BANK OF ENGLAND

Speech

Monetary policy in the intangible economy

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University of Nottingham
11 February 2020

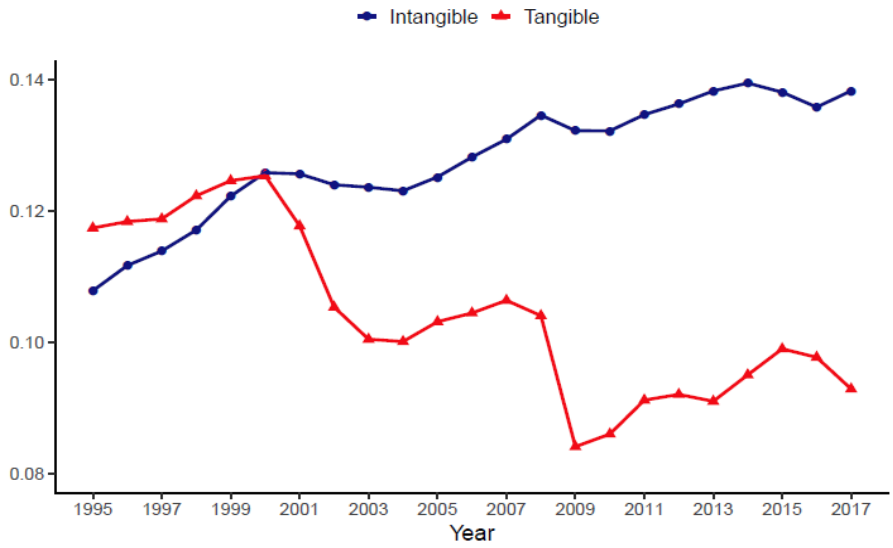
I am grateful to Marco Garofalo and Jamie Lenney for their invaluable comments and assistance with the speech. My thanks also go to Saleem Bahaj, Ben Broadbent, Alan Castle, Ambrogio Cesa-Bianchi, Angus Foulis, Maren Froemel, Clare Macallan, Marko Melolinna, Jitendra Patil, Gabor Pinter, Sophie Piton, Lukasz Rachel, Marek Rojicek, Michael Saunders, Michal Stelmach and Silvana Tenreyro, for their work and helpful suggestions. Much of the thinking in this speech was developed with Stian Westlake and the macro intangibles data draws on my work with Carol Corrado and Cecilia Jona-Lasinio. Errors and opinions are my own.

Introduction

It is an honour to give this lecture at the University of Nottingham. I am an intensive user of the excellent research from the Economics department. In my time as a member of the Monetary Policy Committee (MPC) I have greatly benefited from the insights of the Decision Maker Panel[1] Survey (DMP), an ongoing joint initiative by the University of Nottingham, together with Stanford University and the Bank of England set up in 2016. This innovative survey monitors developments in the UK economy, businesses' expectations and the uncertainties surrounding them. In particular, the DMP has been invaluable to policymakers analysing the effect of uncertainty created by the Brexit process on the everyday decisions businesses face.

As you may know, my research has focused on intangible capital and investment. This is a type of capital that one cannot easily touch or measure, for example investments in software, databases, research and organisational processes, as opposed to tangible investment in things like machines and equipment[2]. The economies of Europe and US have shifted significantly towards these type of investments over the last decades[3] (**chart 1**).

Chart 1: Intangible and tangible investment shares of adjusted market sector gross value added for advanced economies



Source: www.INTANinvest.net
Note: Shares are of nominal market sector GVA adjusted for intangibles, PPP weighted across countries. For more information on the data source, see Corrado et al (2017).

Since September 2018, I have the privilege to serve as one of the external members of the MPC of the Bank of England, the committee that sets, among other things, short-term UK interest rates to deliver price stability.

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[1] The DMP is a large online representative survey of the UK business population, covering large, medium and small firms from across the economy. The size of the panel has grown rapidly since its inception, reaching 8,000 firms that employ 26% of the labour force.
[2] For non-economists an example might help. When you fly somewhere, you (1) book on the airline's website, (2) go to the airport terminal, (3) pass through a security scan and (4) fly on the plane. So you are being provided a service from a sequence of business capital assets: (1) software and databases (intangible) (2) building (tangible) (3) machines (tangible) and (4) vehicle (tangible). Additional intangible assets that the airline has likely invested in would be: market research/branding, organisational efficiency and design. Additional inputs to that service might be labour (e.g. cabin crew, security guards) and raw materials (electricity, jet fuel). "Working capital" refers, confusingly, not to an asset but the company's cash used during the process. A non-business capital asset would be your home (i.e. a non-business building). Your savings are financial assets, not capital assets.
[3] The original macro work on the knowledge economy was due to Machlup (1962) and Lev (2001) from a micro/accounting standpoint. Nakamura (2001) produced some partial estimates for the US and Corrado, Hulten and Sichel (2005) provided a comprehensive data and analytical treatment. See Corrado et al (2013) for a multi-country study, and Haskel and Westlake (2017) for a broad summary.

Therefore, what I would like to do today is to discuss some ideas around how this trend may affect central banks and their monetary policy. I feel we are still a long way from having a clear picture about this, so I hope with this lecture to foster further thought and research on the topic.

Let me try to summarise my views.

Monetary policy, that is, setting of interest rates and asset purchases by an independent Central Bank to stabilise prices and output, takes place against the background of (a) changing transmission mechanisms by which short-term policy influences the economy and (b) a trending long run "natural" real interest rate (called R* for short). Today I would like to think about the implications of the movement to an economy with more intangible investment, for both the short-run transmission mechanisms and the long-run natural rate.

The main mechanism is through what Cecchetti and Schoenholtz (2018) call the "tyranny of collateral": intangibles are much harder to value and secure loans against. Contrast a firm borrowing to develop a building versus one borrowing to develop software: buildings are readily traded and can be sold on, software development is a sunk cost with little or no independent market. The difficulty of posting collateral could make borrowing constraints more likely to bind for intangible-intensive firms and thus increase the sensitivity of their investment and employment decisions to the tightening or loosening of financial conditions. Pushing against this effect would be the expectation that more established firms will look to insure themselves against more costly and possibly less reliable external finance through increased saving.

In the longer-run these collateral difficulties that arise from sunken intangible investment alongside other factors that make intangibles riskier[4] to invest in, may have made borrowing more difficult and costly on average. If so, this will have reduced the demand for investment at a given safe interest rate and ultimately pushed down on the equilibrium interest rate, with all the resulting implications for monetary policy.

I shall now consider the above in more detail.

How intangibles may affect monetary policy: the short-run

Firm financing and monetary transmission

Let us now focus on firm financing and monetary transmission.[5]

Monetary transmission

Amongst other channels[6], monetary policy affects the "real" economy through business investment. Consider a firm who has a number of projects. Define the marginal project as that project which is just profitable at the prevailing real interest rate. In order to invest in marginal and other profitable projects firms need to raise funds

[4] Intangible investments have unusually high spillovers, that is to say, it is relatively easy for other businesses to take advantage of intangible investments they do not themselves make, e.g. R&D. Copying other people's ideas is relatively easy, unless the law prevents it by means of patents or copyrights.

[5] See Bean et al (2002) for an excellent review of the transmission mechanism. For a more recent survey addressing their evolution over time, see Boivin et al (2010).

[6] For example household saving and borrowing, and adjustments in the exchange rate and asset prices.

in advance. They might do so via access to their own internal sources of finance, such as cash saved from retained earnings, or funds provided by the owners of the firms (equity holders). The real interest rate is the appropriate price at which to discount the series of future cash flows from such projects. If the firm does not have access to enough or any internal funds, they need to raise them externally through a loan from a bank or other outside provider of capital. And if such providers supply such loans with no extra conditions (I explain this below), then the real interest rate is also the appropriate price.

In this set up, if the central bank raises its interest rate, and if that increase raises the real interest rate faced by firms, the marginal project becomes unprofitable. So monetary policy affects the real economy by making the implicit or explicit cost of financing projects higher and in so doing reduces investment.

If this were the whole transmission mechanism, the presence of intangibles makes no difference: firms should just line up their projects and identify the marginal one. However, there is more to it than that.

Bean et al (2002) describe at least two additional channels arising from frictions in the lending process, the "bank lending" channel and the "broad credit" channel. The essential feature of the bank lending channel is that monetary policy affects bank balance sheets which in turn affects their appetite for lending. For example, a rise in interest rates may reduce the value of a bank's assets which in turn may bring them closer to regulatory capital adequacy ratios and in so doing restrict their ability to engage in further lending without first raising new capital. Monetary policy can also influence banks' funding channels. For example a monetary expansion, such as a cut to interest rates or asset purchases through QE, should expand the total volume of reserves and deposits. If deposits are a cheaper source of finance for banks than external wholesale funding, then more reserves and deposits should make banks more willing to lend at a given interest rate. The larger the pool of bank dependent borrowers the greater the effect of the bank lending channel.

The broad credit channel focuses on information frictions between borrowers and lenders, and how the mechanisms created to overcome these frictions can lead to amplification of financial shocks. Suppose lenders in general face problems getting information from borrowers, in particular the likelihood of success of the project or default on the loan. Because of this, they demand a premium for lending and impose conditions on their loans. The oldest and most well-known condition is a *collateral* requirement, whereby the lender has a right to liquidate a specified asset of the borrower in order to recoup any losses. The total amount of debt in these instances is a function of the amount of collateralisable capital a firm has to offer. This is usually a *tangible asset* such as a building (real estate) or a safe liquid financial asset like a government bond. Lenders will also lend on the basis of a firms' *earnings* (revenues minus costs). The two most popular of these loan covenants are to cap lending at a maximum of a firm's earnings or to cap interest payments at a certain percent of a firm's earnings (interest coverage ratio); usually both are applied simultaneously to the same loan. For example, suppose a firm with no debt is projected to earn £100 profit in a year. Suppose further it wants to take out a loan, and say the loan is capped at 4 times that profit with an interest coverage ratio of 2.5, and the lender charges an interest rate of 3 percent. Under these conditions, the firm can borrow up to the cap of ($£400 = 4 \times £100$,$£1333 = \frac{£100}{0.03(2.5)}$). The idea behind these covenants is that in the event of firm bankruptcy the lender has some stronger

legal claim on the value of the restructured firm that emerges from the bankruptcy proceedings (Gilson, 2010), and to help prevent bankruptcy in the first place.

A monetary contraction tends to reduce asset prices and firm cash flows, and raise interest payments. In this scenario we see how the mechanisms detailed above could result in borrowing becoming constrained, above and beyond the effect of the initial change in monetary conditions i.e. it has been amplified[7]. More generally, the "broad credit channel" is a source of amplification because in downturns, just when firms need to borrow, their collateral and prospects have declined, making it harder to borrow.

How do these additional channels then affect a more intangible-based economy? Intangible capital is less easy to pledge as collateral with creditors and young intangible firms may be more likely to have little or no earnings. This may result in an intangible economy that becomes disconnected from debt markets and (traditional) banks[8]. Instead, investments could be funded more through retained earnings and equity. All else being equal, this suggests *reduced* potency of monetary policy via the broad credit channel in an intangible economy.

Against this, it might be that the "broad credit" channel might be stronger. If screening is harder for intangible firms, those that do try to borrow to make intangible investments may face more stringent conditions on their borrowing and hence might be more sensitive to changes in borrowing costs. Furthermore, through their very intangible nature they may find it more difficult to meet the terms placed on their debt, e.g. through lack of collateral, and so be more likely to be close to and constrained by the limits on those terms.

Thus, the overall impact of monetary policy in an intangible economy is a matter of empirical investigation. What is the evidence regarding borrowing conditions and intangibles?

Some evidence

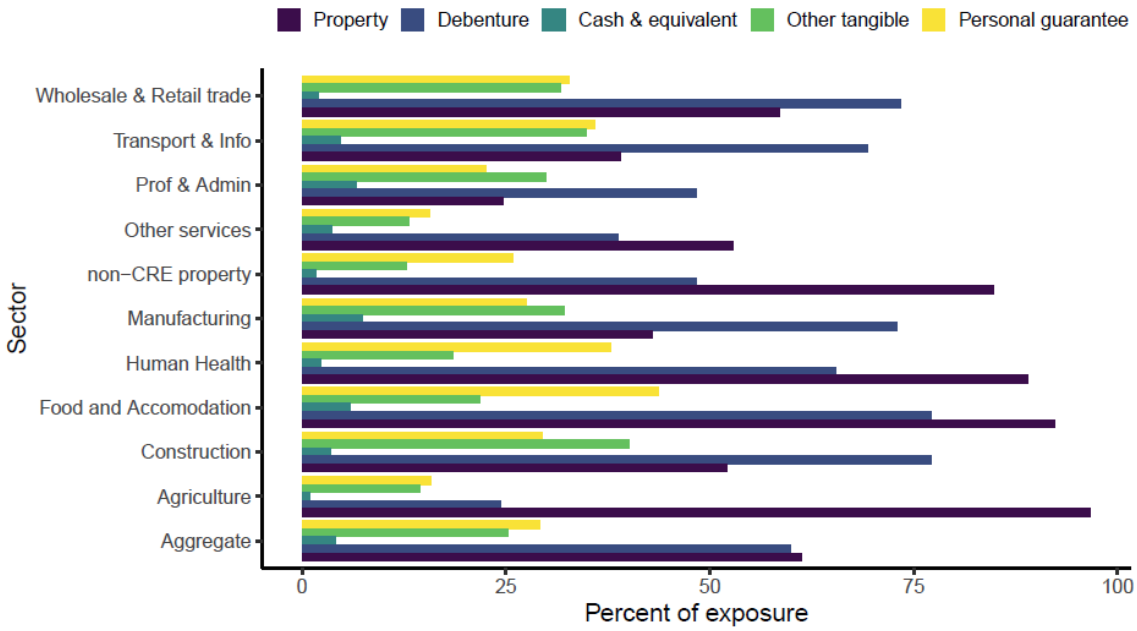
Lending and features of debt contracts

Recent studies e.g. Lian & Ma (2019), Greenwald (2019) and Drechsel (2019) have highlighted the pervasive use of loan covenants related to earnings. Lian and Ma (2019) document that amongst US non-financial listed firms, 80 percent of the volume of debt is based predominantly on cash flows. Of these covenants, the most commonly in place was a cap on the level of debt to earnings and a cap on interest payments to earnings (interest coverage). This is, however, a result for the US and driven by the largest of these firms; the smaller firms in their sample still borrow predominantly on a collateral basis (61% of lending was asset based). Furthermore, these studies investigated listed firms, which are typically larger firms to begin with. It is also worth noting a finding from Greenwald (2019) that most earnings-based loans use both interest and debt coverage covenants simultaneously.

[7] In Kyotaki and Moore (1997) for example, farmers borrow and have to pledge land as collateral. If real estate values decline, then farmers can raise less debt. This further damages the real estate market, meaning less debt, i.e. an amplifying mechanism.
[8] The growth of venture capital and crowd funding is a source of funding for intangible-intensive firms outside what we may think of as the "traditional" banking sector. For more information, see a report from the Intellectual Property Office (IPO, 2013) for a series of case studies setting out how UK companies have difficulty raising loans against their IP.

What about smaller and medium firms? In 2015, the Bank conducted a survey of major UK banks' (MUKB) lending to UK SMEs and mid corporates with revenues less than £500mn excluding CRE. This survey found that over 90% of lending was secured against some sort of collateral. Over 60% of exposures were collateralised by property and/or debentures including charges over plant, equipment and vehicles (**Chart 2**). While the survey did not explicitly interrogate respondents about intangibles, to the extent that these are difficult to use as collateral for the reasons described above, it is reasonable to think that this large reliance of banks on collateralised lending may make access to credit more difficult for intangible-intensive firms.[9]

Chart 2: Proportion of major UK banks' exposures to SMEs and mid corporates secured by collateral



Source: 2015 Survey of the MUKB on their SME and mid corporate lending.
Note: SMEs and mid corporates are defined as businesses with turnover less than £500mn.

Dell'Ariccia et al. (2018) examine the composition of commercial Bank lending in the US using comprehensive data from 1977 to 2010, a period over which the ratio of intangible to tangible capital in their sample of US firms has risen from below 40% to just over 100%. They document that the fraction of total bank loans going to commercial and industrial lending (C&I) has fallen: in 1977 C&I loans were 22% of US commercial bank balance sheets, falling to 15% in 2010, whereas real estate loans went from around 35% to 75%. Further, they show that it has fallen more in areas where intangible assets have grown.[10] Thus, they argue that the move to the intangible economy has contributed to the (substantial) change in commercial bank balance sheets towards real estate loans.[11]

[9] As already pointed out by Carney (2019), growth in bank lending to SMEs did not recover as strongly following the crisis and recently has flattened. One possible reason for this is that they are increasingly intangible intensive and thus may lack tangible capital to use as collateral.
[10] Using loan-firm-level data and controlling for a range of other factors, they find that a one standard deviation increase in intangible capital for a firm is associated with close to 10% lower loan volumes and 5 basis points higher loan spreads (their sample mean of loan spreads is about 100bps).
[11] These are data for the fraction of bank balance sheets, raising the question of whether the overall amount of lending has gone up or down: in fact they find that banks exposed to a higher growth rate of corporate intangible capital "…respond with a higher growth rate of non-C&I assets, especially residential real estate loans and liquid assets. This result suggests that banks respond to fewer opportunities in corporate lending by reallocating their lending capacity to different types of assets rather than by contracting their balance sheets."

All this then suggests the shift towards intangibles may have indeed made borrowing more difficult and/or costly, particularly for small firms.

Firm financing

To gather some additional evidence, we look at some UK firm-level data. Whilst company accounts are informative regarding debt, earnings and the like, they have very little information on intangibles since accounting conventions list only a partial measure of intangibles on firm-balance sheets, namely goodwill[12]. To gain some further insights, we use UK data on listed non-financial firms from the Worldscope financial accounts. For each of these firms we construct an (admittedly imperfect) measure of intangible capital that follows approaches by other economists e.g. Peters and Taylor (2017) or Falato et al (2013). This adds reported intangible capital to the capitalisation of R&D spending and a share of general and administrative expense (see the appendix). **Table 1** sets out our results.

Table 1: UK firm characteristics by intangible intensity in 2017

		Within quintile medians							
Quintile	Intangible intensity	Age	Employees	Revenue (m)	Assets (m)	Debt ratio	Cash ratio	Earnings ratio	Pays dividend
Q1	0.21	33	2,432	438	952	0.22	0.06	0.18	90%
Q2	0.66	31	2,522	457	430	0.17	0.08	0.11	71%
Q3	0.83	30	2,121	342	278	0.15	0.11	0.13	81%
Q4	0.92	23	1,238	225	211	0.12	0.10	0.09	68%
Q5	0.98	19	481	81	73	0.06	0.10	0.10	62%

Source: Eikon from Refinitiv and author calculations.
Note: Intangible intensity defined as capitalised intangible assets divided by capitalised intangible assets plus property, plant and machinery. Debt ratio is the ratio of total debt to total booked assets. Cash ratio is the ratio of cash and short term liquid assets to total booked assets. Earnings ratio is EBITDA to revenue. Pays dividend is the share of firms within each quintile that paid a dividend in 2017. Sample contains 470 UK listed firms in 2017.

Table 1 organises these firms by ascending quintiles of intangible intensity and illustrates how some selected firm characteristics co-vary. Firstly, column 2, shows most of these UK listed firms in 2017 appear to have significant intangible assets relative to their fixed tangible assets. **Table 1** also indicates that the most intangible-intensive firms tend to be younger and smaller. Finally, we see some evidence that intangible firms, at least listed ones, may finance themselves differently. Intangibly intense firms seem to hold less debt and more cash, and are less likely to pay dividends. Therefore, as hypothesized, we see some suggestive evidence of firms (at least for listed firms) pivoting their financing channels towards internal funds. This has been more rigorously explored on US data by others such as Falato et al (2013), who have linked rising levels of US corporate cash holding to intangible capital. In their study, they show that intangible capital is the most important

[12] Goodwill in accounting is an intangible asset that arises when a buyer acquires an existing business. This is the difference between the price paid to purchase that business and the price value as represented by the sum of its net assets. It would include, for example, the value of the brand of that company.

firm-level determinant for corporate cash holdings and explain this through firms' desire to save cash to avoid costly external finance.

Sensitivity to financial conditions

We turn now to whether intangible-intensive firms are more or less sensitive to changes in monetary policy. As we have seen, the move to an intangible economy, without financial innovation, may raise borrowing costs and give rise to less borrowing and more internal funding. Thus, we might imagine that (relatively) older, cash-rich, intangible intensive firms such as Microsoft, Apple, would have no need for external financing (these particular superstar firms, who are incredibly cash rich, are perhaps extreme examples). On the other hand, perhaps young intangible-intensive firms without cash reserves might be more constrained by more onerous borrowing conditions and/or might have to borrow proportionately more against whatever tangible assets they possess.

To look further into this I asked Bank of England economists to repeat some of their previous exercises (Bahaj et al (2017) & (2019)) on the response of employment and investment to monetary policy and the collateral channel, and asked how their results differed for firms with intangible assets. The data[13] they use represents the universe of firms (listed and non-listed) in the UK courtesy of Bureau van Dijk (BVD), and so crucially includes all the small firms.

They have kindly built on two broad streams of previous work. The first is based on the idea that the homes of directors of firms can be an important source of collateral for that firm. Bahaj et al (2017) examine the response of investment to changes in the value of director homes. Controlling for a range of other factors, they find that on average when the value of the residence of a firms' director rises, the firms' investment also rises (and the effect is statistically significant).

The importance of housing is consistent with the idea that firms are indeed constrained in what they can borrow. One might additionally ask: is this effect more important when the firm has more intangible assets? Perhaps because in this case the firm is even more reliant on the (tangible) collateral? To explore this, they run the following regression relating firm investment to real estate values:

$$Investment_{i,t} = \alpha_i + \delta_{j,t} + \mu_{I,t} + \sum_{w=1}^{2} \theta \times 1_w + \eta_w \times 1_w \times Residential\ RE_{i,t} + \sum_{w=1}^{2} \beta_w \times 1_w \times Corporate\ RE_{i,t} + \gamma \times controls + \epsilon_{i,t} \quad (1)$$

Where i is firm, t is time, j is region, I is industry and w separates firms into those with ratios of intangible to tangible assets of less than or more than 25 percent[14]; controls are cash and profits. *Residential RE* is the value of the directors' homes and *Corporate RE* is the value of the firms' commercial real estate. For more details on this specification, see Bahaj et al (2017).

[13] This full dataset covers 1.5 million firms per year for the period 1997-2016. For exact sample sizes, see Bahaj et al (2017) & (2019).
[14] Firms are intangible based if they reported intangible assets in their financial statements: intangible intensity is the ratio of reported intangibles to fixed assets.

It turns out that the investment of intangible-intensive firms is more sensitive[15] to an increase in the house value of their directors. This falls in line with the hypothesis that the more intangible intensive firms may have to rely more on outside tangible assets to overcome lending frictions. Whilst this interaction is not statistically significant at conventional levels (p=0.08), intangibles are poorly measured in company accounts, likely biasing down the effect. Further, the effect is economically significant, with the point estimate of the response of investment twice as large for intangible-intensive firms. Along the same lines, there is also twice the response to appreciations in the value of corporate real estate (see appendix table A1 for more details). Undoubtedly, there is more to discover in this area, but the findings are suggestive.

A second exercise is inspired by a second stream of work on these data reported in Bahaj et al (2019). They establish that the employment of younger and more levered firms in the UK respond more to changes in interest rates. We expand this analysis to ask whether employment responds to monetary policy differently for more intangible-intensive firms. The regressions are of the following form:

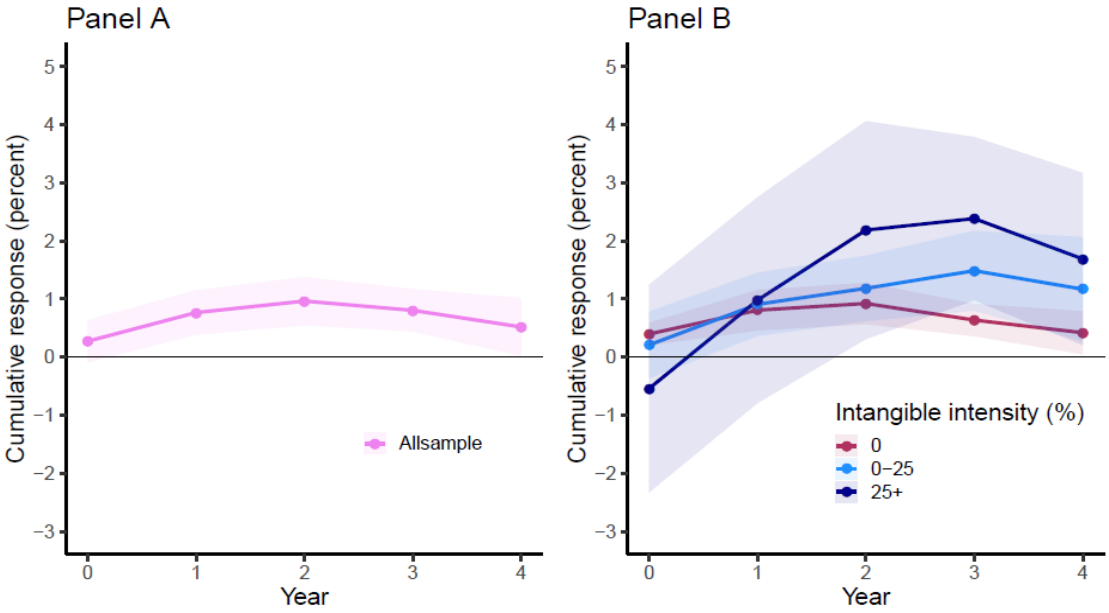
$$\ln\left(Employment_{t+h,i}\right) - \ln\left(Employment_{t-1,i}\right) = \sum_{g} \theta_g^h \times 1_g + \beta_g^h \times 1_{g,t-1} \times \Delta r_t + \epsilon_{i,t}^h \qquad (2)$$

Where *h* is the number of periods after the change in interest rate *r* at time *t*, and g denotes the firms group/type, e.g. tangible or intangible firm. For more details see Bahaj et al (2019).

Chart 3 shows the response of employment of firms to an unexpected 25 basis point decrease in interest rates. **Panel A** shows the results for the whole sample and indicates a peak response of employment to a 25 basis point decrease in interest rates of around 1 percent after two years (that is statistically significantly different from zero). **Panel B** divides the sample by intangible intensity: those firms reporting no intangibles (intangible intensity=0), those reported intangible/tangible asset ratio between 0 and 25% and those above 25%.

[15] A £1 increase in house value increases investment by 4.5 pence versus 2.3 pence for firms with high versus low intangible/fixed assets ratios. The difference has a p value of 0.08 and so is statistically significant at the 10% level.

Chart 3: Employment response of firms to an unexpected decrease in interest rates



Note: Both panels show the average cumulative percentage change in firm employment to an unexpected 25 basis point decrease in interest rates in the year preceding Year 0. The shaded areas correspond to 90 percent confidence intervals. For more details, see Bahaj et al (2019). Intangible intensity is the ratio of reported intangible to fixed assets. The response of employment to an unexpected decrease in interest rates is identified using a high frequency identification strategy; see Gerko and Rey (2017).

As the panel shows, the year 0 and year 1 response of all firm types is similar. However, by year 2 the ordering of the firm responses is consistent: the most intangible-intensive firms have the biggest response. There is, however, considerable uncertainty around these estimates, as indicated by the wide confidence intervals, and so future work will need to investigate if there is genuinely no difference between firms' types, or if the uncertainty over the measure of intangibles is widening the error bands.

In other work, we further divided in the firms into old and young. As the **appendix chart A1** shows, the error bands around these subgroups were wide, but we did find the same ordering: the largest response for the old and young intangible-intensive groups; followed by the response for the young tangible intensive firms. The old tangible-intensive firms reacted the least.

Future work is clearly needed. For the moment, our point estimates at least are consistent: the largest response of investment and employment to the three sets of results on house price and interest rate changes is from the most intangible-intensive firms. This is consistent with the idea that intangibles may indeed interact with collateral constraints, so that with more intangibles in the economy there is heightened sensitivity of firms to monetary policy[16].

[16] Chart A.1 in the appendix raises somewhat of a puzzle in that the older, intangible-intensive firms are more sensitive to monetary policy than younger tangible ones. When one thinks of older intangible-intensive firms one thinks of Apple and Microsoft who, being so cash rich, would seem to have little need for borrowing and hence little exposure to the types of bank and credit channels described in the monetary transmission literature. Therefore, this finding is perhaps a puzzle, unless such examples are unrepresentative: after all, if intangibles are properly accounted for, pharmaceutical and high-tech engineering companies are intangible rich as well.

How intangibles may affect monetary policy: the long-run

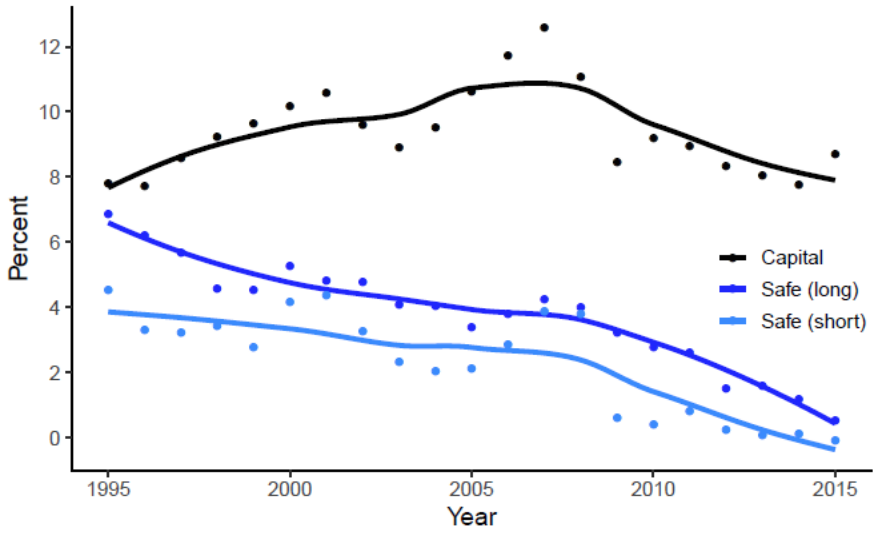
Regardless of these short-run effects, policy has all taken place in the context of a declining longer run equilibrium interest rate that poses a possible constraint on conventional monetary policy. I believe intangibles are part of this story as well.

Setting the scene: interest rates and investment trends

Before moving to the long-run effects on monetary policy from the rise of intangibles, let us first consider two long-run trends.

Chart 4: Yields on safe assets and capital

(average across 11 countries)



Source: www.INTANInvest.net and Jorda et al (2019).
Note: Lines are exchange rate adjusted nominal GDP weighted averages of the available countries: Austria, Czech Republic, Germany, Denmark, Finland, France, Italy, Netherlands, Sweden, UK and US. Yield on capital is the ex-post yield on the market sector invested capital stock based on the approach of Hall and Jorgenson (1967).The capital stocks includes a broader measure of intangible assets. The residential sector has been excluded. For more details, see Corrado et al (2016). Safe rates are nominal sovereign bond yields. The solid lines are smoothed representations of the data points (dots).

Diverging safe and risky returns

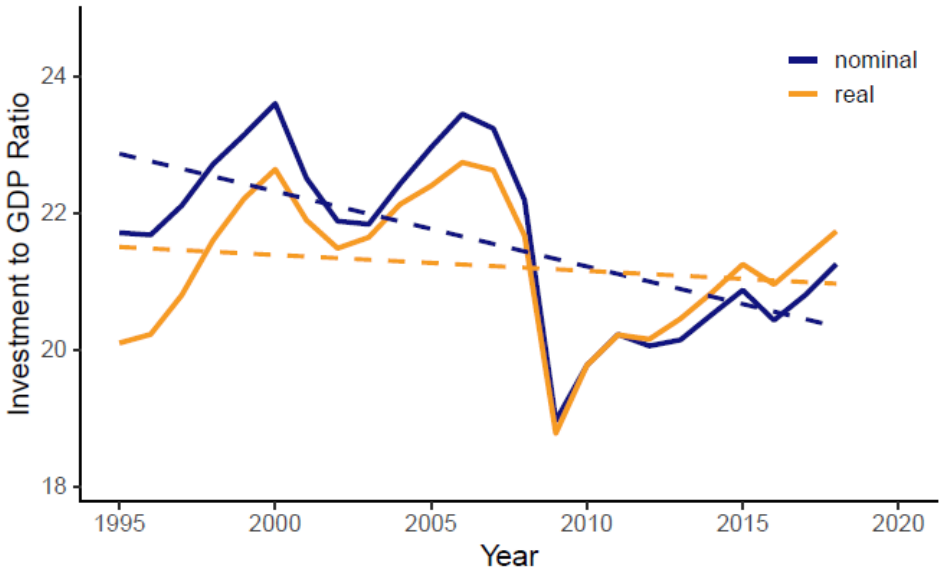
Chart 4 shows two types of yield for advanced economies (weighted averages across a sample of countries). The lower lines are the yields on short and long safe government securities, which we shall call a "safe rate". As can be seen, these safe rates have fallen consistently over the period by about 4 percentage points. The figure also shows an average rate of return[17] for the business sector. Interestingly, this has not really been falling and so the wedge between these rates, meaning the gap between the rates an investor would make in a safe government bond and the return on investing in a unit of capital in the business sector has been increasing. Other measures such as the spread between bank deposit and lending rates, corporate bond spreads and equity risk premia have also been measured as increasing over this period, see for example Rachel and Smith (2015).[18]

[17] This is measured as the rate of return in the Hall-Jorgenson capital rental price formula, calculated as the rate of return to make post-tax capital rental rates equal value added less labour payments for the business sector.
[18] Rachel and Smith (2015) consider the IMF's weighted indicator of spread for the world as a whole (Chart D28). This spans across different measures, such as bank credit spreads (the difference between bank deposit and lending rates), fixed income spreads (the

Stable or falling investment

Chart 4 shows changes in yields on capital. But what has happened to investment quantities? As **chart 5** shows, they have remained flat or declined depending on whether one measures on a nominal or real basis. Therefore, despite a potential fall in the user cost of capital at least calculated using the safe rate, investment has not taken off.[19]

Chart 5: Combined Investment shares in advanced economies



Source: OECD
Note: Lines are GDP (at PPP) weighted averages of the INTANInvest countries: Austria, Czech Republic, Germany, Denmark, Finland, France, Italy, Netherlands, Sweden, UK and US. The dashed lines is the linear trend over the illustrated period.

Intangibles and the equilibrium or neutral real interest rate

With these trends in mind, in this section I would like to discuss the possible role played by the rise of intangibles in the decline of the equilibrium real interest rate estimated across several economies over the last decades.[20]

But first, what is the equilibrium real interest rate of an economy?

*A framework for R**

The *equilibrium interest rate* is the real interest rate that is consistent with the economy at target inflation and with zero output gap (BoE, 2018).This is illustrated in **chart 6**.

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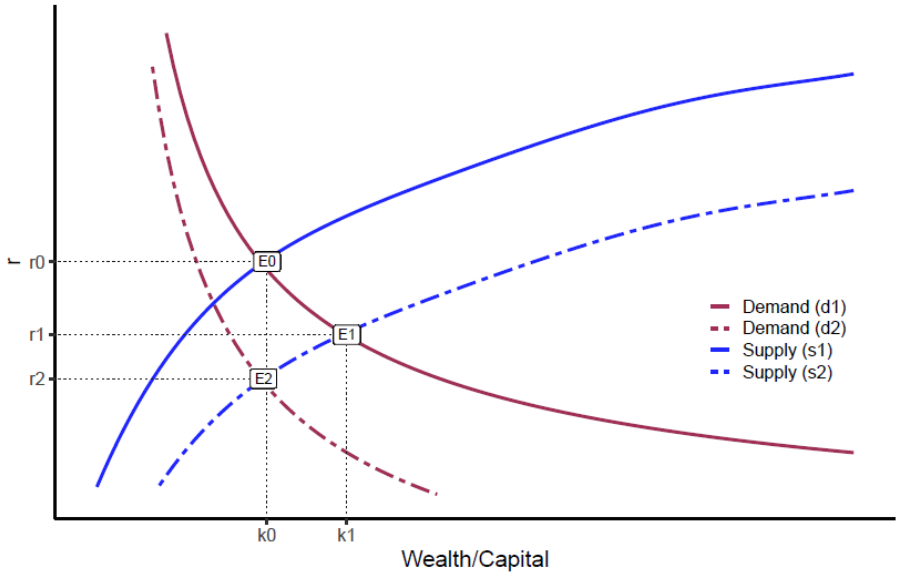
difference between yields on corporate and government bonds), and equity market spreads (earning yields minus government bond yield). According to the IMF measure, the rate of return on capital has fallen since the early 1990s, but not by as much as the risk free rate – the spread has increased by around 100bps, in line but substantial smaller than our results in **Chart 4**.

[19] Some caveats to this include the following. Investment in these data is business investment plus government investment plus residential housing, so the appropriate return for this investment is not, strictly speaking, the business rate of return as used above. Nor do these investment data include a more comprehensive measure of intangibles. Also, investment has fallen in developed countries but risen in developing countries, but overall it does not look like it has risen.

[20] See for example, among many others, Del Negro et al. (2018).

Chart 6: Determinations of real interest rates (r), wealth and capital



The upward-sloping blue lines in **chart 6** show that the quantity of wealth individuals want to hold tends to increase as real interest rates rise. Thus if we put the "safe" real interest rate *r* on the vertical axis, then the blue lines trace out the increased willingness to save when safe rates rise.

In contrast, the demand for capital (shown in the maroon lines) tends to be downward sloping: as the quantity of capital rises, its marginal product falls and so each extra unit of wealth will earn a lower return. The intersection of the demand for capital and supply of savings determine the safe interest rate, e.g. at r0 point *E0* in **chart 6**. The equilibrium should be thought of as being determined by slow-moving structural factors that affect the balance between the demand for capital and the stock of wealth available to finance it. For an open economy like the UK, those factors will reflect global influences as well as domestic ones.

*How intangibles may influence R**

We have three facts to explain:

a. the trend safe rate has fallen.
b. the wedge between the safe rate of return and the average rate of return earned by companies has risen.
c. Investment as a share of national income has hardly changed.

How can the graph explain this? Let us start at E0, where the real rate of interest is r0 and capital is at k0 and consider a shift in desired saving for the given interest rate r0. In the graph that is the shift of supply of savings from *s1* to *s2* and a new lower equilibrium interest rate of r1 at *E1*. Such a shift has been widely discussed (e.g. Rachel and Smith (2015)) as being due to increased population longevity, lower expected future incomes (lower productivity growth) and a rise in inequality (which raises savings due to a compositional effect if the rich save more).

This however does not explain the fact that capital/investment demand has not increased in response to this lower interest rate as is the case at *E1*. Nor does it explain the growing wedge between safe and risky rates.

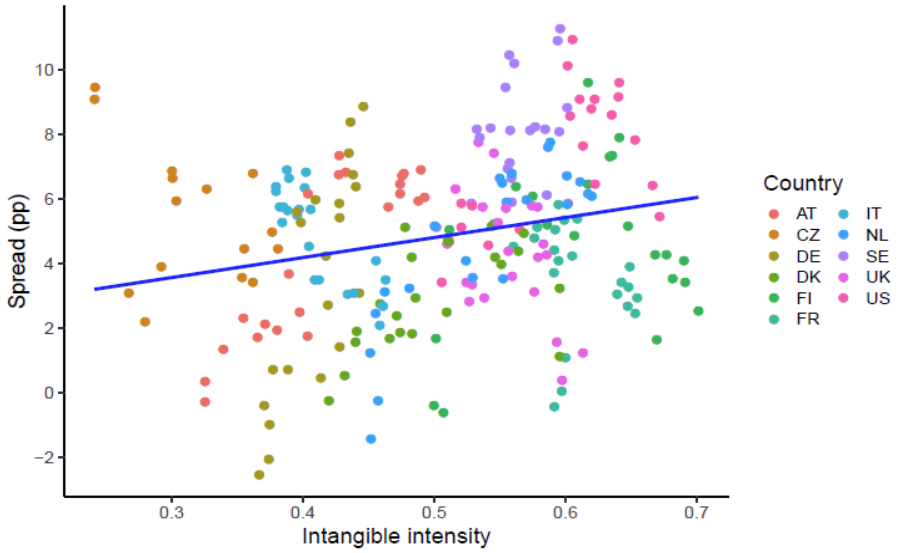
What would explain this is an inward shift in capital demand for a given safe rate (think of firm's demand for capital as depending on the risky rate and so a rise in this wedge shifts the demand curve inwards with the safe rate on the vertical axis). In **chart 6** this would be a movement in demand from *d1* to *d2* and a further decrease in the equilibrium interest rate to *r2* at *E2*, leaving capital unchanged at *k0*.

It has been documented and we have seen evidence in **chart 4** that the spread between the risk free rate and return on capital has increased. This means that for a given risk free rate, firms are paying more for capital and hence we would expect a decline in demand for a given risk free rate. This is our inward shift in from d1 to d2 in **chart 6**. But why have these spreads grown?

It seems reasonable that at least part of the rise in the risk premium might have been driven by the trend towards intangible investment. As we have discussed, the "sunkeness" of intangible assets makes them much more difficult to use as a collateral, at least through traditional channels like a loan. This shortage of collateral will drive risk spreads higher in a more intangible economy. Over and above the issue of collateral, intangibles may just be generally more risky to invest in. For example, spillovers create a risk that the returns generated by an intangible investment may be reaped by a free-riding third party. This will also—all else equal—drive spreads higher. This rise in spreads has the effect of lowering *d1* to *d2* in **chart 6**.

If the above is a mechanism by which growing intangible intensity lowers R*, how can we test it? We have documented rising intangibles and a falling R* over recent decades, but many other things might be going on, so this is not very strong evidence. A slightly better way is to look at how the wedge documented in **chart 4** co-varies by countries' intangible intensity. If the trend towards intangibles is raising risk spreads, then there should be a positive correlation between spreads and intangible intensity.

Chart 7: Intangible intensity and the return on capital spread



Source: www.INTANInvest.net and Jorda et al (2019).
Note: Chart plots the spread between the return on capital and long run safe rates for the period 1995-2015. Returns on capital are adjusted for tax rate differences. The safe rate is the nominal return on 10 year sovereign bonds. Due to the significant variance in sovereign yields in the euro area, the German 10 year was used across the euro area in each year. Intangible intensity is the ratio of intangible investment to total investment. Intangible intensity is significantly correlated with the spread after controlling for year fixed effects (coef: 0.042, se: 0.015). After controlling for country and time fixed effects it was positive but insignificant (coef: 0.076, se: 0.049). Spain was excluded, as an outlier.

To test this, **chart 7** plots the wedge between returns to capital and risk free bonds (i.e. the gap for each country between the upper black line and darker blue line in **chart 4**) against intangible intensity for our sample of countries. The line of best fit is positive and statistically significant when including year fixed effects, suggesting that those countries with higher intangible intensity have on average a larger wedge. This is, of course, only tentative evidence based on a small sample of countries and there will be other confounding factors[21]. Furthermore some individual countries wedges (e.g. Finland), have declined as they have become more intangible. Overall, it is suggestive that the positive correlation is in line with our hypothesis.

*Other avenues for intangibles to affect R**

Compositional effects, lower trend productivity and inequality are three other routes that have been documented as lowering the equilibrium safe interest rate. But they in turn may be affected by the shift towards intangibles.

First, if intangible assets can be scaled more readily than tangibles, a shift towards intangibles might lower the demand for capital as a matter of composition. This argument has been made by economist Lawrence Summers using the example of WhatsApp, an intangible intensive firm.

"Ponder the fact that WhatsApp has a greater market value than Sony, with next to no capital investment required to achieve it. Ponder the fact that it used to require tens of millions of dollars to start a significant new venture, and significant new ventures today are seeded with hundreds of thousands of dollars. All of this means reduced demand for investment, with consequences for equilibrium levels of interest rates." (Summers, 2014)

Overall, this compositional shift towards intangibles reduces demand for investment and the availability of investable assets, which results in downward pressure on interest rates. This argument is spelled out in more detail and modelled by Dottling and Perotti (2019).

Second, lower productivity growth drives R* downward as capital becomes less productive (reducing demand for it) and people are induced to save more when they expect their future incomes to be lower. Intangibles might have contributed to this in at least two ways. First, much of lower productivity is lower TFP growth. As **chart 1** shows intangible accumulation has slowed since the financial crisis; TFP growth may have slowed through a reduction in the positive externalities associated with intangible investment via spillovers.[22]

Another mechanism might be that while intangibles adoption may initially boost productivity in an economy, in the long-run it may actually drag on productivity[23]. This is because large intangible-intensive incumbents through their scale and networks can undercut and prevent the entry of innovative new firms. Think of a young firm with a better search engine algorithm trying to compete with Google.

Third, scale and synergies might have raised inequality, as large firms scale up and better capture the synergies of intangibles working together. Crouzet and Eberly (2018) argue these features have enabled the rise in

[21] A rise in mark-ups for example, but of course such a rise, if it exists, might be due to intangibles themselves; see Barkai (2019) and Caballero et al (2020).
[22] See for example Garcia-Macia (2017). For more on intangibles and spillovers see Haskel and Westlake (2017).
[23] This mechanism is discussed and modelled by de Ridder (2019).

industry concentration over the last two decades in the United States. Now, as the society becomes more unequal, with more and more of national income concentrated in the hands of few, this may have also contribute to the decline in R*. This happens as richer segments of the populations have lower marginal propensities to consume and thus save more. In this case, intangibles shift the supply of capital curve[24].

Concluding thoughts

We have explored some ideas and seen some evidence for the implications of intangibles on monetary transmission and the natural rate of interest. We have two main findings:

1. The shift to intangibles might affect the monetary transmission mechanisms if intangibles are harder to borrow against and so firms seeking external finance find it harder to do so. Our point estimates consistently indicate that intangible-intensive firms are more affected by changes in financial conditions than tangible-intensive firms.
2. If the conventional financial system finds it hard to value and so lend against intangible assets, then over the long-run risk spreads will rise as the economy becomes more intangible-based. This depresses the safe rate of interest and so contributes to a lower R*.

In terms of monetary transmission, firms and the financial system are in a constant state of evolution and need to continue to adapt[25] to a more intangible world. These forces, including increased cash holdings, lower debt levels, and a smaller role for traditional banking, may all reduce the potency of monetary policy in the intangible world. Pushing in the opposite direction, recent studies such as (Cloyne et al, 2018) and (Bahaj et al, 2019) have shown young financially constrained firms are more *responsive* to monetary policy, experience larger increases in the cost of external finance (Anderson & Cesa-Bianchi (2020)), and explain a large share of the aggregate dynamic response despite accounting for a small share of overall investment and employment. We have seen above some evidence that intangibles are a part of this story. Overall, we need more work to fully understand and quantify the balance of these two forces on the aggregate response of the economy to monetary policy.

The falling natural rate of interest has been extensively studied. As it is well acknowledged, explanations of falling R* have also to explain the divergence between risky and safe rates and the related decline in the demand for capital. I think the inability to finance intangible investment is a part of this story. Given that, it is important that the financial system evolves and innovates to meet the trend towards intangibles.[26] A failure to do so could see a continuing low neutral rate of interest.

This much-discussed low interest rate environment we find ourselves in, reinforced by the trend towards intangible assets that I have discussed today, in part informs my recent votes on the MPC, where limited

[24] Vlieghe (2016) neatly summarises the drives of lower interest rates into three D's: Debt, Demographics and Distribution of income. To which we might like to add a fourth "D": disembodied knowledge.
[25] There are perhaps some limits on the scope for adaption. For example, the expertise around successful venture capital firms takes many years to build up and is difficult to scale, unlike the ideas they invest in.
[26] Relatedly, the Bank is working closely with HM Treasury, BEIS, FCA and industry to explore how a common set of standards and protocols could enable permissioned data portability throughout the economy and improve access to finance for SMEs in the UK. This should partly help to overcome some of the issues many SMEs may face from a lack of tangible collateral when trying to access finance, as illustrated in this speech.

conventional monetary policy space means I continue to prefer to move now in order to ensure we achieve a sustainable return of inflation to target.

Finally, today I have not touched on all the possible interactions between intangibles and monetary policy. Alongside a declining natural rate of interest, monetary policymakers across advanced economies are also grappling with below target inflation despite tight labour markets and what we think is accommodative monetary policy. Are intangibles playing a role here? Perhaps one angle is that intangible investments—directly through investment in process and indirectly through increased scalability—have brought about an increased scope for variable capacity utilisation and in so doing have flattened the short run relationship between aggregate demand and inflation. This, alongside the other points we have discussed today, would benefit from further research and analysis.

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Appendix: *Capitalising intangibles*

To conduct our analysis we add to firm-level reported intangible assets by following the approach of Peters and Taylor (2017) amongst others and capitalising their R&D spending and a share of their sales, general and administrative (SGA) spending such that the intangible capital stock (K_{it}^{int}) is defined as:

$$K_{it}^{int} = INT_{it} + A_{it} + B_{it}$$

Where INT_{it} is intangible assets in the balance sheet for firm *i* at time *t*, A_{it} is accumulated R&D (RD) spending (defined below) and B_{it} is accumulated SGA spending (defined below).

$$A_{it} = (1 - d_{rd})A_{i,t-1} + RD_{it}$$

Where d_{rd} is the R&D depreciation rate (assumed to be 15% economy-wide, following previous literature).

$$B_{it} = \left(1 - d_{sga}\right)B_{i,t-1} + 0.3 * SGA_{it}$$

Where d_{sga} is the SGA depreciation rate, assumed to be 20%, and 30% of SGA is assumed to be related to intangible investment, following Peters and Taylor (2017).

A choice needs to be made on what to do about starting RD and SGA stocks (A_{i0} and B_{i0}), as the firms are not usually observed from the year they were formed. We assume these to be zero and focus on the final year of our sample 2017. There is also a small number of cases, where a firm exits the dataset and then re-enters n number of years later. For the accumulation of RD (and analogously for SGA), we use the following proxy formula to calculate the accumulated stocks in the year of re-entry:

$$A_{it} = (1 - d_{rd})^n A_{i,t-n} + (n - 1)\left[\frac{(1 - d_{rd})^n RD_{i,t-n} + RD_{it}}{2}\right]$$

Our data source is the Worldscope financial account database for UK (listed) firms (excl. finance and oil and gas firms); sample 2000-2018. We start the accumulation of capital in 2000.

Table A1: Investment response to collateral based on intangible intensity

Table 1: Intangibles

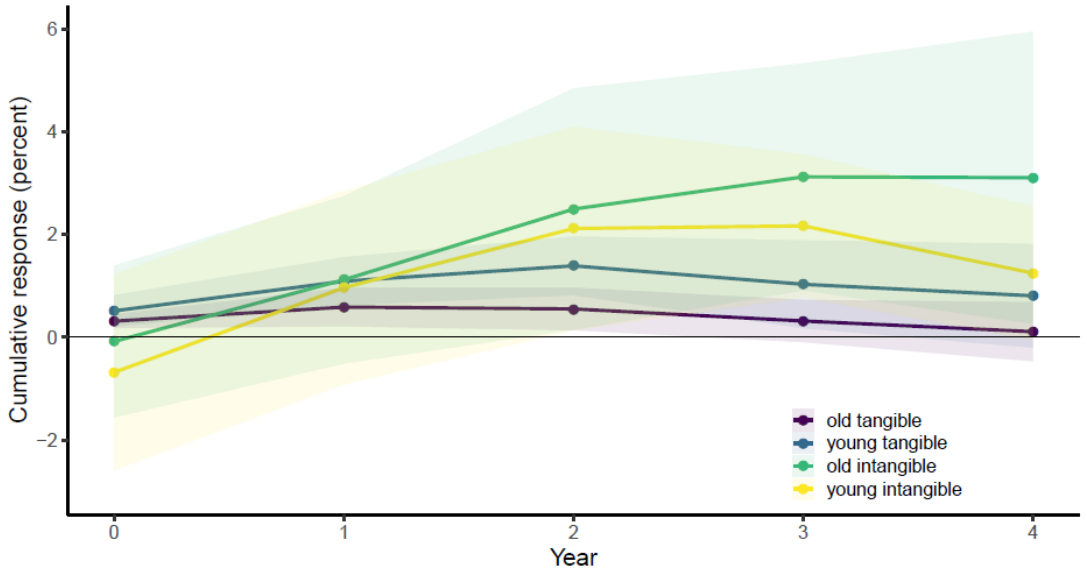
Investment Response to Collateral Based on Intangible Intensity

	Intangibles/Fixed Assets	
	$0\% \leq x \leq 25\%$	$25\% < x$
	(1)	(2)
Residential RE	0.0234***	0.0452***
	(0.007)	(0.014)
Corporate RE	0.0447***	0.0855***
	(0.016)	(0.028)
Cash	0.0776***	
	(0.013)	
Profit	0.1097***	
	(0.017)	
Observations	31213	
Adjusted R^2	0.25	
P-val., Equal of Res. Coeffs	0.08	
Add. Firm, Dir. Controls	Yes	
Region-time FE	Yes	
Industry-time FE	Yes	
Firm FE	Yes	

Firm region clustered standard errors in parentheses

$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$.

Chart A1: Employment response of firms to a decrease in interest rates



Note: Chart show the average cumulative percentage change in firm employment to an unexpected 25 basis point decrease in interest rates in the year preceding Year 0. The shaded areas correspond to 90 percent confidence intervals. For more details, see Bahaj et al (2019). Intangible intensity is the ratio of reported intangible to fixed assets. Intangible firms are those with intangible intensity greater than 25%. Tangible firms are those with intangible intensity of 0%. Young firms are firms less than 15 years old. The response of employment to an unexpected decrease in interest rates is identified using a high frequency identification strategy; see Gerko and Rey (2017).