Panel on Changing Market Structure and Implications for Monetary Policy

Market Power and Monetary Policy

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The topic for this panel is the link between developments in product markets and monetary policy. It is a great one. A lot of attention has been paid by central bankers over recent years to the relationship between *labor markets* and monetary policy (for example, Yellen 2014 and Constâncio 2017). And rightly so. The relationship between monetary policy and *product* markets has, by comparison, been the road less traveled.[1,2]

Labor markets have been subject to big structural shifts over recent years, including the secular fall in the degree of worker unionisation in a number of industries (for example, Schnabel 2013), the emergence of the so-called “gig economy” (for example, Taylor 2017, and Katz and Krueger 2017) and secular rise in the degree of globalization and automation in the workplace (for example, Brynjolfsson and McAfee 2014, and Acemoglu and Restrepo 2018). Each of these shifts has led to a change in employment patterns and tenures and in workers’ bargaining power.

These structural shifts have been used to help explain the secular fall in labor’s share of national income and the recent weakness of wage growth across a number of advanced economies (for example, Dao et al. 2017, and Abdih and Danninger 2017).[3]

They have also been used to justify potential shifts in the position and/or the slope of the Phillips curve (for example, Blanchard 2016, and Kuttner and Robinson 2010). Each of these potentially has a bearing on the setting of monetary policy.

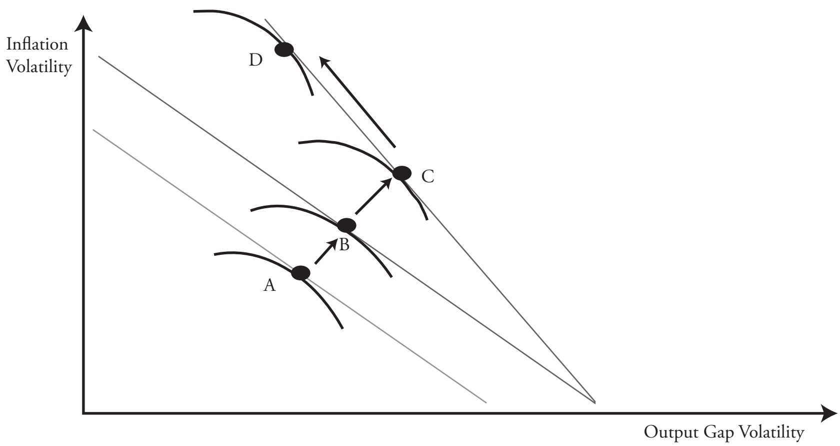
Yet, over the same period, structural shifts in the product market have been no less profound. They include the emergence of highly integrated global supply chains, increasing the degree of specialization of product markets (Baldwin 2016); the blossoming of companies benefitting from global network economies of scale and scope, who acquire "superstar" status (Autor et al. 2017); and the rapid emergence of e-commerce and price-comparison technology (Cavallo 2017).

The associated shifts in market power, too, might plausibly have altered some of the key macroeconomic relationships in the economy (De Loecker and Eeckhout 2017). They may have influenced the pricing and provision of goods and services in the economy and hence the Phillips curve. And they may have influenced the amount of investment and innovation undertaken by firms and hence the aggregate demand curve (Aghion et al. 2005). They too might thus have a bearing on the setting of monetary policy.

These structural shifts in product and labor markets may, in some cases, have had common cause. For example, network economies of scale and scope could potentially have increased some companies' market power both over their labor inputs (through monopsony effects) and product outputs (through monopoly effects). This could show up in both a *falling* labor and a *rising* profit share, with potential macroeconomic implications for activity, costs and prices (Autor et al. 2017, Barkai 2017).

To explore these issues, we start by discussing briefly recent empirical evidence on market power and its potential macroeconomic explanations and implications. We then explore its effects on monetary policy, using counterfactual policy simulations and adaptations of a simple New Keynesian model. Taken together, this evidence suggests that an increase in market power and markups could have potentially important consequences for the economy and policy. These are summarized, in stylized terms, in Figure 1.

Figure 1
Inflation and Output Gap Variability with Increased Prevalence of Markup Shocks and Higher Steady-State Markups



Notes: See text for a discussion of what points A-D represent.
Source: Bank of England.

To the extent a secular rise in markups reflects a set of trade-off inducing shocks, that would shift outwards the output/inflation variability (policy possibility) frontier (from A to B). It may steepen the Phillips curve, causing the policy possibility frontier to rotate clockwise (B to C). And it may also potentially alter the optimal weights placed on output and inflation stabilization by the policymaker, shifting the point of tangency between the policy possibility frontier and policymakers' loss function (C to D).

Taken together, the net effect of increased market power could be a potentially significant rise in inflation (but less so output) variability, relative to the counterfactual case of stable and static markups (A to D). As for monetary policy, the fact that these are trade-off inducing shock places limits on its stabilization capacity. The (level and variability) of the optimal interest rate path is, as a result, less affected by increased market power, despite significant shifts in policy possibility frontiers and policymaker preferences.

There are two ways in which the path of monetary policy might potentially be affected to a greater degree by increases in market power. When companies have a significant degree of market power, the level of output produced is likely to be below the social optimum, creating an incentive for monetary policy to try to offset that by running the economy hotter ("inflation bias"). And if market power lowered companies' investment rates, this could reduce the economy's neutral rate of interest. Neither, however, at present has a strong empirical basis. To the extent these channels do operate, they reinforce the institutional case for independent central banks charged with pursuing well-defined inflation targets.

At the same time, actual inflation across advanced economies has of course been relatively low and stable over recent decades. So while the microeconomic evidence—a secular increase in markups—is striking, it is not easily reconciled with the macroeconomic evidence on measured inflation, including on the impact of markups on inflation (for example, Smets and Wouters 2007). Reconciliation of the two strands of evidence—micro and macro—means that some combination of the following would have to be true.

First, the microeconomic *firm-level* evidence may not accurately describe how *economywide* markups have evolved since the 1980s. Second, other macroeconomic factors may have more than offset the impact of rising markups on the behavior of inflation. Third, the theoretical macroeconomic framework we use here—a New Keynesian model with monopolistic competition—may not be appropriate to analyse firm-level changes in markups. The apparent puzzle between the microeconomic and macroeconomic evidence deserves further research, given its potential impact on inflation dynamics and monetary policy.

Market Power—Evidence and Implications

There is a rich microeconomic literature that assesses the impact of market power on pricing and other firm decisions (for example, Tirole 1988). There has been rather less evidence linking the industrial organization of firms to developments in the wider macroeconomy. That has changed recently, with a number of papers exploring the empirical evolution of (firm, sectoral and national) measures of market power and their implications for the macroeconomy (for example, De Loecker and Eeckhout 2017, 2018 and Díez et al. 2018).

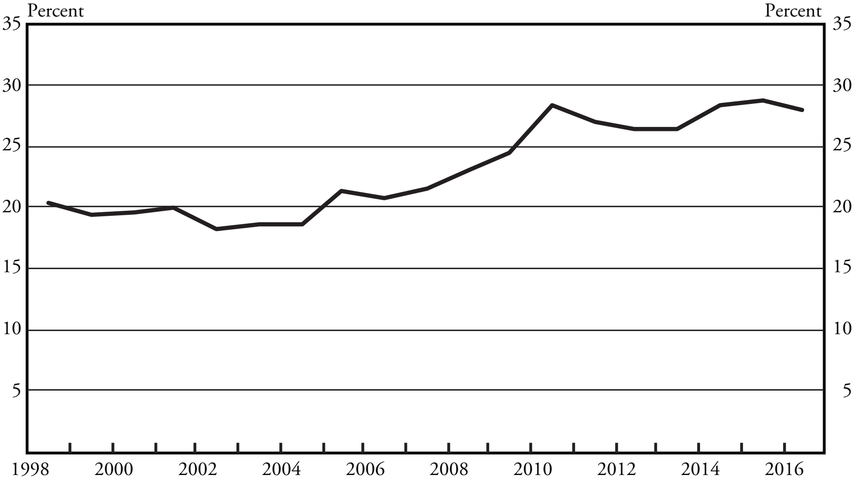
Perhaps the simplest way of capturing market power is through measures of market concentration, such as Herfindahl-Hirschman Indices (HHI) (Hirschman 1964) or concentration ratios (the share of sales that accrues to the largest firms within an economy or sector). Evidence suggests that market concentration, measured either through HHIs or concentration ratios, may have increased in the United States over recent decades, across a broad range of sectors (for example, Autor et al. 2017). This pattern is not uniform, however, with concentration among European companies showing no such trend (Gutiérrez and Philippon 2018).

The evidence on industry concentration in the U.K. suggests it occupies a mid-Atlantic position. Chart 1 plots the turnover share of the largest 100 U.K. businesses since 1998 (i.e., concentration ratio).[4] This ticks up in the lead-up to the financial crisis, although this pickup is more modest than in the United States, from 20 percent to around 28 percent.[5] Concentration has flattened off in the period since the crisis, however, in line with other European countries.

Turning to measures of concentration within the financial services industry, the international pattern is somewhat more uniform. Chart 2 plots the largest five banks' share of total banking assets in the United States, euro area and the U.K. Levels of banking concentration started fairly high, averaging around 30 percent. They drifted further upward in the run-up to the crisis, although this drift was again fairly modest. Since the crisis, however, measures of banking concentration have flatlined and, in the U.K., have fallen slightly.

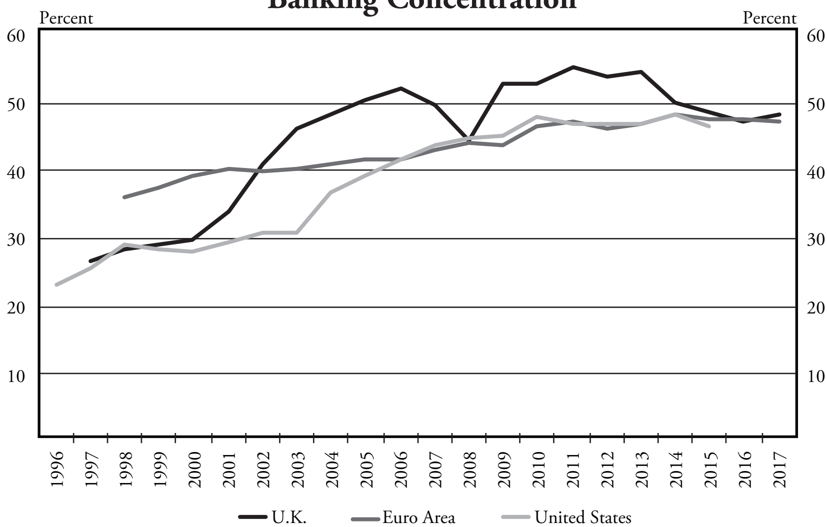
Concentration indices have their limitations, though, and need not always be associated with market power. Some firms may be able to exercise market power in setting prices even without having a large share of a market if, for example, there is brand loyalty. And in a world of differentiated products, concentration measures such as HHIs or concentration ratios no longer correlate closely with market power (Bresnahan 1989). With nonhomogenous goods and non-Cournot competition, a better measure of market power is often provided by firms' markups—the ratio of their price to their marginal cost (De Loecker and Eeckhout 2018). The larger the markup, the greater the degree of market power, whether at the firm, sector or national

Chart 1
U.K. Product Market Concentration



Note: Data and calculations exclude the financial sector.
Sources: ONS and Bank calculations.

Chart 2
Banking Concentration



Notes: Data refer to banking sector assets of the five largest institutions in each region as a share of total banking sector assets. U.K. banks are all U.K. resident monetary financial institutions (MFIs). These data cover only the U.K. assets of the MFIs. As such they differ from the institutions' own published accounts that will comprise the global assets of the group. Euro-area data prior to 2006 are constructed using data for the Netherlands, Germany, France, Italy and Spain holding the share of these countries relative banking sector sizes constant, at their 2006 level. This is due to data availability limitations pre-2006.
Sources: Bank of England, European Central Bank, Federal Reserve Bank of St. Louis and Bank calculations.

level. Markups also have the benefit of being the relevant measure of market power in the workhorse models of the macroeconomy used by policymakers.

In that spirit, a number of recent papers have estimated measures of markups based on individual company accounts data. These cover a wide range of companies, sectors, countries and time periods (for example, Díez et al. 2018). The findings from these studies are, in macroeconomic terms, both quite striking and quite strikingly uniform in the broad trends they reveal.

For example, De Loecker and Eeckhout (2018) have recently calculated markups for around 70,000 firms across 134 countries over almost four decades.[6] Since 1980, they estimate that the sales-weighted markup for the average firm across countries has risen by a remarkable 50 percentage points.[7] Table 1 shows their markup measures for the G-7 economies over the period. Though there is cross-country variation, average markups have risen significantly in every G-7 country, by between 30 and 150 percentage points.

Taken at face value, the macroeconomic implications of these shifts in markups could be very large. The most direct and immediate impact would be on measured inflation rates. According to Table 1, markups will have been adding, on average, over 1 percentage point *each year* to measured inflation rates across the G-7 countries between 1980 and 2016, other things equal. As context, over the same period average G-7 inflation rates have fallen by over 10 percentage points.[8]

A second potential macroeconomic impact of higher markups is on sales. Higher markups will, other things equal, have pushed down on aggregate demand and generated a deadweight loss of consumer surplus ("Harberger triangle"). Baquee and Farhi (2018) estimate the size of this effect and find that *eliminating* markups entirely would raise aggregate U.S. total factor productivity (TFP) by as much as 35 percent.[9]

To better understand some of the drivers of higher markups, it is useful to look at more granular data. Using a similar approach to De Loecker and Eeckhout (2017, 2018), we draw on data for around 3,500 unique U.K.-listed companies from the late-1980s to construct around 33,500 firm-year markup estimates.[10] Using that

Table 1
G-7 Markups

Country	Markup Level (2016)	Markup Increase from 1980-2016	Implied Impact on Annual Price Inflation (pp)
Canada	1.53	0.61	1.3
France	1.50	0.53	1.2
Germany	1.35	0.29	0.7
Italy	2.46	1.46	2.5
Japan	1.33	0.30	0.7
U.K.	1.68	0.74	1.6
U.S.	1.78	0.63	1.4
G-7 average	**1.66**	**0.65**	**1.3**

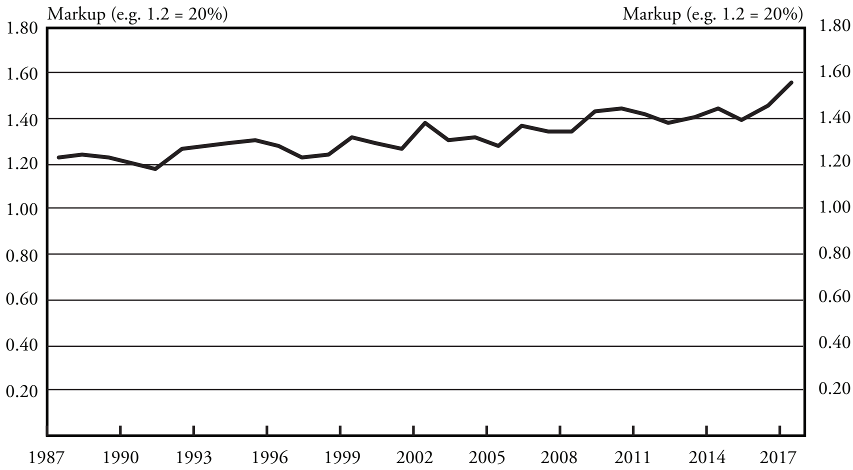
Note: Final column shows a simple indicative calculation where we assume that higher firm-level markups have been fully reflected in a higher economywide price level and therefore higher inflation rates between 1980 and 2016.
Sources: De Loecker and Eeckhout (2018) and Bank calculations.

methodology, Chart 3 plots a sales-weighted measure of mean markups for U.K.-listed companies since 1987. It shows a striking rise, from 1.2 to around 1.6, over the period. This broadly mirrors international trends.

Although they capture subtly different dimensions of market power, there is a weakly positive relationship between measures of markup and market concentration at the sector level (Chart 4), which is statistically significant at the firm level.[11] The same has been found among companies in other countries (Díez et al. 2018). This gives some degree of reassurance that the rise in measured market power has been a genuine one.

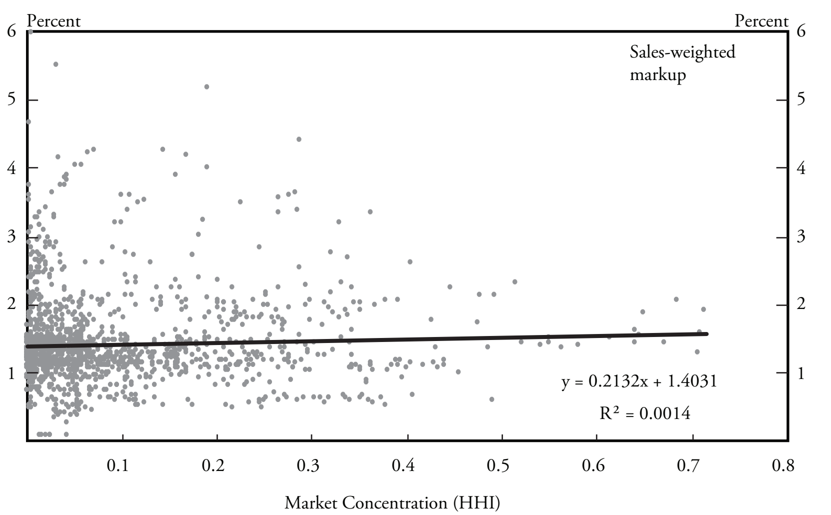
If we slice the markup data for nonfinancial companies on a sectoral basis, this suggests this rise has been reasonably broad based (Chart 5). All but two of the 10 sectors have seen markups rise since 1987, although some are volatile. Six of the 10 have seen them rise by more than 30 percentage points. Among the largest rises have been in manufacturing (70 percentage points), professional, scientific and technical (62 percentage points) and transport and storage (57 percentage points). This broadly mirrors the international evidence.[12]

Chart 3
U.K. Listed Firms' Average Markups



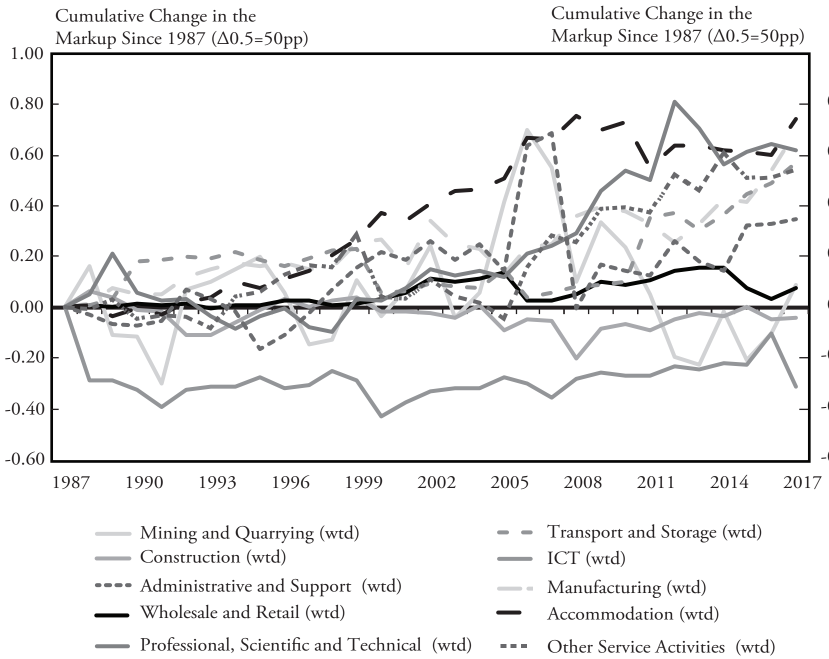
Note: Details of how markups are estimated are described in the appendix. Individual markups are weighted by their share of total sales in the sample in a given year.
Sources: Thomson Reuters Worldscope and Bank calculations.

Chart 4
U.K. Market Concentration and Markups



Notes: Data show market concentration and the average firm-level markup at the two-digit sectoral level. The market concentration metric shown here, the HHI, is normalised to be between 0 and 1. While the relationship shown here, at the sector level, is only weakly positive, the relationship between firm-level markups and the HHI is statistically significant in a regression when firm and time fixed effects are included. Markups also exhibit a positive relationship with other broad measures of profitability, such as the dividends-to-sales ratio and the market capitalisation-to-sales ratio.
Sources: ONS, Thomson Reuters Worldscope and Bank calculations.

Chart 5
U.K. Listed Firms' Sectoral Markups

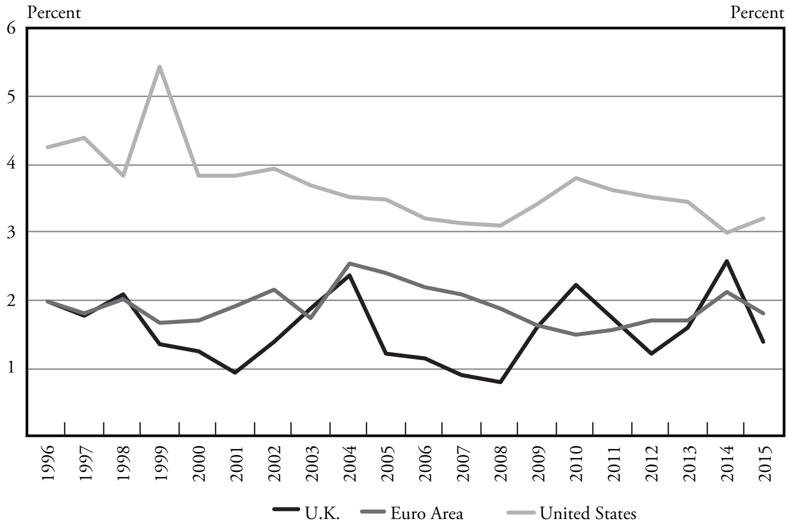


Note: The Arts, Entertainment and Recreation sector is excluded.
Sources: Thomson Reuters Worldscope and Bank calculations.

One apparent exception is the banking sector. Chart 6 plots a measure of banks' net interest margins (NIMs), as a proxy for markups, in the U.K., United States and euro area since 1996. NIMs appear to have been broadly flat in these countries over recent decades. If anything, they may have fallen over the past decade. The latter is potentially the result of the low levels of official interest rates, constraining the ability of banks to lower their deposit rates in order to protect margins (for example, Claessens, Coleman and Donnelly 2017).

Another way of slicing the data is to ask how much of the rise in markups is due to a compositional shift over time toward sectors whose markups are already high and how much reflects a generalized rise in markups within each sector. Chart 7 shows this decomposition for U.K.-listed firms. Compositional effects do not explain any of the rise in markups in the U.K.; and even if we do the same exercise at the firm level, compositional shifts towards firms with high

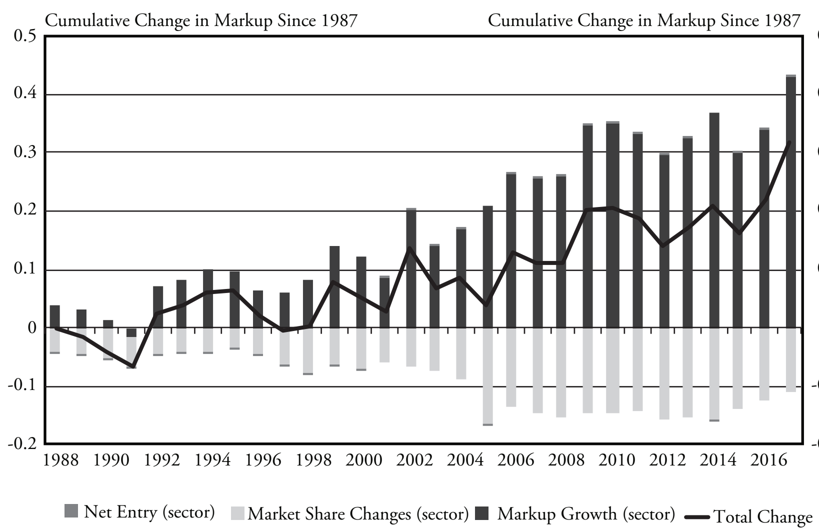
Chart 6
Banks' Net Interest Margins



Notes: Data sourced from the Federal Reserve Bank of St. Louis as that provides a consistent long-run international comparison of net interest margins. The broad post-financial crisis trend for U.K. banks in this data are consistent with the series for U.K. banks' net interest margins published in the Bank's Inflation Report in August 2016 (Chart C, Page 10).

Source: Federal Reserve Bank of St. Louis.

Chart 7
Contribution of Changing Sectoral Composition to U.K.-Listed Firms' Markups



Sources: Thomson Reuters Worldscope and Bank calculations.

markups cannot explain the rise. Rather, the rise in markups appears to be reasonably generalized across sectors.[13]

Although relatively broadly-based *across* sectors, the rise in markups need not necessarily be broadly based *within* sectors. One way of showing that is by looking at the evolution of the distribution of markups over time (Chart 8). This suggests the increase in markups is heavily concentrated in the upper tail of the distribution—companies whose markups are in, say, the top quartile. Markups among firms in this upper quartile of the distribution have, on average, increased by a remarkable 50 percentage points since 1987.

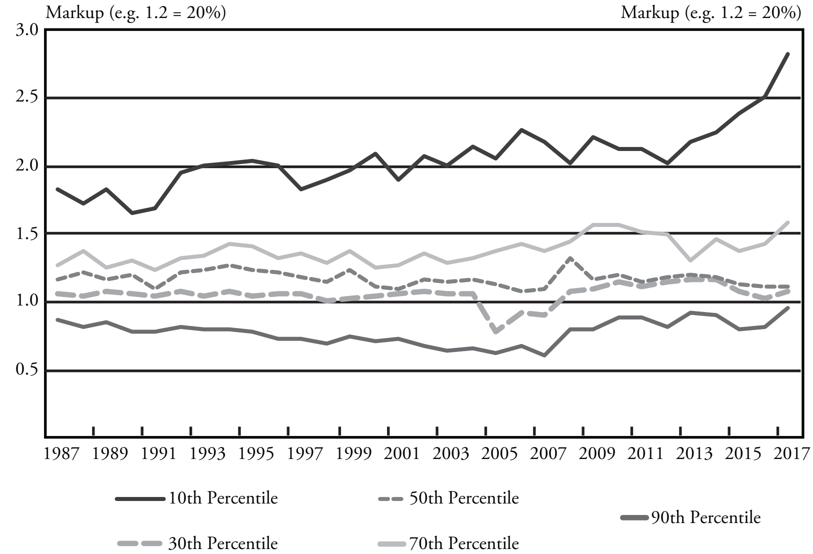
By contrast, markups among firms in the bottom three quartiles of the markup distribution have scarcely risen over the period. This distributional effect can also be seen from the large and widening gap between mean and median markups (Chart 9). In 1987, this gap was 7 percentage points. By 2016, it had reached 44 percentage points. This strongly suggests that the rise in aggregate markups over the past 30 years can largely be accounted for by a subset of high markup firms raising their markups and/or market share.

This fattening of the upper tail of the markup distribution is not uniform across sectors. Chart 10 plots a measure of the skew of the markup distribution across different sectors over time. The fattening of the upper tail of the distribution is most pronounced in the ICT, transport and storage and manufacturing sectors, each of which is associated with higher average levels of markup.

In understanding the characteristics of these firms, one revealing cut comes from taking into the account the extent to which U.K.-based firms' sales are domestic or foreign-focused (Chart 11). While both categories have seen their markups rise somewhat, this has been far larger among firms selling predominantly into foreign markets (almost 60 percentage points) than domestic markets (around 15 percentage points).[14] Within that, this rise in markups among foreign relative to domestic sales-focused firms is largest in the manufacturing and ICT sectors.

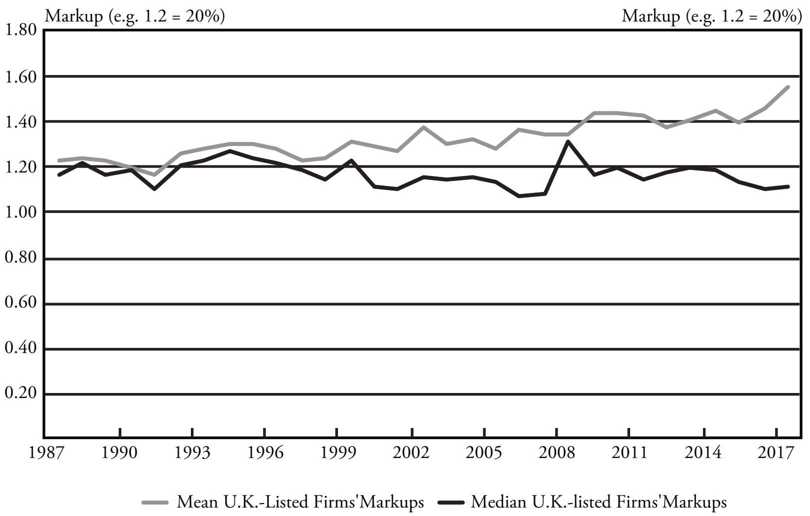
Taken together, this evidence is consistent with a story of rising markups being concentrated among internationally-operating firms, who perhaps benefit disproportionately from global network

Chart 8
U.K.-Listed Firms' Markup Distribution Over Time



Sources: Thomson Reuters Worldscope and Bank calculations.

Chart 9
Mean and Median U.K.-Listed Firms' Markups



Sources: Thomson Reuters Worldscope and Bank calculations.

Chart 10
Skewness of U.K.-Listed Firms' Markup Distribution by Sector

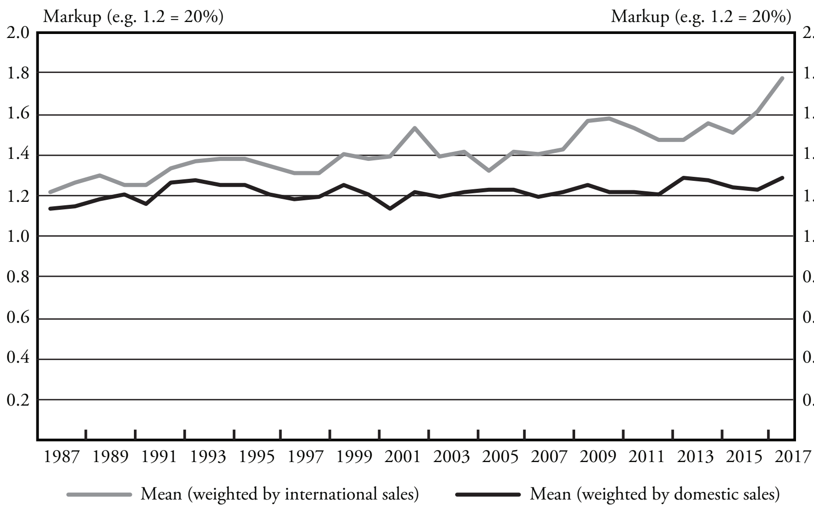
Sources: Thomson Reuters Worldscope and Bank calculations.

economies of scale and scope. These firms tend to occupy the fat and fattening upper tail of the markup distribution. These are firms that might legitimately be termed "superstars" (Autor et al. 2017).

Given this diagnosis, what impact might the rise in markups have had on the macroeconomy? One aspect is what impact increased market power may have had on firms' incentives to invest and innovate and hence on firms' productivity. With investment and productivity each having underperformed over recent years, the relationship with market power has been subject to increased academic scrutiny recently (for example, Eggertsson, Robbins and Wold 2018).

The relationship between markups and productivity is vital in understanding their macroeconomic effects (Van Reenen 2018). On the one hand, if highly productive "superstar" firms, benefiting from network economies of scale and scope, have become more dominant, then higher markups could be the side effect of a *positive* supply shock

Chart 11
Markups for Domestic and Foreign-Focussed U.K.-Listed Firms



Sources: Thomson Reuters Worldscope and Bank calculations.

in the economy. On the other hand, if markups are the counterpart to increased market power and reduced competitive pressures, that would suggest a *negative* supply shock.

These effects are not mutually exclusive. For example, Aghion et al. (2005) develop a model which generates a concave relationship between competition and investment. Within some range, increased market power raises rents and acts as a spur to investment, innovation and productivity. But beyond a point, those forces go into reverse. Market power is associated with a fall in innovation and investment incentives, with knock-on negative effects for productivity.

There is some empirical support for such a relationship. Jones and Philippon (2016) and Gutiérrez and Philippon (2017) suggest increased market power may have reduced investment among U.S. companies. De Loecker and Eeckhout (2017) document a negative relationship between markups and the capital share among global companies. And Díez et al. (2018) identify empirically a concave relationship between markups and investment, in line with Aghion et al. (2005).

We can re-run the Díez et al. (2018) investment equations using the panel of U.K.-listed firms. This also finds a concave relationship with markups (Table 2, column 1). The same relationship holds between markups and R&D expenditure (Table 2, column 2). Chart 12 plots the estimated investment curve. It suggests that firms with markups above around two tend to be associated with lower investment rates, in line with Díez et al. With estimated firm-level markups having risen secularly in a number of countries, this is potentially a cause for concern.

It is important, however, not to overstate the likely impact of this rise in markups on aggregate investment, innovation and productivity. The rise in mean markups in the U.K. over the past 30 years would still leave them below the levels at which investment rates start falling. The same is true among global firms. Indeed, among our panel of U.K.-listed companies, the shift in average U.K. markups since the late-1980s would, using the estimated investment equation, be expected to have *raised* average investment rates by around 1 percentage point.

Finally, there is the question of whether any potential negative effects of increased market power on investment and R&D translate into a negative effect on productivity. Evidence suggests there could be an effect. De Loecker and Eeckhout (2017) argue that, once account is taken of the rise in markups, it is possible to account for the slowdown in U.S. productivity growth after 1980. And Díez et al. (2018) find that the greater the distance to the technological frontier, the lower a firm's investment—a "reverse catch-up" effect.

If we look at the relationship between productivity and markups across U.K.-listed firms, there is evidence of a positive relationship with TFP but no significant relationship with labor productivity (Table 2, columns 3 and 4). If anything the relationship with TFP may be convex, with higher markup firms being associated with proportionately higher levels of total factor productivity. There is some evidence of "reverse catch-up" effects, but only at high levels of markups.

Overall, then, while the theoretical and empirical evidence suggests it is possible higher market power and markups may have come

Table 2
Regressions of Investment, R&D and Productivity on U.K.-Listed Firms' Markups

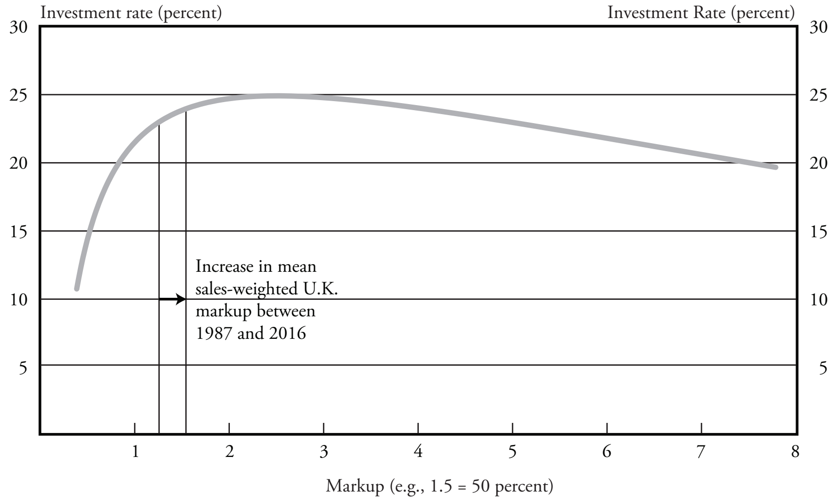
	Investment Rate	Innovation Rate	Log TFP	Log Labor Productivity
Log Markup	0.095*** (0.027)	0.023*** (0.009)	0.097*** (0.026)	-0.036 (0.045)
Log Markup Squared	-0.041** (0.017)	-0.018** (0.008)	0.162*** (0.014)	0.041 (0.034)
TFP Distance	-0.002 (0.006)	-0.000 (0.002)	-0.054*** (0.005)	-0.022** (0.013)
Log Markup * TFP Distance (interaction term)	-0.011 (0.012)	0.007** (0.003)	0.005 (0.006)	0.019 (0.013)
Log Markup Squared * TFP distance (interaction term)	0.018 (0.012)	0.009*** (0.003)	-0.010** (0.004)	-0.018 (0.014)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes
N	21,874	7,386	28,371	21,268
R^2	0.058	0.057	0.305	0.054

* $p < 0.10$
** $p < 0.05$
*** $p < 0.01$
Notes: Standard errors in parentheses; In regressions associated with columns 1 and 2, lagged Tobin's Q and the lagged sales-to-assets ratio were included as controls. In regressions associated with columns 3 and 4, the terms involving TFP distance are lagged by one year. "Investment rate" defined as capital expenditure as a proportion of the previous year's net property, plant and equipment level (PPE). "Innovation rate" defined as R&D expenditure as a proportion of the previous year's total assets. "TFP" defined as (the exponential of) the log of net sales, minus the log of cost of goods sold (COGS), log of net property, plant and equipment level (PPE) multiplied by their respective coefficients retrieved in the estimation of markups, and minus the estimated measurement error. "TFP distance" defined as the gap in a firm's TFP from the most productive firm (in TFP terms) in a given year within the industry (measured at the one-digit SIC level). Labor productivity defined as sum of operating income (before depreciation, depletion and amortization costs) plus labor expenses (to capture value-added), divided by number of employees (in line with Imrohoroğlu and Tüzel (2014)). To deal with outliers, and similar to De Loecker and Eeckhout (2018) and Díez et al (2018), we trim the top and bottom of 2 percent of observations for the investment rate, innovation rate, labor productivity and TFP before running regressions.
Sources: Thomson Reuters Worldscope and Bank calculations.

at some cost in lower investment and innovation, the evidence is not overwhelming and certainly would not imply that the aggregate effect is large.

A second relationship explored recently is between market power and the labor share.[15] Autor et al. (2017) find a negative empirical

Chart 12
U.K.-Listed Firms' Markups and Investment Rates



Notes: Investment function based around the firm-level regression in Table 2. "Investment rate" defined as capital expenditure as a proportion of the previous year's net property, plant and equipment level (PPE).
Sources: Thomson Reuters Worldscope and Bank calculations.

relationship using measures of market concentration among U.S. companies. And Díez et al. (2018) and De Loecker and Eeckhout (2018) identify a weakly negative relationship between markups and the labor share. If we run regressions similar to those in Díez et al. for U.K.-listed companies (Table 3), we also find a negative relationship between markups and the labor share.[16]

The analysis presented here, and much of the recent literature, is based around estimates that suggest a secular rise in firm-level markups. Some caution is advisable when drawing conclusions from these results. First, some macroeconomic evidence points to *falling*, rather than rising, company markups/margins (for example, Chen, Imbs and Scott 2009, 2004). Second, some mismeasurement may be at play in the estimation of markups (for example, Traina 2018). These uncertainties in the measurement of markups should be borne in mind in interpreting what follows.

Market Power and the Macroeconomy—A Simulation Approach

Having assessed some evidence on the evolution, and macroeconomic implications, of increased markups and market power, the next

Table 3
Regressions of Labor Share on U.K.-Listed Firms' Markups

	Log Labor Share	Log Labor Share	Log Labor Share
Log Markup	-0.094*** (0.019)	-0.093*** (0.024)	-0.067*** (0.020)
Log Markup Squared	-0.024 (0.019)		-0.033 (0.020)
Concentration		0.061 (0.074)	0.062 (0.073)
Log Markup * concentration (interaction term)		-0.225 (0.151)	-0.233 (0.151)
Firm Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
N	21,997	17,218	17,218
R^2	0.013	0.014	0.015

* $p < 0.10$
** $p < 0.05$
*** $p < 0.01$
Notes: Standard errors in parentheses; Labor share defined as nominal wage bill divided by nominal value-added, where value-added is defined as the sum of operating income (before depreciation, depletion and amortization costs) and labor expenses. To deal with outliers, we trim observations where the measured labor share is less than zero or greater than one before running regressions.
Sources: Thomson Reuters Worldscope and Bank calculations.

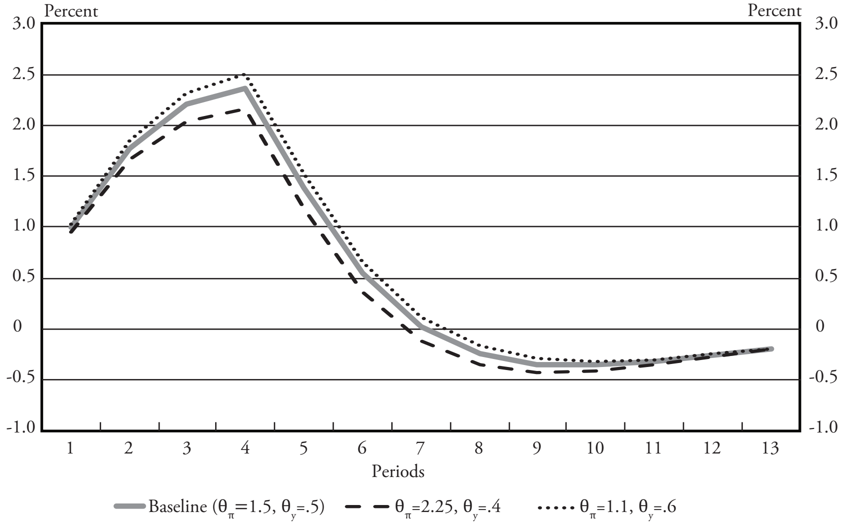
question is what implications these may have for the setting of monetary policy. This does not appear to have been an extensively examined area of research, whether among academics or policymakers.[17] What follows is an initial exploration of some of the potential channels.

One simple way of beginning to gauge how a rise in markups might affect the economy and monetary policy is to simulate their impact using a macroeconomic model. For this purpose, we model the economy using the Bank of England's in-house DSGE model, COMPASS.[18] Monetary policy is assumed to follow a simple Taylor rule, with interest rate smoothing.[19] The simulations are shown for a variety of different values of the relative weight policymakers place on output and inflation deviations from target in the Taylor rule.

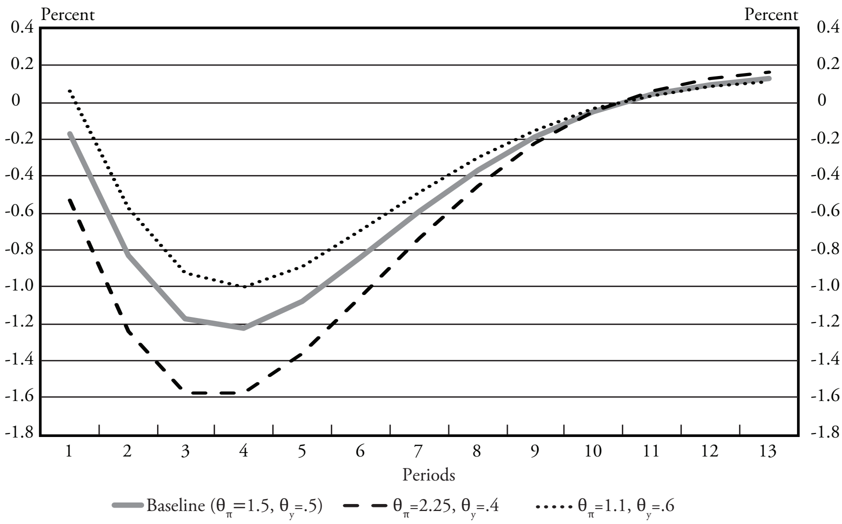
Chart 13 considers the impact on inflation, the output gap and monetary policy of a temporary markup shock that delivers a one percentage point increase in annual inflation. The dynamics of the

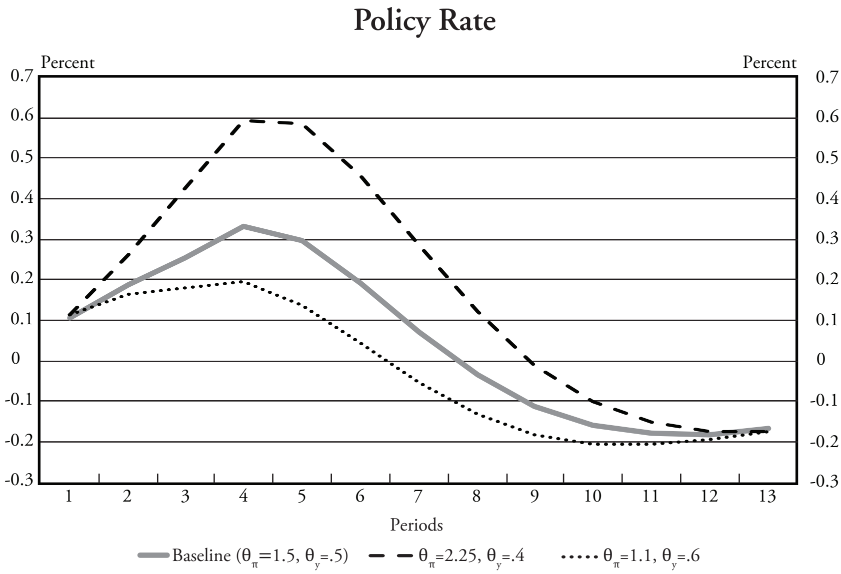
Chart 13
Impact of Markup Shock on Annual Inflation, Output Gap and Policy Rate

Annual Inflation



Output Gap





Notes: COMPASS contains various markups shocks. For simplicity, the shock shown here is the value-added markup shock. The qualitative implications would be little changed if other markup shocks were used instead. θ_π and θ_y show the weights placed on the deviation of inflation from target and the output gap in the Taylor rule, respectively. The Taylor rule also contains a lagged interest rate parameter to allow for interest rate smoothing. Charts here show the deviation of annual CPI inflation, output gap and the policy rate relative to a baseline where no shock occurred.
Source: Bank calculations.

economy are largely as we would expect following an adverse supply shock. The inflation rate rises, and real GDP usually contracts, in both cases temporarily. Although temporary, these disturbances are often material and always persistent, despite monetary policy acting to damp these fluctuations.

The reason monetary policy struggles to damp these fluctuations is because a markup shock is trade-off inducing. Monetary policy is caught between loosening to return output to potential and tightening to return inflation to target. Which wins out depends, crucially, on the relative weight placed on these twin objectives in the policy rule. When inflation deviations are given greatest weight, monetary policy tightens materially. When output deviations are given greatest weight, monetary policy scarcely tightens at all.

With monetary policy facing this trade-off, it follows that an increased prevalence of markup shocks would leave policymakers somewhat constrained in their ability to smooth the economy. Put differently, a sequence of trade-off inducing markup shocks would tend to *worsen* the trade-off between output and inflation variability, for a given monetary policy rule. The "Taylor curve" frontier of policy possibilities would be expected to shift outward.[20]

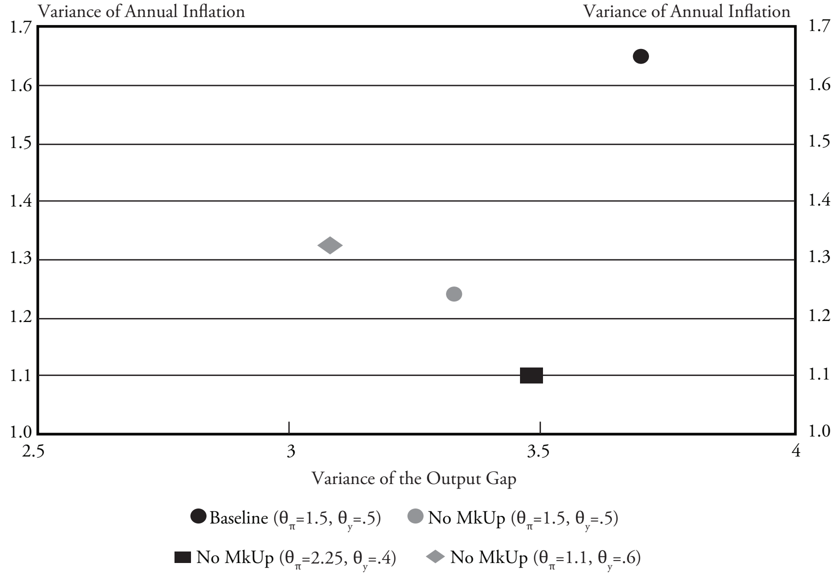
To illustrate that, we can conduct a counterfactual simulation of the effects of markup shocks on the course of output, inflation and interest rate variability. Chart 14 shows the variability of inflation and the output gap (the black dot) generated by the model. It also shows the variability of output and inflation when the economy is re-simulated having "switched off" the shocks to firm markups identified by the model (the red symbols). Policy is again assumed to follow a Taylor rule, with varying weights on output and inflation.

Markup shocks have a material impact on output and especially inflation variability, even with monetary policy cushioning their effects. The variance of inflation is reduced by around a quarter, and variance of the output gap by around 10 percent, when markups shocks are switched off. The policy possibility frontier of output/inflation variabilities is shifted outward materially by the presence of markup shocks.[21]

The scope for monetary policy to cushion these shocks is relatively limited. Chart 15 plots the variability of interest rates alongside output variability, for the same set of policy rules. Markups shocks affect interest rate variability relatively modestly.[22] And the variance of interest rates is reduced by only around 5 percent when markup shocks are switched off. This tells us that trade-off inducing shocks to markups leave the (path and variability) of interest rates less affected than inflation.

Clearly, this simulation places an upper bound on this shift as it effectively removes shocks to markups. In practice, the evidence on how the variability of markups may have evolved is mixed. On the one hand, macro evidence suggests a *fall* in the variability of both output and inflation in many countries recently, a finding that has been attributed by some to a *lower* incidence of markup shocks (for example, Smets and Wouters (2007) and Kapetanios et al. (2017)). On the other, direct micro-level evidence on markup behavior over recent years suggests a potential pick-up in their trend and variability.

Chart 14
Variability of Inflation and Output Gap With and Without Markup Shocks

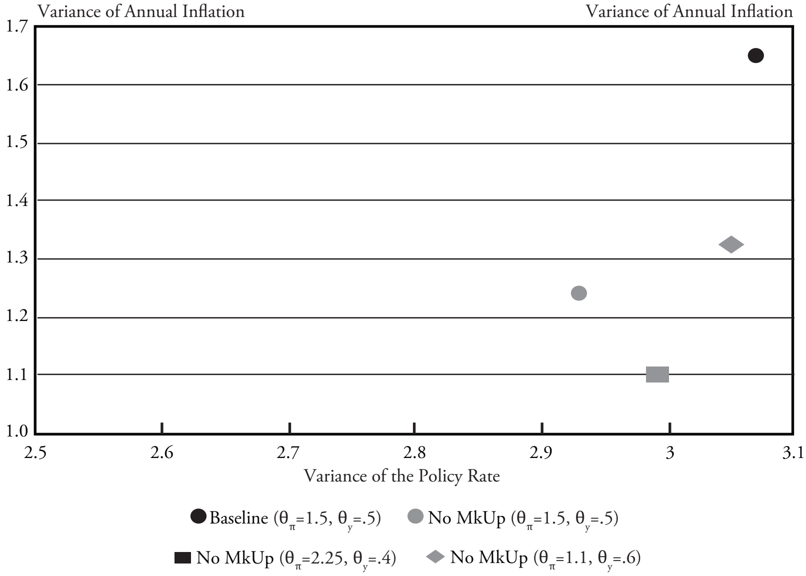


Notes: Chart shows the model-based variance of the inflation and the output gap for different calibrations of the Taylor rule, which alter the weight placed by the policymaker on deviations of inflation from target and output from potential. When moving from the baseline to the markers indicating no markup the various price markup shocks in the model are turned off.
Sources: Bank calculations.

To the extent that the historical evidence is consistent with a sequence of larger markup shocks, it would be expected to have made the task of monetary policy makers somewhat harder. Both output and inflation will have deviated more significantly and persistently from their long-run values. And although interest rates will have been adjusted somewhat more often in response, the trade-off inducing nature of these shocks places constraints on the degree of stabilization monetary policy can achieve.

The limitations of this simulation approach need also to be borne in mind. First, the simulations consider only the effects of *temporary* markup shocks, whereas in practice shocks may have been repeated and persistent, as well as large. Second, more fundamentally, these simulations take the underlying model of the economy as given—a strong, and probably unrealistic, assumption.

Chart 15
Variability of Inflation and Policy Rate With and Without Markup Shocks



Notes: Chart shows the model-based variance of the inflation and the output gap for different calibrations of the Taylor rule, which alter the weight placed by the policymaker on deviations of inflation from target and output from potential. When moving from the baseline to the markers indicating no markup, the various price markup shocks in the model are turned off.
Source: Bank calculations.

The competitive structure of the product market is one of the "deep parameters" in most standard macroeconomic models. So we would not expect the relationships embedded in those models necessarily to be invariant to a rise in market power and markups. Nor do these models typically take into account any of the potentially macroeconomic side effects of a shift in market power—for example, on productivity.

Market Power and the Macroeconomy—A Theoretical Approach

To explore those questions, we draw on the textbook New Keynesian model of the macroeconomy, the type of which is often used to justify and assess the effects of flexible inflation targeting (Clarida et al. 1999 and Woodford 2003). Specifically, we use the well-known textbook New Keynesian model in Galí (2008) to consider how changes in market power might affect the setting of monetary policy. We analyse the case where higher markups are effectively the result of reduced competitive pressures, rather than the rise of highly productive "superstar" firms.

The model takes the following generic form:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t + u_t \tag{1}$$

$$x_t = E_t x_{t+1} - \sigma(i_t - E_t \pi_{t+1} - r^*_t) \tag{2}$$

where π is inflation, x is the output gap, i is the policy rate, while u is a cost-push shock.

The first equation is a New Keynesian Phillips curve, the second a forward-looking investment/saving (IS) curve. This two-equation system contains three key structural parameters: the slope of the Phillips curve, κ; the interest elasticity of demand, σ; and the long-run neutral rate of interest, r^*. We discuss in turn how each might potentially be affected by the degree of market power in product markets and higher markups.

(i) Phillips curve

In the New Keynesian model, firms operate in imperfectly competitive product markets defined by monopolistic competition (Blanchard and Kiyotaki 1987), with nominal rigidities (Calvo 1983). As first described by Chamberlin (1933), and formalized by Dixit and Stiglitz (1977), monopolistic competition is an environment in which a large number of firms each face a downward-sloping demand curve for their respective differentiated product. This typically takes the functional form:

$$Y^d(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\in} Y_t \tag{3}$$

$Y^d(i)$ is the demand for good i, whose price is $P_t(i)$. P_t and Y_t are the overall price level and aggregate demand at time t, respectively, while $\in$ is the elasticity of substitution between the monopolistically competitive products.

Individual firms are assumed to be small enough that a price change by one firm has a negligible effect on the demand faced by other firms. By implication, there is no strategic interaction between firms. Firms can set prices above marginal costs because of a finite elasticity of substitution between individual goods in consumer preferences, regardless of the fact that their share of the total market is small.

There are clear limitations of this product market formulation when addressing issues of market power. Market power, in this setting, is captured by the capacity of firms to charge prices in excess of marginal costs, rather than by their capacity to build up ever-larger market shares. Market power means higher markups, but not higher degrees of market concentration. Different competitive settings might generate quite different pricing behavior and Phillips curves (for example, Rotemberg 1982).

In this setting, the monopolistically competitive firm maximises profits by setting its price ($P^*(i)$) as a markup over nominal marginal costs (MC):

$$P_t^*(i) = \mu MC_t \quad (4)$$

$$\mu = \frac{\epsilon}{\epsilon - 1} \quad (5)$$

where μ is the markup defined in terms of the elasticity of substitution.

This tells us a firm increases its markup as the demand for its good becomes more inelastic. That might arise for a variety of reasons. Customer loyalty or brand might be one reason. Network economies of scale and scope might be another. In either case, the implication is that prices are being set above (and sales below) their socially optimal value—that is to say, their value under perfect competition when price equals marginal cost (ϵ tends towards infinity).

When prices are sticky, firms set prices in a forward-looking manner to get as close as possible to the desired markup over time. The forward-looking Phillips curve in (1) summarizes that price-setting behavior in the economy at large. The slope of the Phillips curve, κ, is a composite of deep structural parameters in the model. In the baseline specification in Galí (2008), the slope is:

$$\kappa = \frac{(1-\theta)(1-\beta\theta)}{\theta} \frac{1-\alpha}{1-\alpha+\alpha \in} \left(\sigma + \frac{\varphi+\alpha}{1-\alpha} \right) \tag{6}$$

θ is the degree of price stickiness, β is the discount factor in household preferences, α is the degree of decreasing returns to labor in production, φ is the inverse of the elasticity of labor supply with respect to real wages (holding marginal utility of consumption constant), and σ is the inverse of the elasticity of intertemporal substitution in consumption.

Significantly, the elasticity of demand, ϵ, and hence the markup, μ, affect the slope of the Phillips curve. The higher the degree of market power and higher the markups firms charge, the steeper the slope of the Phillips curve (or, equivalently, the smaller the sacrifice ratio). We can roughly gauge the scale of this effect by calibrating the model. Chart 16 looks at the relationship between the slope of the Phillips curve, κ and markups, μ, for a given parameterization of the model.

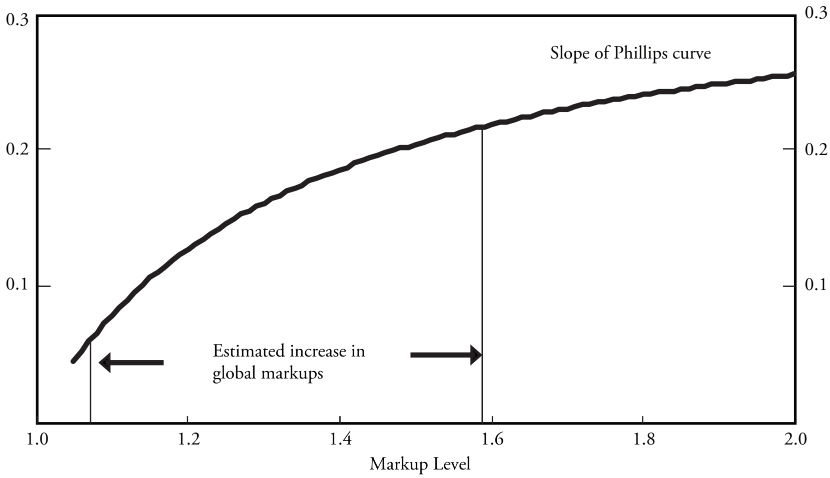
The relationship is, as we expect, a positive one. As a thought experiment, consider the scale of increase in markups seen by the average firm globally since 1980, from around 1.1 to around 1.6.[23] Other things equal, this would be expected on this calibration to have steepened the slope of the Phillips curve from just under 0.1 to around 0.2. This is a significant change in the parameterization of a key macroeconomic relationship for the setting of monetary policy.

One way of explaining the intuition behind this steepening of the Phillips curve is that market power reduces the degree of strategic complementarity in price-setting. In a product market closer to perfect competition, firms will be reluctant to raise prices fearful that, with other prices in the economy sticky, demand would fall away sharply. By reducing the elasticity of demand, market power reduces this risk and thus gives rise to greater flexibility in prices—and hence a lower sacrifice ratio (for example, Ball and Romer 1990).

Let us now put this model into a stochastic setting, by assuming desired markups fluctuate around a trend level according to some stationary stochastic process, log μ_t. These would now appear as cost-push disturbances in the Phillips curve:

$$u_t = \frac{(1-\theta)(1-\beta\theta)}{\theta} \frac{1-\alpha}{1-\alpha+\alpha \in} log\, \mu_t \tag{7}$$

Chart 16
Markups and the Slope of the Phillips Curve



Notes: Parametrization such that β = 0.99, θ = ⅔, α = 1/3, $\varphi = \sigma$ =1.
Sources: De Loecker and Eeckhout (2018), Galí (2008) model and Bank calculations.

This tells us that, when markup shocks strike, a greater degree of market power will mean that a larger fraction of the shock will fall on prices than activity. A rise in market power, through its effect on the slope of the Phillips curve, will cause the Taylor output/inflation variability (policy possibility) frontier to rotate clockwise, with more of the burden following a shock felt by inflation than by output variability.

(ii) Impact on IS Curve

The second way in which a shift in market power could potentially influence macroeconomic outcomes is through the IS curve. One structural parameter in that relationship is r*, the neutral rate of interest. In the baseline model, the path of r* is determined by the path of shocks to households' marginal utility of consumption (z) and firms' TFP (a):

$$r_t^* = (1 - p_z) z_t - \frac{1 - p_a}{\sigma} \frac{1 + \varphi}{\sigma^{-1}(1 - \alpha) + \varphi + \alpha} a_t \tag{8}$$

In steady-state, the equilibrium real rate is determined by household discount rates (determining saving) and firms' trend productivity growth (determining investment).

$$r^* = -\log \beta + \Delta a \tag{9}$$

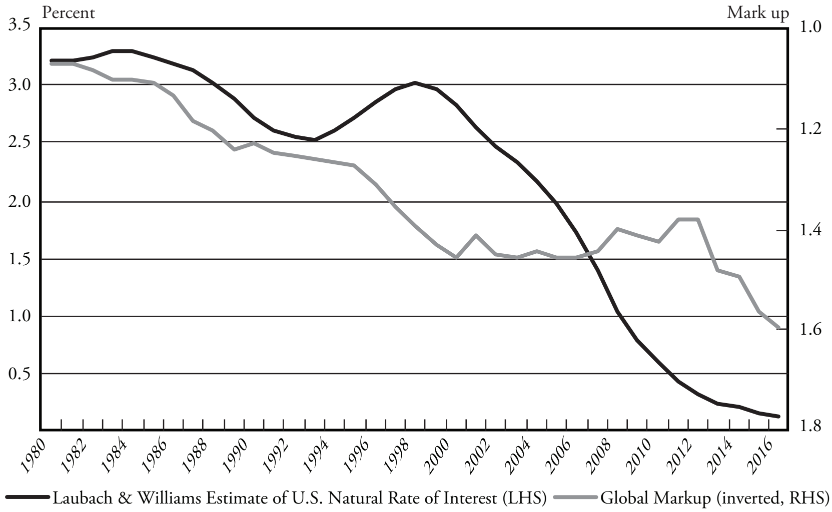
This suggests that, if there is any impact of market power and markups on productivity, this could in turn have an impact on r*.[24] Consistent with that, and taken at face value, there is a positive correlation between estimates of the U.S. natural rate of interest and (the inverse) of global markups since 1980 (Chart 17).

But whether higher markups might in practice have contributed significantly to the global slowdown in investment and productivity, and hence r*, is far from clear. The microeconomic evidence discussed earlier suggests these effects are difficult to detect and, to the extent they do exist, might be relatively modest in the contribution they have made to slowing aggregate investment and productivity growth. And if higher markups have, in fact, been the counterpart to a rise of "superstar" firms, benefiting from network economies, that would, in principle, raise productivity growth and r*.

A second structural parameter in the IS curve is the interest elasticity of aggregate demand, σ. In the simplest baseline model, this is determined by (the inverse of) the intertemporal elasticity of substitution. In more general settings, with credit constraints, it may depend additionally on the balance sheet characteristics either of borrowers or lenders or both (for example, Kashyap, Stein and Wilcox 1993). A rise in market power could, in principle at least, affect the balance sheets of borrowers and/or lenders in ways which could influence σ.

For borrowers, a rise in market power might raise equilibrium profit rates and market valuations. It may thus reduce companies' collateral constraints and their reliance on external sources of finance (for example, Bernanke, Gertler and Gilchrist 1999). For lenders, a rise in market concentration could in principle reduce the speed of pass through of policy rates to retail deposit and lending rates (Gerali et al. 2010). Each of these would tend, therefore, to reduce the interest elasticity of investment demand, σ. Whether these effects are significant at the macroeconomic level is, however, far from clear.

Chart 17
Global Markups and Real Interest Rates



Notes: Estimate of U.S. natural rate of interest shown here uses annual averages of quarterly Laubach and Williams estimates. We would like to thank Jan De Loecker and Jan Eeckhout for kindly sharing their series of global markups.
Sources: Updated estimates from Laubach and Williams (2003) (available online), De Loecker and Eeckhout (2018) and Bank calculations.

Market Power and Monetary Policy

Taking this evidence together, we now summarize the various channels we have discussed through which monetary policy might prospectively be influenced by a rise in market power and markups.

First, if shocks to firms' markups have increased over recent decades, this would tend to shift outwards both output and especially inflation variability. Because these shocks are trade-off inducing, monetary policy is constrained in its capacity to cushion them. In consequence, the path of interest rates (both its level and variability) is affected only modestly by a rise in the incidence of markup shocks.

Second, a rise in market power also has the potential to alter the slope of the Phillips curve, as discussed above. This, too, may affect the setting of monetary policy. To see that, consider the period loss function for monetary policy makers in the textbook model. This can be derived from the utility function of the representative household (Galí 2008). It takes the form:

$$L_t = \pi_t^2 + \lambda x_t^2 \qquad (10)$$

where the weight on the output gap is:

$$\lambda = \frac{\kappa}{\in} \qquad (11)$$

Under optimal discretionary monetary policy, the policymaker minimizes this loss function each period, subject to the Phillips curve, taking expectations as given. The optimal targeting rule for monetary policy is:

$$\pi_t = -\frac{\lambda}{\kappa} x_t \qquad (12)$$

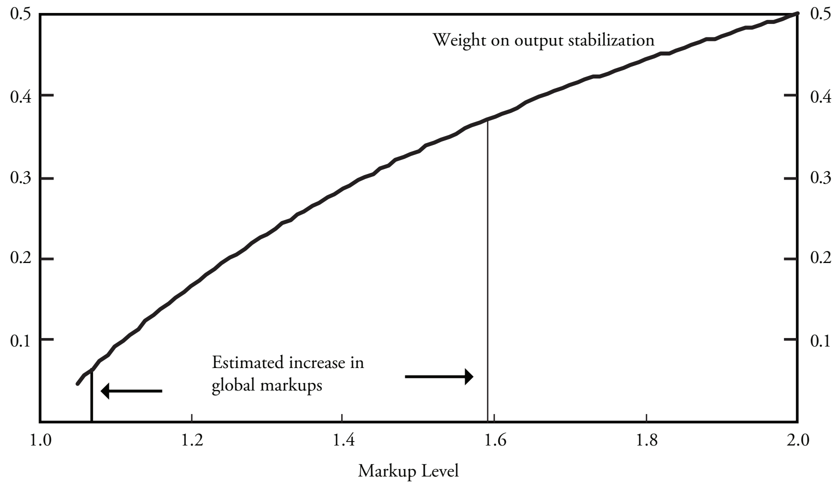
This "Golden Rule" of monetary policy strategy simply states that the policymaker should let inflation absorb more of the adjustment, after a trade-off inducing shock, either when the relative weight on output in the loss function is high (λ) or when the sacrifice ratio is low (κ). If λ is set to its welfare-optimizing level, this gives a refinement of the "Golden Rule":

$$\pi_t = -\frac{1}{\in} x_t \qquad (13)$$

This tells us that, once the dust has settled, the degree of market power in steady state is *all* that matters for monetary policymakers in our simple framework when choosing the optimal trade-off between inflation and the output gap.

Specifically, the greater this degree of market power, the steeper the slope of the optimal targeting rule: the policymaker should let inflation absorb more, and the output gap less, of a trade-off inducing shock. The intuition here is simply that market power increases the degree of price flexibility in the model and lowers the sacrifice ratio. This makes it optimal to do a greater amount of (now less costly) output-smoothing in the face of trade-off inducing shocks in the optimal policy rule.

Chart 18
Markups and Optimal Policy Weight on Output Stabilization



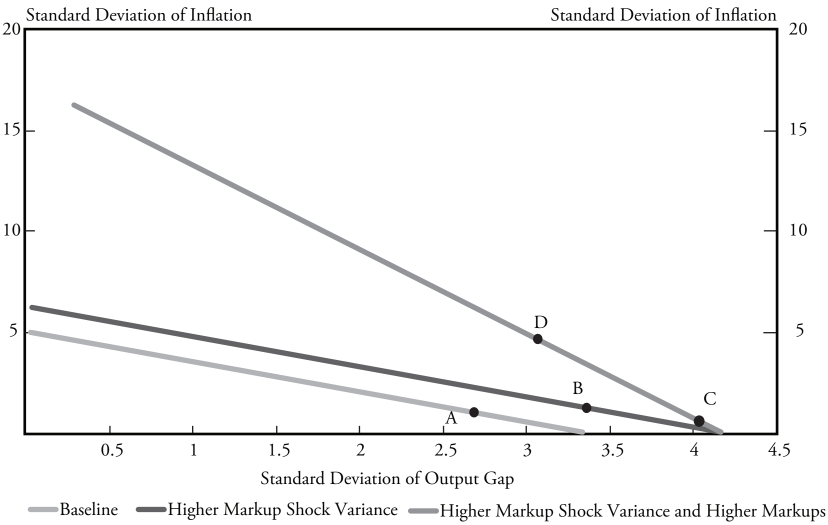
Note: Parametrization such that β = 0.99, θ = ⅔, α = ⅓, φ = σ =1
Sources: De Loecker and Eeckhout (2018), Galí (2008) model and Bank calculations.

It is possible to calibrate this parameter in the optimal targeting rule. Chart 18 plots the relationship between it and markups. The rise in average markups globally since 1980 would, on this calibration, be expected to raise the trade-off parameter in the Golden Rule $\left(\frac{1}{\epsilon}\right)$ from around 0.1 to 0.4. This is a reasonably significant shift in the terms of trade between inflation and output variability.

Chart 19 seeks to bring all of these points together graphically; it is an empirically-calibrated version of Figure 1. Point A is the starting equilibrium, before any rise in the (trend and variability) of markup shocks, with the policy possibility curve tangent to the policymaker's loss function. A rise in the (trend and variability) of markups then has three distinct effects.

First, an increase in markup volatility causes an outward shift in the policy possibility frontier (A to B), calibrated here to be equivalent in scale to the outward shift from the counterfactual simulations. Second, there is the clockwise rotation of the Phillips curve, and hence in the policy possibility frontier (B to C), calibrated to be equivalent to the markup rise among firms globally since 1980. And third, there

Chart 19
Impact of Markups on Inflation and Output Gap Volatility



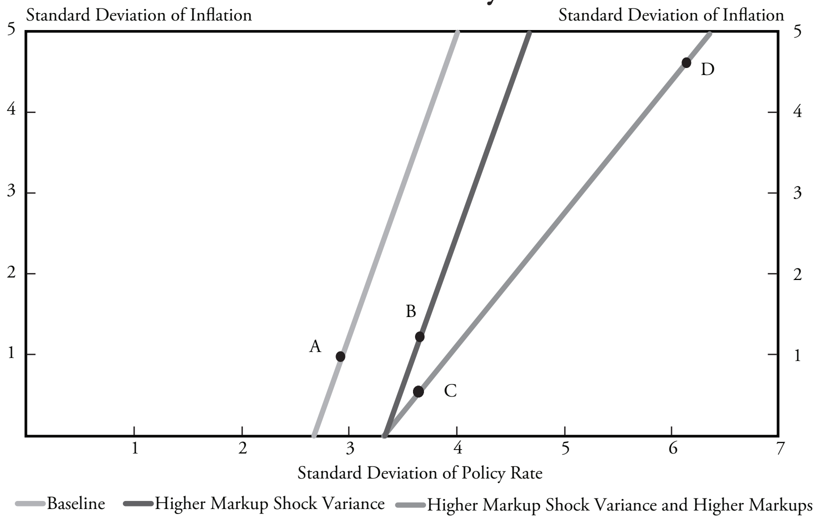
Notes: Parametrization such that β = 0.99, θ = ⅔, α = ⅓, $\varphi = \sigma$ =1. Standard deviation of markup shock increases from 0.1 to 0.125 when moving from the bottom line to the middle line. The steady-state markup level increases from 1.1 to 1.6 when moving from the middle line to the top line. The policymaker re-optimises λ when moving from point C to D.
Sources: Galí (2008) model and Bank calculations.

is the shift in the relative weight placed on output stabilization by the policymaker, calibrated in line with the markup shift (C to D).

The net effect of increased market power is a significant rise in inflation variability but relatively less change in output variability. Chart 20 uses the same calibration, but looks at the relationship between inflation and interest rate variability. Despite the significant shifts in macroeconomic relationships and in policymakers' preferences arising from a rise in market power, the net effect on the (level and variability) of the optimal interest rate path is more modest. At root, that is because of the trade-off inducing nature of markup shocks.

Third, the presence of market power and higher markups also has implications for the level of output in the economy which could provide additional incentives to generate inflation. Monopolistic competition implies that output is inefficiently low relative to its (perfectly competitive) social optimum. For sufficiently small deviations from the steady state, the policymakers' loss function can be re-written to reflect that inefficiency:

Chart 20
Impact of Markups on Inflation and Nominal Interest Rate Volatility



Notes: Parametrization such that β = 0.99, θ = ⅔, α = ⅓, $\varphi = \sigma$ =1. Standard deviation of markup shock increases from 0.1 to 0.125 when moving from the left line to the middle line. The steady-state markup level increases from 1.1 to 1.6 when moving from the middle to the right line. The policymaker re-optimises λ when moving from point C to D.
Sources: Galí (2008) model and Bank calculations.

$$L_t = \pi_t^2 + \lambda x_t^2 - \Lambda x_t \tag{14}$$

Where

$$\Lambda = \frac{1}{\in^2} \frac{(1-\theta)(1-\beta\theta)}{\theta} \frac{1-\alpha}{1-\alpha+(\varsigma+\varphi)\in} \tag{15}$$

The optimal targeting rule is also then altered to become:

$$\pi_t = \frac{1}{\in^2}\left(\sigma^{-1} + \frac{\varphi+\alpha}{1-\alpha}\right)^{-1} - \frac{1}{\in} x_t \tag{16}$$

The additional constant term reflects the well-known inflationary bias under discretionary policy, first articulated by Barro and Gordon (1983). Output at a suboptimally low level increases the incentives of a discretionary policy maker to run looser monetary policy to push output toward its social optimum, thereby generating an inflation bias. In steady-state, this inflation bias is:

$$\pi_t = \frac{\Lambda\kappa}{\kappa^2 + \lambda(1-\beta)} \quad (17)$$

This inflation bias is clearly bigger, the greater is the degree of market power. Chart 21 plots the relationship between markups and the inflation bias implied by the model. Using our simple model, the rise in markups by global firms since 1980 might have added as much as 20 percentage points to the inflation bias.

This calibrated effect is implausibly large. Nonetheless, the qualitative point remains: a rise in market power may, by constraining demand, generate an added incentive to run loose monetary policy. That makes institutional arrangements which resist those temptations—such as independent central banks charged with meeting an inflation target—more important than ever (Rogoff 1985 and Svensson 1997).

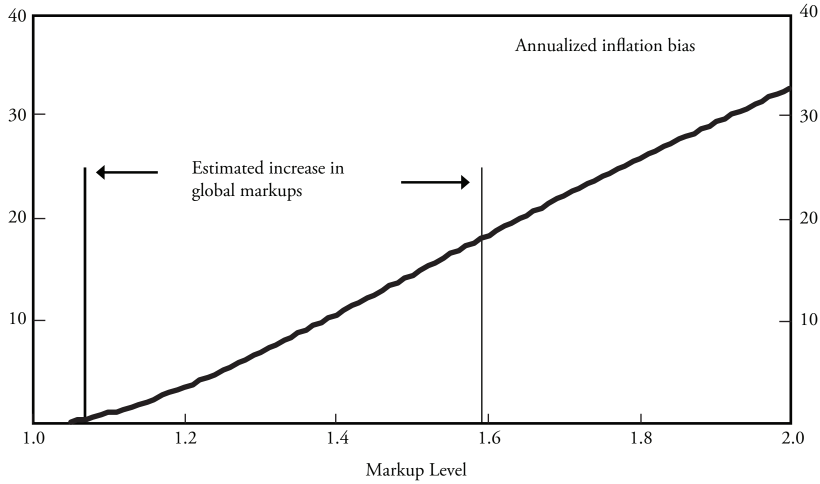
Finally, while we find little evidence of markups having a material effect on investment, market power also gives rise to at least the possibility of lower productivity growth, and hence, r*. There are a number of other structural forces currently lowering productivity growth (for example, Gordon 2012 and Andrews et al. 2016). And there are a larger number still of structural factors bearing down on r* (for example, Monetary Policy Committee 2018). To the extent market power is another, this increases the chances of those falls in productivity growth and r* proving long-lasting.

The empirical link between market power and productivity is not, at present, well-defined. But the implications of a persistently lower r* for the setting of monetary policy are reasonably well understood. They include the fact that the probability of the zero lower bound constraint binding is likely to be materially higher than it has been historically. Recent simulation studies have suggested this probability may be as high as around one-third, if r* remains around current levels (for example, Kiley and Roberts 2017).

Implications for Future Research

The link between the competitive structure of product markets, the macroeconomy and the setting of monetary policy is a relatively

Chart 21
Markups and Inflation Bias



Notes: Parametrization such that β = 0.99, θ = ⅔, α = ⅓, φ = σ =1.
Sources: De Loecker and Eeckhout (2018), Galí (2008) model and Bank calculations.

underresearched area. This paper has only scratched the surface of this important topic. But trends in concentration and market power have clear potential to impact on the macroeconomy and monetary policy, justifying ongoing research on the topic. To that end, we conclude with a few reflections on potentially fruitful future research avenues.

First, the framework used here to understand the macroeconomic implications of increased market power assumes a particular competitive structure—monopolistic competition. This has limitations, assuming as it does that no one firm is sufficiently large to have a significant bearing on others' behavior. In practice, strategic interactions between firms are likely to be important in many markets, especially network markets (for example, Bramoullé, Kranton and D'Amours 2014), with potentially important implications for pricing and the Phillips curve.

Second, the framework developed here also sidesteps questions about the competitive structure of the market for inputs, especially labor inputs. Dominant firms may exercise monopsonistic power over workers, in ways which have implications for profit and labor shares. Consistent with that, there is some empirical evidence linking market concentration to a lower labor share (Autor et al. 2017).

How monopsony power influences wage growth and the slope of the Phillips curve are important areas to consider further.

Third, there is further work to be done in understanding the balance sheets and decision incentives of so-called "superstar" firms. This includes their choice of debt versus equity, distributing versus reinvesting profits and intangible versus tangible sources of capital. These choices might imply quite different incentives and behaviors—for example, about the level of investment and its interest elasticity. These are yet to be fully explored, at a micro and macro level.

Fourth, the emergence of a set of firms with significant degrees of market power clearly raises big questions about the appropriate stance of competition policy (Gutiérrez and Philippon 2018). These policy issues are clearly outside of the remit of central banks. Nonetheless, how these antitrust issues are tackled could have implications for the structure and dynamics of the economy and hence for the setting of monetary policy. This, too, is an area ripe for further research.

Finally, the apparent puzzle between the secular rise in markups at the firm level on the one hand, and relatively low and stable aggregate inflation on the other hand, could usefully be reconciled. Current estimates of markups using firm-level data may suffer from mismeasurement. Or other macroeconomic factors may have more than offset their impact in order to keep inflation stable. How the evidence is reconciled could have important implications for inflation dynamics and the setting of monetary policy.

Author's Note: The views expressed here are not necessarily those of the Bank of England or the Monetary Policy Committee. I would like to thank Federico Di Pace, Laure Fauchet, Rebecca Freeman, Jeremy Leake, Clare Macallan, Colm Manning, Roland Meeks, Kate Reinold, Natalja Sekhan, Silvana Tenreyro, Jan Vlieghe and Robert Zymek for their comments and contributions. This work contains statistical data from ONS which is Crown Copyright. The use of the ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce National Statistics aggregates.

Co-authors: Tommaso Aquilante, Shiv Chowla, Nikola Dacic, Riccardo Masolo, Patrick Schneider, Martin Seneca and Srdan Tatomir.

Appendix

Estimation of Firm-Level Markups

To estimate firm-level markups, we follow De Loecker and Eeckhout (2017, 2018) and Díez et al. (2018), all of which are based on the original methodology proposed by De Loecker and Warzynski (2012).

Theory

Consider a firm i at time t that produces output with a production function whose arguments are variable inputs, capital, and technology.

Assume firms are cost-minimizers. Then, the Lagrangian associated with the cost minimisation problem (subject to the production function) leads to the following first-order condition for any variable input V (free of adjustment costs):

$$p_{it}^{V} = \lambda_{it}\left(\frac{\partial Q_{it}(\cdot)}{\partial V_{it}}\right) \quad \text{(A1)}$$

where p_{it}^{V} is the input price of variable input V faced by firm i at time t, λ_{it} denotes the marginal cost of production, and $\left(\frac{\partial Q_{it}(\cdot)}{\partial V_{it}}\right)$ denotes the marginal product of this input. Defining the markup as the ratio of price to marginal cost, $\mu_{it} \equiv \frac{p_{it}}{\lambda_{it}}$ we have that the above equation can be rearranged to give

$$\mu_{it} \equiv \frac{p_{it}}{p_{it}^{V}}\left(\frac{\partial Q_{it}(\cdot)}{\partial V_{it}}\right) \quad \text{(A2)}$$

We can rewrite this as

$$\mu_{it} = \frac{p_{it}}{p_{it}^{V}}\frac{Q_{it}}{V_{it}}\left(\frac{\partial Q_{it}(\cdot)}{\partial V_{it}}\right)\frac{V_{it}}{Q_{it}} = \left(\alpha_{it}^{V}\right)^{-1}\theta_{it}^{V} \quad \text{(A3)}$$

where α_{it}^{V} denotes the share of expenditures on input V_{it} in total sales ($P_{it}Q_{it}$), and θ_{it}^{V} denotes the output elasticity of input V. This gives us an expression for the firm-level markup in terms of observable α_{it}^{V} and the unobserved (but estimable) θ_{it}^{V}. The procedure below is all about consistently estimating this output elasticity.

Estimation

We generally follow De Loecker and Eeckhout (2017, 2018) and Díez et al. (2018) in our empirical application of the theory above. The production function they take to the data is given by

$$y_{it} = f(v_{it}, k_{it}; \boldsymbol{\beta}_j) + \omega_{it} + \epsilon_{it} \text{ for all } i \in j \tag{A4}$$

where i indexes a firm and j denotes a two-digit SIC07 industry, lower cases denote logs, y_{it} denotes deflated net sales, v_{it} denotes deflated cost of goods sold (COGS) (which are taken to be a measure of variable inputs), k_{it} denotes deflated net plant, property & equipment (PPE), ω_{it} denotes unobserved (to the econometrician) technology, and ϵ_{it} denotes the measurement error of net sales. Note that the production function parameters $\boldsymbol{\beta}_j$ are assumed to be *industry-specific* and time-invariant.

We consider two specifications for f: Cobb-Douglas and translog. Under the former, the output elasticity with respect to COGS is exactly equal to β_j^V. Under the latter, the output elasticity with respect to COGS is equal to $\beta_j^V + 2\beta_j^{vv} v_{it} + \beta_j^{vk} k_{it}$.

A key challenge in estimating (A4) is the endogeneity of optimal input choices with respect to technology ω_{it}. More precisely, whilst ω_{it} is unobserved to the econometrician directly, it is assumed to consist of two components: a part that's *observable* to the firm (but not to the econometrician) and a part that's *unanticipated* to the firm itself when it makes its input demand choices. The key identifying assumption is that we can express ω_{it} as a function of inputs (one of which is a so-called *control variable*, in our case COGS), i.e., $\omega_{it} = h(v_{it}, k_{it})$. We don't know what $h(\cdot)$ is, but we can approximate it as a high-order polynomial (in our case, of order 2).

The estimation approach, which we run separately for all observations in a given two-digit industry since $\boldsymbol{\beta}_j$ are assumed to be industry-specific, relies on two stages:

First stage: In the first stage, we run a regression of y_{ijt} on $v_{it,} v_{it}^2, k_{it}, \text{and} v_{it}, k_{it}$ Note that—to the extent that ω_{it} depends linearly on v_{it} and k_{it}—the estimated coefficients on these two variables will subsume the coefficients corresponding to these inputs *and* how ω_{it} depends on them. This step allows us to control for unobserved productivity (up to our approximation) and obtain an estimate of expected output, $\hat{y}_{ijt}$ and an estimate of the measurement error, $\hat{\epsilon}_{ijt}$. Since we have arguably controlled for unobserved productivity, our $\hat{y}_{ijt}$ should be a consistent estimate of $E(y_{ijt})$.

Second stage: As mentioned earlier, to get the GMM moment conditions, we need to purge ω_{it} from its component observable to the firm. We assume ω_{it} follows an AR(1) process so that

$$\omega_{\text{it}} = \rho\omega_{i,-1} + \xi_{it} \tag{A5}$$

where ξ_{it} is an idiosyncratic, unobservable (to both the firm and econometrician) shock to technology. This is the part of ω_{it} that is assumed to be uncorrelated with optimal input choices and thus forms the basis for the GMM conditions. We know that our $\hat{y}_{ijt}$ estimate subsumes both the inputs v_{it}, k_{it} directly and indirectly through $\omega_{it} = h(v_{it}, k_{it})$. But since it is consistent, we can express unobserved technology ω_{it} as a function of to-be-estimated $\boldsymbol{\beta}_j$:

$$\omega_{\text{it}}(\boldsymbol{\beta}_j) = \hat{y}_{ijt} - f(v_{it}, k_{it}; \boldsymbol{\beta}_j) \tag{A6}$$

So, given a $\boldsymbol{\beta}_j$, we can estimate equation (A5) to back out $\xi_{it}(\boldsymbol{\beta}_j)$. In the Cobb-Douglas case, we then have the GMM moment conditions

$$E\left(\xi_{it}\left(\boldsymbol{\beta}_j\right)\begin{pmatrix} k_{it} \\ v_{i,t-1} \end{pmatrix}\right) = 0 \tag{A7}$$

Note that capital is assumed to be decided one period ahead and therefore should not be correlated with the innovation in productivity. We rely on *lagged* COGS to identify the coefficients on COGS since current COGS is expected to react to shocks to productivity and hence $E(v_{it}\xi_{it})$ is expected to be non-zero.

The GMM estimation thus boils down to searching for those $\boldsymbol{\beta}_j$ that simultaneously minimize the sample moment conditions in (A7).

Once we have finally obtained $\hat{\boldsymbol{\beta}}_j$ from the above procedure, we can compute the output elasticity w.r.t. COGS θ_{it}^{V} (which is just equal to β_j^{v} in the Cobb-Douglas case). In addition, we can use the estimated measurement error in net sales $\hat{\epsilon}_{it}$ to adjust the denominator in the COGS share of net sales, α_{it}^{v}. We can then compute our estimates of firm-level markups $\hat{\mu}_{it} = \left(\tilde{\alpha}_{it}^{v}\right)^{-1} \tilde{\theta}_{it}^{v}$ *where* $\tilde{\alpha}_{it}^{v}$ is the measurement-error adjusted (COGS/net sales) ratio, and $\hat{\theta}_{it}^{v}$ is the estimated output elasticity with respect to COGS.

Endnotes

[1]As Blanchard (2008) said, "How markups move, in response to what, and why, is however nearly terra incognita for macro."

[2]Some notable papers that discuss the impact of product market developments on the macroeconomy include Cacciatore and Fiori (2016) and Eggertsson, Ferrero and Raffo (2014).

[3]Unlike many other advanced economies, it is worth noting that the U.K. labor share has not been on a downward trend.

[4]Excluding financial services firms.

[5]See, also, Bell and Tomlinson (2018).

[6]De Loecker and Eeckhout (2018) use a dataset that largely includes publicly-traded companies, but there are also some privately held firms.

[7]Similar estimates have recently been provided by Díez et al. (2018).

[8]OECD data.

[9]De Loecker and Eeckhout (2018) estimate that markups in the United States are a little larger than in the U.K., so the boost to U.K. TFP from eliminating them would be smaller than the 35 percent estimate for the United States in Baquee and Farhi (2018), albeit of a similar order of magnitude.

[10]The methodology is explained in the appendix. The data include around a little over 1,000 firms, on average, per year. These firms account for around one-third of U.K. employment. Their sales are equivalent to around one-third of U.K. turnover and around two-thirds of U.K. nominal GDP. We exclude financial sector firms and, having estimated markups, trim outliers, i.e., those firm-level markups that are below the 1st percentile and above the 99th percentile of the firm-level markup distribution in a given year,

[11]While the positive unconditional correlation between average firm-level markups and concentration at the sector level shown in Chart 4 is not statistically significant, a regression of individual firm-level markups on market concentration in their sector (at the two-digit SIC level) shows a statistically significant positive relationship when we include firm and time fixed effects.

[12]For example, Díez et al. (2018) find that the majority of industries in the United States have seen markups rise since 1980.

[13]Díez et al. (2018) find that the increase in U.S. markups since 1980 is also relatively broad based across sectors.

[14]Our results are consistent with De Loecker and Warzynski (2012) who find that exporters charge, on average, higher markups and that firm markups increase upon export entry.

[15]The relationship between labor, capital and profit shares is discussed in Barkai (2017).

[16]Unlike Díez et al. (2018), we use the reported data on staff costs in our firm-level dataset when calculating the labor share.

[17]A recent exception would be the work of Mongey (2018).

[18]Burgess et al. (2013).

[19]Taylor (1993).

[20]Taylor (1979).

[21]The larger proportionate reduction in inflation than in output gap variability arises because markup shocks account for a larger proportion of the historical variance of inflation than output.

[22]The interest rate smoothing term in the COMPASS Taylor rule will also have a role to play here in limiting the extent of the policy response to the markup shock.

[23]De Loecker and Eeckhout (2018).

[24]Equation (9) is specific to the Galí model presented here, but equation (10) is a more general feature of macroeconomic models, where r^* is a function of the household discount rate and productivity growth.

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