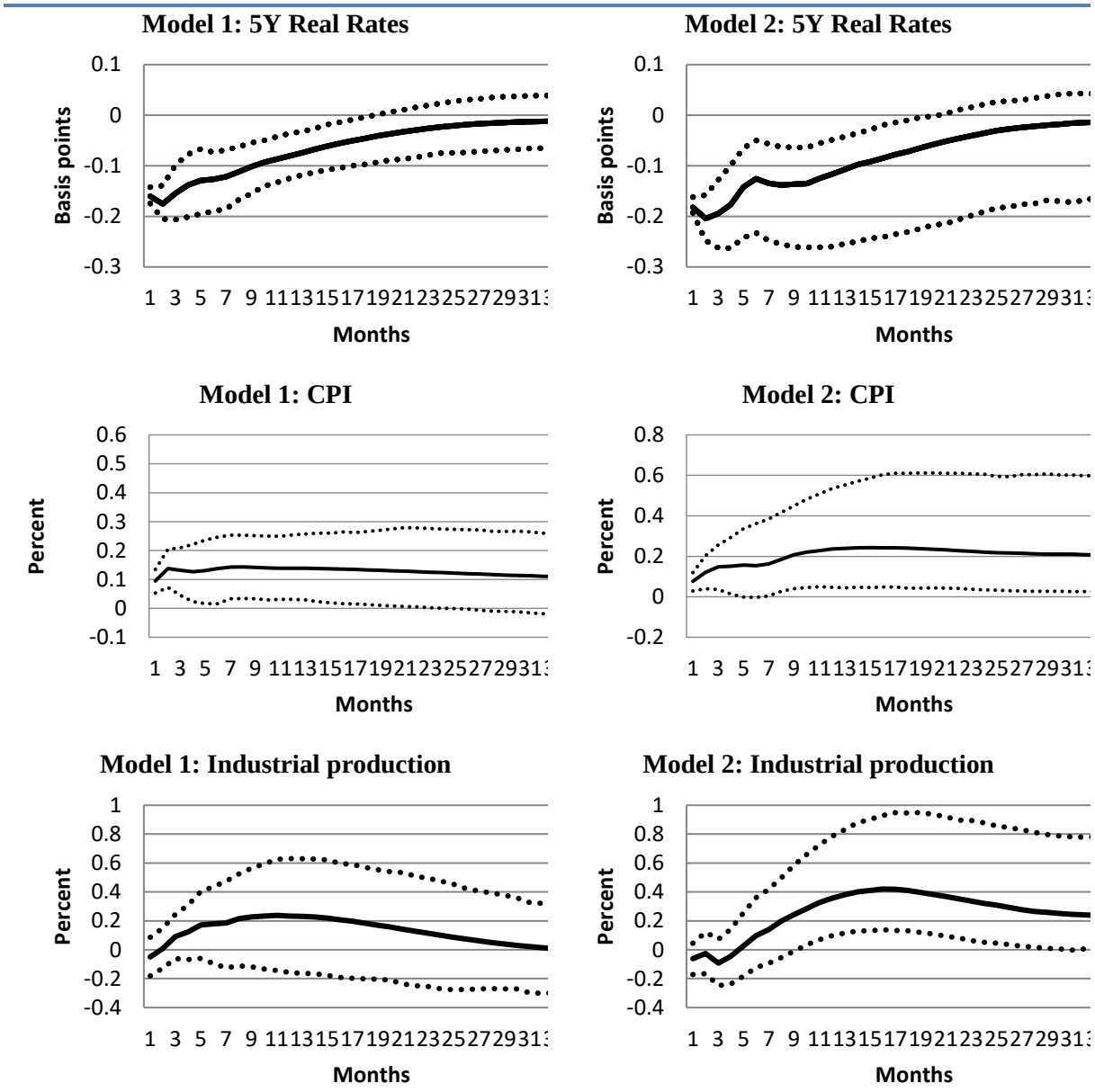
are deflated using 2-digit industry deflators constructed based on OECD STAN and national accounts.

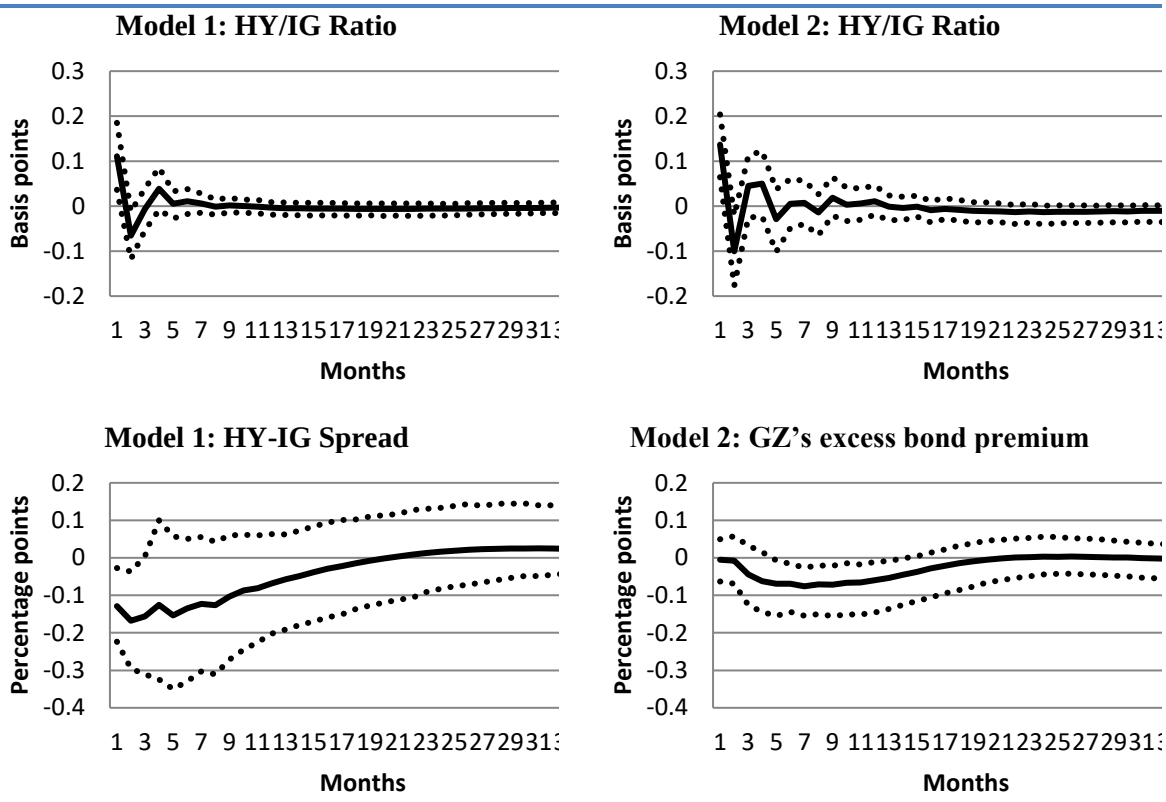
Table A.2. 2-Digit SIC (Standard Industrial Classification) Codes included in the dataset

SIC code	Name
	Construction
15	General Building Contractors
16	Heavy Construction, Except Building
17	Special Trade Contractors
	Manufacturing
20	Food & Kindred Products
21	Tobacco Products
22	Textile Mill Products
24	Lumber & Wood Products
25	Furniture & Fixtures
26	Paper & Allied Products
27	Printing & Publishing
28	Chemical & Allied Products
29	Petroleum & Coal Products
30	Rubber & Miscellaneous Plastics Products
32	Stone, Clay, & Glass Products
33	Primary Metal Industries
34	Fabricated Metal Products
35	Industrial Machinery & Equipment
36	Electronic & Other Electric Equipment
37	Transportation Equipment
38	Instruments & Related Products
39	Miscellaneous Manufacturing Industries
	Transportation & Public Utilities
40	Railroad Transportation
41	Local & Interurban Passenger Transit
42	Trucking & Warehousing
45	Transportation by Air
46	Pipelines, Except Natural Gas
48	Communications
49	Electric, Gas, & Sanitary Services
	Wholesale Trade
50	Wholesale Trade – Durable Goods
51	Wholesale Trade – Nondurable Goods
	Retail Trade
52	Building Materials & Gardening Supplies
53	General Merchandise Stores
54	Food Stores
55	Automotive Dealers & Service Stations
56	Apparel & Accessory Stores
57	Furniture & Home furnishings Stores
58	Eating & Drinking Places
59	Miscellaneous Retail
	Finance, Insurance, & Real Estate
65	Real Estate
	Services
70	Hotels & Other Lodging Places
73	Business Services
78	Motion Pictures
81	Legal Services
87	Engineering & Management Services

Annex B. Robustness and additional results

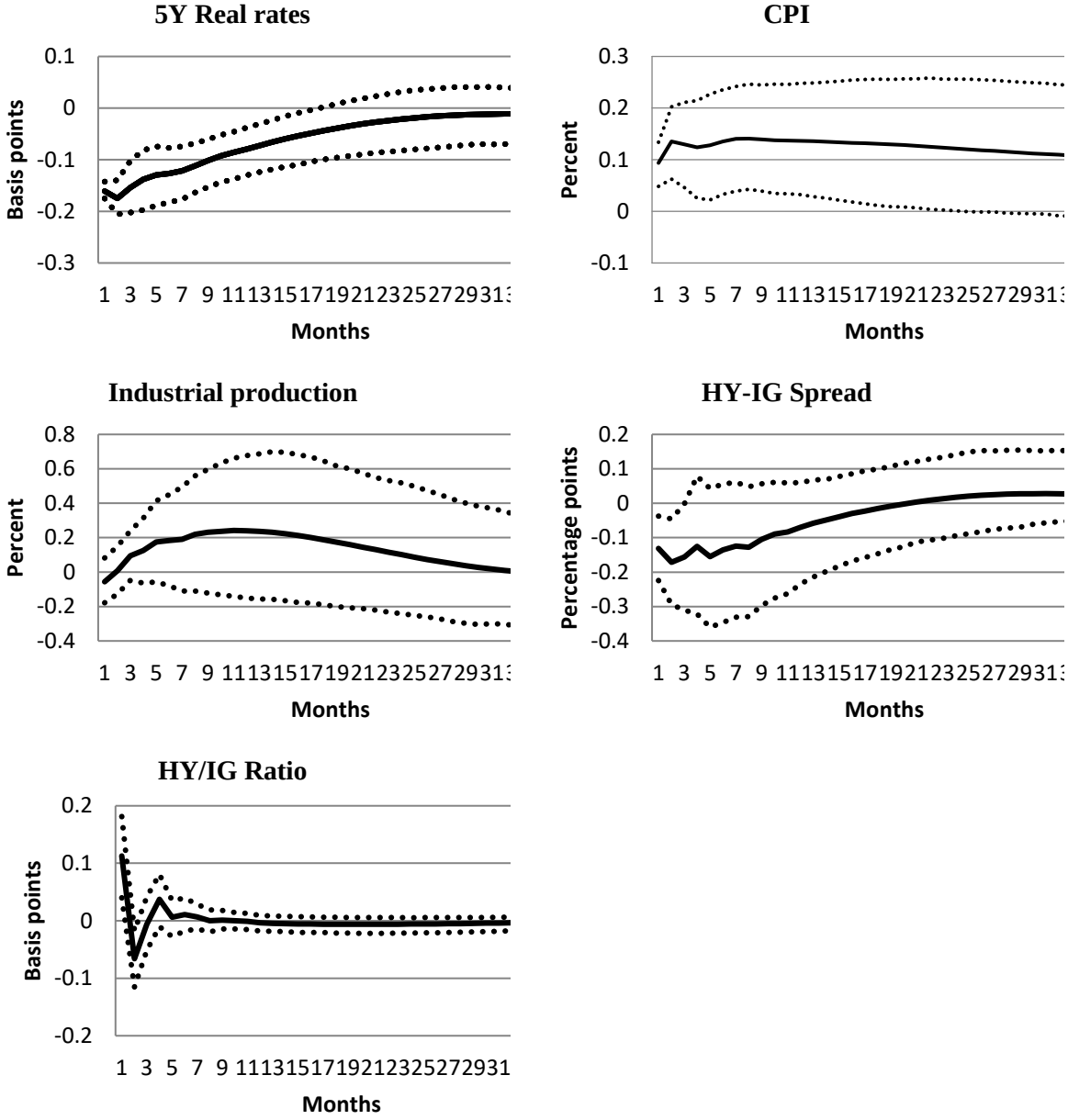
Figure B.1. Impulse-response functions after an expansionary monetary policy shock





Note: This figure depicts the impulse response functions of a one-unit standard deviation expansionary surprise in monetary policy. We identify the monetary policy shock using an instrumental variable approach. The IRF are shown for VAR specifications with the 5Y real rates as policy indicator and mensualized daily surprises in 3Y real rates as instruments. Both VAR models include industrial production and CPI as further variables. The reduced-form VAR is estimated over the 2008M06-2016M12 period. We obtained the IRFs using a wild bootstrap with 2,000 repetitions. The solid black line shows median responses. The dashed lines the lower and upper bounds of a 90% confidence band.

Figure B.2. Different VAR estimation window: Impulse-response functions after an expansionary monetary policy shock



Note: This figure depicts the impulse response functions of a one-unit standard deviation expansionary surprise in monetary policy. We identify the monetary policy shock using an instrumental variable approach. The IRF are shown for VAR specifications with the 5Y real rates as policy indicator and mensualized daily surprises in 3Y real rates as instruments. Both VAR models include industrial production and CPI as further variables. The reduced form VAR is estimated over the 1993M01-2016M12 period. We obtained the IRFs using a wild bootstrap with 2,000 repetitions. The solid black line shows median responses. The dashed lines the lower and upper bounds of a 90% confidence band.

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