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Original Article

The resilience of the British and European goods industry: Challenge of Brexit

Moshfique Uddin[1,*], Anup Chowdhury[2] and Geoffrey Wood[3]

[1]Leeds University Business School, University of Leeds, Leeds LS2 9JT, UK. Email: m.m.uddin@leeds.ac.uk, [2]Leeds Business School, Leeds Beckett University, Leeds LS1 3HB, UK.
Email: a.chowdhury@leedsbeckett.ac.uk and [3]DAN Management School, Western University, London, Ontario N6A 5C2, Canada. Email: gwood23@uwo.ca

*Main author for correspondence.

Abstract

This is a study of the volume flexibility of the British and European goods industry, and its relative ability to cope with exogenous shocks, using the case of the Brexit process in a comparative context. It is located within the literature on comparative capitalism, and what it tells us in terms of how different institutional orders may be equipped to deal with such events. Using data for goods firms across 27 EU countries and the UK, we find that the UK goods industry has coped poorly with the shocks related to the Brexit process: its volume flexibility has declined. Brexit also has had an, albeit lesser, impact on the volume flexibility of their European firms counterparts. In particular, smaller firms in the EU coped better, a possible reflection of stronger institutional supports. However, firms that investing more in R&D, provide training to improve management efficiency, and apply innovation to improve asset efficiency, seem to be coping better. This study illustrates how the withdrawal of Britain from supra-national European institutions seems to have accentuated any negative effects of domestic institutions on firms, and, indeed, has had even worse consequences than the 2008 economic crisis for the British goods industry. The latter would suggest it is ill equipped to cope with further shocks, such as the 2020 pandemic. We draw out the implications for theorizing, policy and future research.

JEL classification: E44, E65, L1, L23

1. Introduction

This paper evaluates the ability of firms in the goods industry to cope with exogenous shocks. Examining goods industry is of particular importance as Acha *et al*. (2004) point out that goods industry plays a critical role is shaping and enabling industrial and economic progress. Using volume flexibility, we assess the resilience of UK firms to the demand uncertainty caused by Brexit, when compared to that of the remaining EU states. Demand volatility is a major risk for goods firms as it is likely to make for a mismatch with supply, and make forecasting very challenging (see De Giovanni and Massabo, 2018). During the financial crisis, industrial production fell between 3.0% and 4.0% in Europe in just three months between November 2008 and January 2009, which is equivalent to annual declines between 12% and 16%. The UK alone lost 6.4% of its gross domestic product (GDP) in the six subsequent quarters from September 2008 (Cowling *et al*., 2012), and inflation-adjusted real manufacturing output fell by 13%, placing the survival of manufacturing sector firms in serious question (Gasiorek *et al*., 2019). Brexit came as another major exogenous shock, following on from the earlier shocks caused by the financial crisis, and

created a further round of uncertainty in the UK and, to some extent, European economies. Since the referendum, there has been considerable discussion about Brexit's causes, which typically links economic change, and increased occupational, job, income and retirement security, with political blowback (see Morgan, 2016; Carreras *et al*., 2019). In turn, Brexit's consequences may engender a negative feedback loop back into the economy.

These exogenous shocks including Brexit have caused significant uncertainties in the market. Bloom *et al*. (2018) state that Brexit has created substantial uncertainty for UK businesses and this uncertainty is unique and different from others due to its length, breadth and political complexity. Gupta and Goyal (1989) mention that flexibility is considered as an adaptive response to uncertainty. In order to cope with demand uncertainty, firms need to have some degree of flexibility in order to remain profitable and competitive (Bengtsson and Olhager, 2002). Management must be capable of coping with uncertainty in product markets and manufacturing process. To be able to deal with uncertainty some degree of volume flexibility is required (Gerwin, 1993; Jack and Raturi, 2002). Volume flexibility allows firms to adjust production upward or downward without affecting cost and profitability. Volume flexible firms enjoy maintaining lower level of invesntory at high demand periods and never pile up excess inventories at the time of slow demand in the economy. Vickery *et al*. (1999) provide evidence that volume flexible firms are more profitable than others without volume flexibility. Given the strategic importance of volume flexibility in time of market uncertainty such as Brexit, it would be interesting to explore the resilience of UK and EU goods firms in terms of their volume flexibility. As such, the objectives of this paper are: (i) to examine if the UK and EU goods industry is flexible enough to cope with the Brexit shock, (ii) to examine if the profitability of the UK and EU goods industry is unaffected by the Brexit as the firms successfully use their flexibility to neutralise the impact of this shock and (iii) to draw out the implications for theorising and practice.

The UK is widely seen as an archetypical Liberal Market Economy[1] (LMEs), quite distinct from the Coordinated Market Economies of the Rhineland, Scandinavia and Japan (CMEs) (Hall and Soskice, 2001; Jackson and Deeg, 2019). Although within the 1990s, proponents of the LME model held that these were superior as with light regulation, high competition, and strong private property rights, agents had strong incentives to optimise their economic choices (La Porta *et al*., 2000). Indeed, it appeared to have assumed ecosystemic dominance as the preferred policy choice within global capitalism (McLaughlin and Wright, 2018; Jessop, 2019). However, and since then, LMEs seem to have been worse affected by major systemic shocks than CMEs; examples of such events would include the 2008- economic crisis (even if some more peripheral economies fared even worse) (Davies and McGoey, 2012; Reisenbichler and Morgan, 2012), the Covid-19 pandemic (Norrlöf, 2020), and, indeed, the right wing populist turn (Cumming *et al*., 2020). This might suggest that even if faced with the same shock, LME firms may face greater challenges in coping to their CME counterparts, or at least not exhibit superiority; there is less prospective of state led coordinated action to mitigate the effects of events. Much of the existing literature on such issues focuses on broad socio-economic outcomes than what goes on within the firm, and hence the latter represents the focus of this study. Again, if a principle feature of LMEs is the maximization of shareholder value, firms may be under great pressure not to reinvest sufficiently, and this may be particularly challenging in the goods sector, given, as Aoki (2010) argues, the

1 By Liberal Market Economy (LME), it is meant the developed Anglo-Saxon economies, characterized by shareholder primacy (ie US, UK, and Canada, Australia and New Zealand (Hall and Soskice, 2001). LMEs are market driven, and it is assumed that adversarial competition forces firms to continuously seek to raise their game (ibid; Jackson and Deeg, 2019). Actors who benefit from this system are likely to have an interest in pressing for futher deregulation over time (ibid.). At the same time, adverserialism exerts costs, in that it can constrain knowledge sharing across industries, which, however, may be alleviated through high job mobility of managers with generic tertiary skills (ibid.). Inter-firm relations tend to be transational and arms length (Hall and Soskice, 2001). This is in contrast to the Rhineland economies, Scandinavia, and Japan, which are commonly called Coordinated Market Economies (CMEs), which are are characterized by stronger stakeholder rights (ibid.). CMEs represent "negotiated economies". Here, competitiveness depends on higher regulation, encouraging knowledge sharing between firms, and the incremental development of industry capabilities. There is a relatively high degree of coordination in terms of both the financial system and labour markets, and, indeed, these two are interconnected (Hall and Soskice, 2001). Ties between actors tend to be denser, closer and more long term (Jackson and Deeg, 2019). Global pressures towards liberalization are mitigated by indigenous firms and other actors who have an interest in maintaining the present order owing to the complementarities it confers (Hall and Soskice, 2001). The original Hall and Soskice (2001) collection held that each national archetype was equally viable, but also that each posed challenges and opportunities for actors.

need to implement new technological advances and develop organization-specific human capital. This study focuses on the case of the UK and Brexit's effects on local and European firms; at the same time, it sheds broader light on the consequences of disruptions to trade on firms in an archetypical LME and those seeking to access its market. In turn, this provides further insights into the nature of LMEs more broadly, and the relative ability of LME firms to cope with changes in, and disruptions, to global trade.

This study reveals that the UK goods industry is and remains highly susceptible to shocks related to the Brexit process, and accordingly is likely to be disproportionately vulnerable to other shocks (e.g., Covid-19). We conclude that the goods industry's volume flexibility was significantly and negatively affected by the Brexit; the latter also posed (albeit lesser) challenges to their continental European counterparts. Moreover, we find that firms that are investing more into R&D, provide training to improve management efficiency, and apply innovation to improve asset efficiency could reduce the negative impact of Brexit shocks both in the UK and the EU. However, based on our dataset, none of these factors could fully neutralise the negative impact.

The rest of the paper is organised as follows. In Section two, we have presented some theoretical discussion and developed relevant hypotheses. Section three presents data collection, description of data and empirical models used in this paper. Section four summarises our analysis and presents our findings. Section five presents the conclusions, and draws out the implications of this study.

2. Theory, existing evidence and hypotheses

There is a growing body of literature that highlights the negative effects of Brexit for UK firms (O'Reilly *et al.*, 2016; Dhingra *et al.*, 2017). The day after the referendum on Britain's continued membership of the EU, held on June 23, 2016 the pound sterling fell to its lowest level against the US dollar since 1985, losing 10% of its value (see Aristeidis and Elias, 2018) and, by the end of October 2016, the pound had lost 18% of its value against the dollar and 15% against the euro. It might seem that it would render British exports of manufactured goods much cheaper; however, owing to close integration of supply chains within and beyond Europe, a weak pound had an immediate effect of raising the costs of materials. Moreover, domestic demand was suppressed by price rises for sought-after foreign goods (see Rhodes, 2017). A volatile pound makes it much harder for businesses to plan. Future projections are similarly gloomy. For example, Steinberg (2019) suggests that Brexit will reduce the trade flow with the EU by 8.2–44.8%, consumption by 0.5–1.3%, and the present value of UK households' welfare losses will be between £7000 and £19,000 per person. Lower household income further suppresses demand. Business investment declined after Brexit. It has been argued that, in such circumstances, volume flexibility, which is the ability to adapt production to suit demand level and the ability to operate profitably at different output levels, is critical to survival (see Jack and Raturi, 2003; Oke, 2003; De Giovanni and Massabo, 2018). In other words, volume flexibility is vital in order to cope with aggregate demand uncertainty (Goyal and Netessine, 2011), and to plan investments with a basic degree of confidence (De Giovanni and Massabo, 2018). Finally, whilst quantitative easing enabled UK financial services to recover quite rapidly from the 2008- financial crisis, other areas of the economy continued to experience lasting damage; in other words, it worsened existing distortions, and there is a real risk that Brexit will do the same (Rosamond, 2019).

There is a very extensive theoretical literature on flexibility in the goods industry. It is generally held that, in response to the exogenous shocks of the 1970s—volatility in input costs intensified global competition—firms were forced to introduce a greater degree of flexibility into their production paradigms (Boyer and Durand, 2016; Thursfield, 2017). This may be through flexible forms of work and production and/or numerical flexibility, in turn making for volume flexibility; that is, the ability to rapidly increase or decrease production without placing the financial sustainability of the firm in doubt. Moreover, it has been stated that, owing to highly flexible labour markets, Liberal Market Economy (LME) based firms (e.g., those operating in the UK) have some inherent advantages in terms of numerical flexibility (Boyer and Durand, 2016). However, it has been argued that ease in hiring and firing makes it difficult to accumulate a basis of organisation-specific skills, leading to short-term gains rapidly exhausting themselves (Aloisi and De Stefano,

2020). Again, it has been further argued that, in addition to the effects of labour market institutions, highly mobile investors are likely to desert, rather than persist with, firms in difficult times (Crouzet *et al.*, 2020), hence amplifying shocks, whilst the UK training system has been poor in matching skill with demand (O'Donovan, 2020). Moreover, whilst having typically higher levels of job protection, the Coordinated Market Economies (CMEs) of the Rhineland make effective usage of other ways of securing labour flexibility, for example, by "parking" labour through shortening the working week, should the need arise (c.f. Gehrke *et al.*, 2019). Finally, the relative importance of goods production in LMEs has declined since the 1970s; the CME goods industry has also faced periodic challenges, but has proven more resilient, probably owing to institutional complementarities that are more supportive of the sector (Hertwig *et al.*, 2019). The fortunes of the goods industry within other types of economy in the EU (eg. the Mediterranean Mixed, and East European Emerging) have been more variable, although such firms remain under European supranational institutions, whilst national institutions generally remain some way off the LME model (Witt and Jackson, 2016).

There is much debate as to the consequences of European supra-national institutions for firms Although they have both promoted liberalisation and infused aspects of the European social model (Carmel and Papadopoulos, 2016), it is widely held that Brexit will result in the UK becoming a more lightly regulated economy, intensifying existing systemic features and distortions, and the liberalizing influences in the European bloc will be weaker (Egan, 2020). Evidence from the 2008- financial crisis suggests that British manufacturing was left much worse off than financial services, reflecting both the extent to which quantitative easing greatly boosted the latter (Bailey and Tomlinson, 2017), in turn, facilitating a renewed focus on "predatory value extraction" from the former (Lazonick and Shin, 2019). In recent years, successive UK governments have become particularly receptive to vested interests encompassing both financial services and insider interests acting as brokers for outsourced public services and interests (Standing, 2016). This might suggest that the more orthodox goods industry will have to contrive solutions of its own; although this might encourage firms to devise internal fixes to ensure greater flexibility in coping with an unpredictable environment. However, theoretical work on internal institutional diversity suggests that even within sectors, some types of firm may be better equipped to cope than others, owing to organization specific complementarities, and specific organizational characteristics such as size and regional locale (Lane and Wood, 2009).

This raises more specific questions as to how national context might impact on resilience of firms, and their ability to cope with exogenous shocks. The literature on comparative capitalism suggests that the dominant mode of contracting in LMEs is "arms length" or transactional, in contrast to the "thicker" or denser ties between parties more typically encountered in CMEs (Jackson and Deeg, 2019). This might suggest that firms may have lower trust relations with their suppliers and other partners in the former (Goergen *et al.*, 2013), and, in turn, this might lead to much less willingness to make ad hoc accommodations in the event of exogenous disruptions (Weiss, 2021). Again, in event of the latter, suppliers might be more likely to rapidly seek other customers, knowing that existing ones might readily dispense with them at a whim (c.f. Ehnert *et al.*, 2016; Walker *et al.*, 2019). Finally, present day LME external corporate governance encourages firms to become asset lighter, in order to maximise shareholder returns (Gooderham *et al.*, 2019). This may mean that financial flexibility is prioritized over operational flexibility (Dilli *et al.*, 2018). Just in Time approaches towards inventories were, at least to some extent pioneered in Japan; this enabled firms to save inventory costs, but was at least partially predicated on the assumption that close relations with suppliers would help mitigate the effects of any disruptions (Thelen and Kume, 2018). Again, CMEs tend to have better physical infrastructures to LMEs (Ebner, 2010), in turn, reducing friction, and making it easier to rapidly recover from any disruptions. In short, this would suggest that CME goods firms are better equipped to cope with exogenous shocks (Busemeyer, 2009), even if LME non-manufacturing firms may be somewhat more agile.

Two issues emerge here. Firstly, supply chains that cross national boundaries impart effects on firms based under different institutional regimes (Goerzen *et al.*, 2020). Hence, it is not just UK (i.e., LME) rather than CME based firms that are potentially affected by possible Brexit disruptions. CME firms may have to cope with a more transactional approach by their UK based

customers, albeit that they may compensate for this through building even stronger ties with their CME based ones (c.f. Jackson and Deeg, 2019). In other words, if some customers (whether through faulty of their own or not) become less reliable, stronger relations with others mean that risks can be mitigated. Indeed, whilst CME firms remain embedded in the EU trading block, UK ones can only automatically access the home market, and through whatever other trade deals may be secured (Latorre *et al.*, 2020). Again, CME states are likely to be more proactive in intervening to support specific sectors (see Helfen *et al.*, 2017), which again may make CME firms better equipped to cope with Brexit disruptions. Based on the above discussion, this paper proposes the following hypothesis:

Hypothesis 1a: BREXIT will have a negative impact on volume flexibility of goods firms both in UK and in EU countries.

Hypothesis 1b: CME based goods firms are likely to cope better with Brexit shocks.

The first is that the comparative capitalism literature makes no claims as to uniformity in practice within specific national economies; whilst some way of things may predominate, a significant minority of firms will do things differently, relying on regional or sectoral specific complementarities, the latter being combined sets of practices that generate outcomes superior to those that an analysis of individual component practices might suggest (Crouch *et al.*, 2005). For example, some industries in LMEs may be particularly reliant on particular sets of sectoral specific managerial skills that are developed internally to complement the generic tertiary level educational qualifications that are the norm for managers within such contexts (Herrigel and Zeitlin, 2010). Firms investing in such training are likely to have particular advantages. Again, R&D spending and an ability to apply innovation, may indicate a greater willingness to reinvest and reflect a longer-term view that may be of value in anticipating challenges (Obeidat *et al.*, 2017). Hence, we further hypothesize that:

Hypothesis 2: Firms that spend more on managerial training, on R & D, and evidence an ability to apply innovations will cope better with Brexit disruptions.

3. Data, variables and empirical modelling

In this paper, we assess the resilience of UK firms to the demand uncertainty caused by the Brexit compared to the EU goods industry using volume flexibility. To do this, we have used firm-level data from all 28 EU countries. We have collected data for 3204 companies listed in various stock exchanges across Europe over a period from 2000 to 2019, using the Thompson Reutters DataStream database. This constitutes a total of 64,080 firm-year observations.[2] For empirical analysis of firm-level flexibility around Brexit, we have used three measures of process-based volume flexibility recommended in Jack and Raturi (2003) and an output flexibility measure recommended in Mills and Schumann (1985). The first process-based measure we use is the volume flexibility considering inventory trade-offs (FLX_1). The proposition is that the firms' flexibility may be measured as the ratio of the fluctuations in their sales divided by the fluctuations in their inventory (see Jack and Raturi, 2003). For mathematical estimation, we follow the model suggested by Jack and Raturi (2003) and use the fluctuations in inventory as measured by $SD_{inventories}$ rather than average inventory as the denominator. The equation is as follows:

$$FLX_1 \cong Log\left(\frac{SD_{sales}}{SD_{inventories}}\right) \quad (1)$$

The advantage of using fluctuation in inventory is that the ratio (as in equation (1)) becomes comparable across different firm sizes: this is especially so given that inventory characteristics in different industries are different (see Jack and Raturi, 2003 for further discussion). So, the model

2 Details on data distribution and variables used are provided in Supplementary Tables A1 and A2 in the Appendix.

shows that a firm that responds to demand uncertainty (sales variation) due to an event such as the Brexit by maintaining small variations in inventory is considered more volume flexible. Our second measure of volume flexibility, FLX_2, considers how a firm uses production technology or deploys policies to respond to the sales fluctuations of a goods firm due to the uncertainty created by an event such as the Brexit. As suggested in Jack and Raturi (2003), one should focus on the fluctuation in production (as measured by SD_{COGS}) as opposed to the average level of those costs over time. Therefore, the trade-offs would be between sales fluctuations and fluctuations in cost-of-goods-sold (COGS) as in equation (2). Hence, during Brexit, if a firm can respond to larger sales variations with smaller variations in production cost, it is considered more volume flexible. The equation is:

$$FLX_2 \cong Log\left(\frac{SD_{sales}}{SD_{cost-of-goods-sold}}\right) \tag{2}$$

The third and final measure of process-based flexibility (FLX_3) represents the combination of equations (1) and (2). This assumes that a firm can respond to output fluctuation by combining these two previous approaches. This measure, as Jack and Raturi (2003) argue, is going to incorporate elasticity that the firm might encounter in the market (demand elasticity), cost of goods (cost elasticity), and inventory levels. The quantitative model, as in equation (3) captures the relative fluctuations in both outputs and inputs. So, a firm cannot achieve flexibility by merely improving the technology or by lowering the level of inventory. A firm, under this measure, is considered flexible if that firm can respond to sales fluctuation caused by the Brexit with lower fluctuation in its resource base, as measured by changes in both inventory buffers and cost-of-goods-sold.

$$FLX_3 \cong Log\left(\frac{SD_{sales}}{\sqrt{(SD_{inventories})^2 + (SD_{COGS})^2}}\right) \tag{3}$$

In addition to the three process-based volume flexibility measures, we also estimate a firm's output flexibility (OFLX), as documented in Mills and Schumann (1985). The authors suggest that the real fluctuation of a time series such as sales data must be calculated by first adjusting for inflation and also for natural sales growth. Therefore, by following their procedure, we remove the growth and seasonal trends from the Datastream data before computing our flexibility measures by doing two things: (i) adjusting the data for inflation using the consumer price index of each country; and (ii) avoiding the effect of systematic growth or decline by extracting the standard error from the regression of Log (CPI-adjusted sales) and a linear trend with adjustment for serial correlation. The equation for output flexibility is as follows.

$$OFLX \cong \sigma_{sales} \tag{4}$$

where, σ_{sales} represents the standard error form regression of log (CPI-adjusted sales) for all the UK and EU goods industry, with a linear trend and serial correlation.

Our primary explanatory variable in this study is Brexit (BRX), as our objective is to see the causal impact of this event on the firm-level flexibility. The United Kingdom has voted to leave the European Union on June 23, 2016. Hence, to capture the Brexit shocks in our empirical models, we use a dummy variable equal to one from 2016 till 2019 and zero for other periods. We include several standard firm-level variables in our regression models. Such as, for measuring the causal association between firm-level performance and Brexit, we use return on sales (ROS) as our main dependent variables and return on assets (ROA) for robustness. To control the firm size, we use (logarithm of) inflation-adjusted sales (SIZE) as recommended in earlier studies. Similarly, we control for the capital structure as proxied by the total liabilities scaled by lagged assets (LEV) and firm's (logarithm of) age (AGE), proxied by the number of years listed in the stock exchange. Since the availability of cash largely influences firm-level investment in inventories and technologies, so we control for the net cash flow from operation scaled by lagged total assets (CFO), and cash holding as the cash and short-term investment scaled by lagged total assets (CH). This paper has applied several variables for robustness checks, which includes R&D expenditure

scaled by lagged total assets (RND); inventory turnover ratio (INTR); inflations adjusted sales generated by per employee (EEF) and per dollar assets (AEF); operating leverage (OPL); (logarithm of) total assets (TA); working capital scaled by lagged assets (WC); current ratio (CR); cash conversion cycle (CCC); capital expenditure scaled by lagged total assets (I); the TobinsQ (TQ); and practice management training (MGT). There are several country-specific macroeconomic and market-related variables we use to capture the cross-country economic difference. For example, an average yield of ten years of government bond as a proxy for the long-term interest rate (LTR). Similarly, the average interest rate of three to six months of treasury bills to proxy the short-term interest rate (STR), and year-to-year change in the consumer price index as the inflation rate (INF). The log of dollar value difference between export and import of goods and services (NETRD), is used to determine the net trade relationship between the UK and EU. The country-level economic size and development are controlled respectively by using the (logarithm of) GDP per capita and the aggregate growth rate of GDP of a country. Finally, using dummy variables, we also control for the financial crisis of 2007–2009 (CRI) and the European debt crisis of 2010–2012 (EDC). It is essential to mention that the variables are not suffering from the unit root problem and extreme values. We use various augmented Dickey-Fuller based unit root tests for our panel data to make sure macroeconomic series are stationary. For omitting extreme values, we have winsorised the dataset at the upper and lower one percentile.

This paper uses multivariate models to examine if the UK and EU goods industry is flexible enough to cope with the Brexit shock. The benchmark panel model is specified as follows.

$$FLX_{i,t} = \alpha_1 + \beta_1 (BRX)_t + \beta_2 X_t + \beta_3 Y_{i,t} + \beta_4 Z_{c,t} + Year + Ind + \varepsilon_{i,t} \quad (5)$$

where, $FLX_{i,t}$ in equation (5) is an unobserved dependent variable that measures the firm-level volume and output flexibility, estimated using Jack and Raturi's (2003) and Mills and Schumann's (1985) approach. The Brexit shock $(BRX)_t$ is our primary exogenous variable in this equation. We control for the financial crisis of 2007–2008 and European Debt Crisis of 2010–2012 using X_t. $Y_{i,t}$ represents the matrix for the control variables of firm-level characteristics. The country-level macroeconomic characteristics are controlled using $Z_{c,t}$. The error term is $\varepsilon_{i,t}$ in the model, and we use *Year* and *Ind* level control variables for both time and firm-level heterogeneity. We run various robustness tests using equation (5), including the industry classification of MSCI and S&P Dow Jones Indices.[3] We use the industry classification to see which are the more (less) flexible sectors among the goods industry and thus remain unaffected (affected) by the Brexit shocks both in the UK and EU. To examine if the profitability of UK and EU goods firms is unaffected by the Brexit as the firms successfully use their flexibility to neutralise the impact of this shock, we have used a panel-based regression model which is as follows:

$$ROS_{i,t} = \alpha_1 + \beta_1 (BRX)_t + \beta_2 (FLX)_{i,t} + \beta_3 X_t + \beta_4 Y_{i,t} + \beta_5 Z_{c,t} + Year + Ind + \varepsilon_{i,t} \quad (6)$$

where, $ROS_{i,t}$ is the unobserved dependent variable measuring the firm-level return on sales, as suggested in Jack and Raturi (2003). In this equation (6) we use Brexit ($(BRX)_t$) and firm-level process-based volume flexibility ($(FLX)_{i,t}$)as our main exogenous variables along with all other control variables mentioned in the previous equation, (5). We also control for time and firm-level heterogeneity using *Year* and *Ind* and the error term is $\varepsilon_{i,t}$. For robustness checks, we re-estimate the association as in equation (6) using the return on assets (ROA) as our dependent variable. Finally, we performed detailed diagnostic analyses for each of our regression models to fit with the statistical conditions.

3 The MSCI and S&P developed the Global Industry Classification Standard (GICS) in 1999 to offer an efficient investment tool to capture the breadth, depth, and evolution of industry sectors. GICS is a four-tiered, hierarchical industry classification system, where companies are classified both quantitatively and qualitatively, combining earnings and market perceptions as the most relevant information.

4. Empirical findings

4.1 Descriptive statistics

Supplementary Table A3 in the Appendix exhibits the summary statistics of our dataset. The data required for the tests was available for a total of all 27 EU countries and the UK (all the sample countries and industries are listed in Supplementary Table A2 in the Appendix). Our results given in Panel A of Supplementary Table A3 indicate various notable firm-level dimensions of those countries' goods industries. The descriptive statistics show that the mean and median size of EU firms is higher than that of the UK firms, but UK firms are older than their EU counterparts. UK firms make higher investment into capital expenditure (0.206), working capital (0.439), and R&D expenditure (0.186) scaled by lagged total assets. Furthermore, the median liquidity measured in the current ratio (1.682) and cash holding scaled by lagged total assets (0.247) of the UK firms are also higher than those for the similar EU firms Another notable feature is that the EU goods industry performs better than the UK one, reflected by higher ROA, ROS, and sales per employee and per capita investment. Additionally, EU firms are generating higher average cash flow from their operations scaled by lagged total assets (0.062), making a substantial average change in operating profit with every additional dollar of sales (OPL = 0.190), and it takes less time to recycle the cash in the business, with an average cash conversion cycle of 5.559 days. Moreover, they have higher international sales than in the UK goods industry. The mean and median international sales scaled by total sales of the EU firms are 48.220 and 50.410, but the UK firms are only involved in the international market with an average sale of 42.560 and a median sale of 35.345. The UK firms, however, are highly levered as the average liabilities scaled by lagged total assets is 1.855 and also have higher median Tobin's Q (4.431) than their EU counterparts, where the statistics are 1.566 and 2.625 correspondingly.

In Panel B of Supplementary Table A3, we provide the descriptive statistics for macroeconomic variables used in our regressions. For example, the median value of the log of the UK's per capita GDP (GDPPC) is 10.630, and the EU's is 10.454. However, the median value of GDP growth (GDPGR) is 0.041 in the UK and 0.038 in the EU over the sample period. The mean values of long-term interest, short-term interest, and the spread between 10 year bond yield and three-month risk-free rate are 3.488, 2.414, and 1.074 respectively in the UK economy. The corresponding statistics are 2.060, 3.425, and –1.407 in the EU economies. The net trade relationship between the EU and the UK shows that the median of the log of net trade (i.e., Export minus Import) is –25.019 in the UK with the EU countries and –21.634 in the EU with the UK.

Panel C of Supplementary Table A3 shows the Pearson correlation between our main variables of interest—firm-level flexibility, Brexit, and firm-level characteristics, such as performance, earnings, size, cash flow, and cash holdings. The coefficient indicates that measures of firm-level flexibility (FLX) are significantly and negatively related to the Brexit, but positively correlated with most of the firm-level characteristics. In Panel D of Supplementary Table A3, we compare the differences across the Brexit and non-Brexit period for volume flexibility (FLX_t) and output flexibility ($OFLX$) measures using a nonparametric test (Wilcoxon rank-sum (Mann-Whitney) test). The results show that the differences in flexibility measures are highly statistically significant between the Brexit and non-Brexit period, and reveal systematic differences in firm-level flexibility across the two episodes.

4.2 The firm-level resilience

Tables 1 and 2 present the test results of our hypotheses related to the effect of Brexit on firm-level flexibility applying equation (5). In columns (1), (2), and (3) of these tables, we use process-based volume flexibility, and in column (4) we use output flexibility as the dependent variable. In all columns of Table 1, we find the coefficient of Brexit to be significantly negative, indicating that the Brexit shock significantly challenged firm-level flexibility in the UK. The findings suggest that the UK goods industry is not resilient to demand uncertainty due to the Brexit. The results indicate that the process-based volume flexibility of this industry is reduced by, on average, more than 10% and output flexibility reduced by more than 25% because of the Brexit shock. These figures are all statistically significant at a 99% confidence level. These results strongly support out hypothesis 1a which says that BREXT will have a significant negative impact on volume

Table 1. Baseline regression for the UK goods industry

Dep. var.	(1) FLX_1	(2) FLX_2	(3) FLX_3	(4) $OFLX$
BRX	−0.1328***	−0.1022***	−0.1174***	−0.2677***
	(0.0139)	(0.0118)	(0.0115)	(0.0083)
CRI	−0.0367***	−0.0098	−0.0238**	−0.0676***
	(0.0141)	(0.0108)	(0.0108)	(0.0079)
EDC	−0.0684***	−0.0462***	−0.0561***	−0.1352***
	(0.0134)	(0.0112)	(0.0110)	(0.0076)
SIZE	0.0389***	0.0380***	0.0390***	0.0849***
	(0.0007)	(0.0007)	(0.0006)	(0.0004)
CFO	−0.0050	0.0050	0.0008	0.0004
	(0.0032)	(0.0031)	(0.0028)	(0.0015)
CH	0.0053**	0.0065**	0.0061***	0.0023*
	(0.0026)	(0.0027)	(0.0023)	(0.0013)
LEV	−0.0001	−0.0009	−0.0005	−0.0016***
	(0.0011)	(0.0010)	(0.0009)	(0.0005)
AGE	−0.0407***	−0.0323***	−0.0349***	−0.0272***
	(0.0034)	(0.0031)	(0.0028)	(0.0017)
Intercept	−0.5909***	−0.6761***	−0.9960***	1.9482***
	(0.0183)	(0.0158)	(0.0151)	(0.0116)
Firm years	6923	6923	6923	6923
R^2	0.5780	0.6493	0.6873	0.9675
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Cluster by Firms	Yes	Yes	Yes	Yes

This table reports the results using the regression model described in equation (5) for the UK goods industry. Models (1) to (3) show the results using volume flexibility as dependent variable (as described in equations 1–3), and Model (4) is using output flexibility (as in equation 4). Robust standard errors are reported in the parentheses.
***p < 0.01,
**p < 0.05, and
*p < 0.1 report the level of significance at various levels. We re-estimate these models using total assets as firm size, and our results remain similar.

flexibility of UK goods firms The results also show that larger firms are more volume flexible than smaller firms in the UK; the coefficient of SIZE is positive across the models (0.0389, 0.380, and 0.039) and significant at 1%. In model FLX_1, where we consider how the firm uses its inventory buffer to support its output variation, our results suggest that a large firm has smaller variation in inventory in responding to a similar level of sales fluctuation than a smaller firm. Furthermore, in models FLX_2 and FLX_3, larger firms are more volume flexible in using production technology (i.e., cost-of-goods-sold) and a combined approach against variation in demand. The output flexibility, $OFLX$, also shows that the output of a large firm fluctuates significantly more than that of a small firm; the coefficient of SIZE is 0.0849 and significant at a 99% level of confidence in column (4). Finally, in the UK goods industry, cash holding positively affects and firm age negatively affects flexibility, which is also statistically significant at a 1% to 10% level.

Table 2 reveals that the Brexit shock posed risks for the volume and output flexibility of the EU goods industry as well. The BRX coefficients in columns (1) to (4) are negative (−0.0545, −0.0285, −0.0421 and −0.1729 respectively) and statistically significant at a 99% confidence level. These results, hence, indicate that Brexit has caused a significant risk to the EU goods industry by reducing the firm-level flexibility. Therefore, similar to their UK counterparts, EU firms also have failed to use their resources and production technology (i.e., inventory and cost-of-goods-sold) to respond to the demand fluctuation due to Brexit uncertainty. However, comparing the coefficients for each of the flexibility measures for UK and EU goods firms, it is apparent that UK goods firms are more affected by Brexit compared to EU goods firms This renders strong support to our hypothesis 1b. The size is also positively associated with the level of volume flexibility in this market. The coefficients of size are 0.0201, 0.0240, 0.0232, and 0.0691 across columns (1) to (4), and statistically significant at the 1% level.

Table 2. Baseline regression for the EU goods industry

Dep. var.	(1) FLX_1	(2) FLX_2	(3) FLX_3	(4) $OFLX$
BRX	−0.0545***	−0.0285***	−0.0421***	−0.1729***
	(0.0071)	(0.0047)	(0.0039)	(0.0026)
CRI	−0.0231***	−0.0172***	−0.0216***	−0.0709***
	(0.0086)	(0.0042)	(0.0040)	(0.0027)
EDC	−0.0396***	−0.0280***	−0.0309***	−0.0966***
	(0.0068)	(0.0036)	(0.0035)	(0.0024)
SIZE	0.0201***	0.0240***	0.0232***	0.0691***
	(0.0006)	(0.0006)	(0.0005)	(0.0004)
COF	0.0201***	0.0149***	0.0181***	0.0113***
	(0.0035)	(0.0039)	(0.0031)	(0.0018)
CH	0.0100**	−0.0058	−0.0012	−0.0125***
	(0.0041)	(0.0043)	(0.0035)	(0.0019)
LEV	0.0014*	−0.0002	0.0006	−0.0016***
	(0.0008)	(0.0008)	(0.0007)	(0.0004)
AGE	−0.0114***	−0.0169***	−0.0159***	−0.0096***
	(0.0024)	(0.0019)	(0.0016)	(0.0010)
GDPGR	−0.0017	−0.1093***	−0.0665***	−0.0708***
	(0.0243)	(0.0204)	(0.0187)	(0.0130)
GDPPC	−0.0456	0.0291	0.0266*	0.0588***
	(0.0443)	(0.0177)	(0.0142)	(0.0089)
Intercept	−0.3401***	−0.4745***	−0.7671***	2.1953***
	(0.0135)	(0.0091)	(0.0089)	(0.0059)
Firm years	20,688	20,688	20,688	20,688
R^2	0.154	0.3027	0.4137	0.9505
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes	Yes

This table reports the results using the regression model described in equation (5) for the EU goods industry. Models (1) to (3) show the results using volume flexibility as a dependent variable (as described in equations 1–3), and Model (4) is using output flexibility (as in equation 4). Robust standard errors are reported in the parentheses.
***$p < 0.01$,
**$p < 0.05$, and
*$p < 0.1$ report the level of significance at various levels. We re-estimate these models using total assets as firm size, and our results remain similar.

For the European goods industry (in Table 2), cash flow from operation (COF) is positive (0.0201, 0.0149, 0.0181, and 0.0691, respectively), allowing a firm to be volume and output flexible. However, the AGE variable indicates older firms are less flexible as the coefficients are negative and significant, individually −0.0.114, −0.0169, −0.0159, and −0.0096 in columns (1) to (4). That means younger firms in the EU goods industry could use their production technology more efficiently than firms that have been in the market for a longer period. The economic characteristics of all 27 EU countries are associated with firm-level volume flexibility, some negatively, e.g., GDP growth rate, and some positively, e.g., GDP per capita.

The results reported in Tables 1 and 2 from our data further exhibit that both the UK and EU goods industry were negatively affected by the financial crisis of 2007–2009 (CRI) and European debt crisis (EDC) along with the Brexit shocks. Surprisingly although, the European debt crisis had a more substantial impact on the UK firms' flexibility than did the financial crisis. Finally, our results (i.e., Tables 1 and 2) show that firms' capital structure choice has a mixed impact on the volume and output flexibility. For the UK market, it is only statistically significant for output flexibility (−0.0016), whilst, for the EU market, it is positively related (0.0014) with FLX_1 and negatively (−0.0016) with OFLX.

Table 3. Regression on the profitability (UK)

Dep. var.	(1) ROS	(2) ROS	(3) ROS	(4) ROS Small firms Sales < 100 m	(5) ROS Mid-size firms Sales ≥100 m ≤250 m	(6) ROS Large firms Sales >250 m
BRX	−1.6983*	−2.2052**	−1.0226	−10.9186**	−0.1364	0.0516**
	(1.0234)	(1.0403)	(1.0230)	(4.5236)	(0.3690)	(0.0224)
CRI	−0.1982	−0.4978	0.0614	−1.1269	−0.0938	0.0492***
	(0.6011)	(0.6114)	(0.6017)	(1.2869)	(0.2405)	(0.0172)
EDC	0.3722	−0.0217	0.7125	−1.9692	−0.1089	0.0627***
	(0.6191)	(0.6118)	(0.6289)	(1.2815)	(0.2556)	(0.0179)
FLX_1	20.6944***			0.6803	−13.3650**	−1.0307**
	(2.4217)			(11.1613)	(6.0402)	(0.4223)
FLX_2		21.6810***		−6.0955	−10.7789	−0.9226**
		(4.8803)		(17.7242)	(6.6291)	(0.3848)
FLX_3			38.2280***	33.9450	34.5641**	2.8737***
			(5.4022)	(30.6265)	(16.1952)	(1.0548)
SIZE	1.9191***	1.7758***	1.6822***	5.7263***	0.4431	−0.0090***
	(0.1481)	(0.1413)	(0.1322)	(0.3415)	(0.3590)	(0.0034)
COF	1.7445***	1.7005***	1.4533***	−1.1820**	0.3894***	0.1790***
	(0.4563)	(0.4712)	(0.4640)	(0.5921)	(0.1361)	(0.0171)
CH	−0.2838	−0.2580	−0.3980	−0.4171	0.0296	0.0339**
	(0.4231)	(0.4357)	(0.4183)	(0.4230)	(0.1868)	(0.0153)
LEV	0.1035	0.1735*	0.1112	0.1026	−0.0107	−0.0127***
	(0.0900)	(0.0907)	(0.0879)	(0.1000)	(0.0279)	(0.0032)
AGE	−1.3055***	−1.3010***	−1.2902***	−1.4337**	−0.0754	0.0040
	(0.2550)	(0.2565)	(0.2533)	(0.6307)	(0.0719)	(0.0040)
Intercept	−24.2010***	−20.5556***	−3.7034	−19.2823	8.4124	1.3029***
	(1.9927)	(2.0839)	(2.9370)	(12.4594)	(6.1990)	(0.4538)
Firm years	5608	5608	5608	2462	716	2430
R^2	0.3020	0.2873	0.3140	0.4853	0.3533	0.3252
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes	Yes	Yes	Yes

This table shows the impact of Brexit on the profitability & flexibility nexus of the UK goods industry. Using equation (6), we estimate these panel models. The results are reported in columns (1) to (6), where our dependent variable is the return on sales (ROS). Results in columns (1), (2), and (3) show the impact of Brexit on the connection of each measure of flexibility and ROS. However, columns (4), (5), and (6) present the results related to the influence of Brexit shock on the profit-flexibility nexus of size-sorted portfolios. Robust standard errors are reported in the parentheses.
***$p < 0.01$,
**$p < 0.05$, and
*$p < 0.1$ report the level of significance at various levels. Following the argument of earlier studies (i.e., Jack and Raturi, 2003), we also have re-estimated these models using the return of assets (ROA) as a measure of firm-level profitability and the results remain similar.

4.3 Impact of Brexit on the association of performance and flexibility

In Tables 3 and 4, we report the impact of Brexit on the association between firm-level performance and flexibility using equation (6). Applying return on sales (ROS) as our dependent variable, we examine whether the profitability of the UK and European goods firms are unaffected by the Brexit as these firms could successfully use their flexibility to neutralise the impact of this shock. Columns (1) to (3) in both tables exhibit the impact of Brexit on the nexus between the individual measure of volume flexibility and ROS. Columns (4) to (6) show the impact on the relationship based on the firm's size. We use firm-level CPI-adjusted SALE to create the size-based portfolios: firms with average yearly SALE less than 100 million US dollars are grouped as "Small Firms"; those with average yearly SALE more than 250 million US dollars are grouped as "Large Firms"; and those with average yearly SALE between $100 million and $250 million are categorised as "Mid-size Firms".

Table 4. Regression on the profitability (EU)

Dep. var.	(1) ROS	(2) ROS	(3) ROS	(4) ROS Small firms Sales < 100 m	(5) ROS Mid-size firms Sales ≥100 m ≤250 m	(6) ROS Large firms Sales >250 m
BRX	−1.2148***	−1.0148***	−0.1744	−0.6807	0.0073	0.1179*
	(0.4105)	(0.3685)	(0.3579)	(0.8923)	(0.1100)	(0.0668)
CRI	−1.2338***	−1.1695***	−0.8856***	−2.3635***	−0.0675	0.0938*
	(0.2856)	(0.2720)	(0.2726)	(0.7987)	(0.0965)	(0.0567)
EDC	−1.0907***	−0.8366***	−0.3378	−0.4993	−0.0712	0.1079*
	(0.2573)	(0.2286)	(0.2420)	(0.7619)	(0.1133)	(0.0632)
FLX_1	4.4931*			−10.4202**	1.7400	0.0001
	(2.6675)			(4.9336)	(1.4533)	(0.0163)
FLX_2		16.2802***		−5.1546	2.2161	2.3522**
		(2.1869)		(3.6476)	(1.4744)	(0.9138)
FLX_3			31.0699***	45.7641***	−5.5052	−0.8497
			(3.4490)	(10.4601)	(3.8881)	(0.5537)
SIZE	0.7723***	0.6159***	0.4683***	2.6647***	0.0514	0.0003
	(0.0605)	(0.0492)	(0.0432)	(0.1787)	(0.1012)	(0.0059)
COF	2.5542***	2.4493***	2.1257***	1.1073**	0.0729	0.2125***
	(0.4253)	(0.4179)	(0.4099)	(0.5049)	(0.1091)	(0.0307)
CH	−1.3711***	−1.3839***	−1.7420***	−1.0527**	−0.0009	−0.0429
	(0.4853)	(0.4664)	(0.4595)	(0.4963)	(0.0444)	(0.0741)
LEV	0.0267	0.0400	0.0197	0.2010*	0.0881**	−0.0041
	(0.0994)	(0.0977)	(0.0941)	(0.1200)	(0.0410)	(0.0081)
AGE	−0.1528	−0.0586	−0.0005	0.6187*	−0.0221*	−0.0013
	(0.1342)	(0.1296)	(0.1274)	(0.3414)	(0.0122)	(0.0077)
GDPGR	−9.7534***	−9.2125***	−10.3434***	−17.4659***	0.0583	0.4306***
	(1.1913)	(1.1354)	(1.2098)	(2.2910)	(0.3120)	(0.1561)
GDPPC	6.4795***	6.6229***	7.3302***	16.3883***	0.6158	0.0311
	(1.2241)	(1.1944)	(1.1960)	(2.8329)	(0.3788)	(0.0595)
Intercept	−5.5799***	−1.4295*	13.3017***	−5.5054	−3.2363	0.1365
	(0.8822)	(0.7510)	(2.0377)	(5.1915)	(2.5902)	(0.2655)
Firm years	19,899	19,899	19,899	6777	2909	10,211
R^2	0.1695	0.1931	0.2184	0.3282	0.0807	0.0882
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes	Yes	Yes	Yes

This table shows the impact of Brexit on the profitability & flexibility nexus of the EU goods industry. Using equation (6), we estimate these panel models, and results are reported in columns (1) to (6), where our dependent variable is the return on sales (ROS). Results in columns (1), (2), and (3) show the impact of Brexit on the connection of each measure of flexibility and ROS. However, columns (4), (5), and (6) present the results related to the influence of Brexit shock on the profit-flexibility nexus of size-sorted portfolios. Robust standard errors are reported in the parentheses.
***p < 0.01,
**p < 0.05, and
*p < 0.1 report the level of significance at various levels. Following the argument of earlier studies (i.e., Jack and Raturi, 2003), we also have re-estimated these models using the return of assets (ROA) as a measure of firm-level profitability and the results remain similar.

The results presented in Table 3 indicate that Brexit is significantly affecting the nexus between ROS and flexibility in the UK. For example, in columns (1) and (2), the Brexit impact on profitability is negative, −1.6983 and −2.2052, respectively, which is statistically significant. Furthermore, in column (3), the relationship of Brexit with ROS is also negative, yet not significantly so. In addition to Brexit, each of our individual measures of flexibility has reported a strong positive association with the firm-level profitability. The coefficients are 20.69, 21.68, and 38.23 separately in columns (1) to (3), and all are significant at a 99% level of confidence. This implies, a firm might not be able to respond to profitability loss from output fluctuation as

a result of Brexit by either using inventory buffer or production technology, but could respond by combining these two approaches, and hence mitigate the negative impact.

The combination of inventory buffer and production technology seems to represent an effective strategy for larger firms to respond to their profit fluctuation due to the impact of Brexit shock on output variation. Results in columns (4) to (6) show that smaller firms are severely affected by the Brexit (–10.9186 and significant at a 95% level of confidence), and indicate that these firms have failed to use their volume flexibility to respond to the adverse Brexit shocks as none of their flexibility measures are statistically significant. However, larger firms, on the other hand, could use a combined strategy (i.e., FLX_3) not only to neutralise the impact of Brexit but also to positively respond to output fluctuations. As reported, the coefficients of BRX and FLX_3 for larger firms are 0.0516 and 2.8737, respectively, in column 6, and these are significant at 95 and 99% level of confidence. However, the results for other flexibility measures—FLX_1 (–1.0307) and FLX_2 (–0.9226)—are unfavourable and significant, meaning that individual strategy is not sufficient. Results for mid-size firms reported in column 5 are not statistically significant.

Brexit's impact on the link between flexibility and profitability of the EU goods industry is summarised in Table 4. As is the case with their UK counterparts, a strong and positive link is exhibited between each measure of volume flexibility of the EU goods industry and ROS. In columns (1) to (3), the coefficients of volume flexibility are 4.49, 16.28, and 31.07, which are statistically significant at confidence levels ranging between 90 and 99%. Brexit negatively affected EU firms' profitability, but the significance of this finding varied. Applying the size-sorted portfolios, we found a quite different result for the EU goods industry compared to their UK counterparts; small firms were better off in the former.

4.4 Robustness of the association

In this section, we present some test results to check the robustness of the association between Brexit and firm-level volume flexibility. We have included various firm-level variables in our models to see whether those variables could improve the volume flexibility to respond to output fluctuation due to Brexit or similar uncertainty. In Tables 5 and 6, for the UK and EU goods industry, respectively, we show the impact of R&D investment, employee efficiency, and assets efficiency on the relationship between flexibility and Brexit. As noted above, functional flexibility may contribute to overall volume flexibility (Boyer and Durand, 2016). The former may be secured through R&D investment, employee efficiency, and assets efficiency (c.f. Raturi and Jack (2004), among others). From our results, we see that these three variables have a significant positive influence on the volume flexibility of both UK and EU firms For example, by improving its assets' efficiency, a UK firm could increase the maximum of its volume flexibility, i.e., 0.6448, 0.4378, and 0.5224, respectively, of FLX_1, FLX_2, and FLX_3 (see Table 5). The next maximum positive impact a UK firm could achieve is by improving its employees' efficiency, i.e., 0.1474, 0.1033, and 0.1210, respectively. The investment in research and development (R&D) could also increase each of the flexibility measures by 0.0849, 0.0558, and 0.0658. Additionally, efficiency and R&D investment could also reduce the negative impact of Brexit. This renders support to our second hypothesis.

As reported in Table 5, across columns (1) to (9), the coefficients of Brexit are negative and significant, but the magnitude of this negative impact is less than the results reported in Table 1. That means the UK goods industry might enhance its capacity to respond to output fluctuation risk by improving asset and employee efficiency or R&D investment but fail to neutralise the negative impact of Brexit or similar shocks. Based on the results reported in Table 6, the EU goods industry receives a similar effect from the efficiency and R&D investment on its volume flexibility. For example, the coefficients of asset efficiency are 0.4744, 0.3786, and 0.4270, which generate a maximum positive impact on the enhancement of volume flexibility. The employee efficiency and R&D investment are two following significant variables, as these could increase a firm's volume flexibility separately, on average by 0.1098 and 0.0457. However, like their UK counterparts, using these three variables, the EU firms have failed to neutralise the effect of Brexit on their volume flexibility. The effect remains negative and statistically significant across the table. This renders further support to our second hypothesis.

Table 5. Additional test with additional firm-level variables for Firm-level policy (UK)

Dep. var.	(1) FLX_1	(2) FLX_2	(3) FLX_3	(4) FLX_1	(5) FLX_2	(6) FLX_3	(7) FLX_1	(8) FLX_2	(9) FLX_3
BRX	−0.1001***	−0.0574***	−0.0774***	−0.1012***	−0.0628***	−0.0820***	−0.0893***	−0.0658***	−0.0791***
	(0.0183)	(0.0170)	(0.0161)	(0.0156)	(0.0134)	(0.0116)	(0.0141)	(0.0141)	(0.0117)
CRI	−0.0139	−0.0003	−0.0084	−0.0446***	−0.0218**	−0.0333***	−0.0109	0.0024	−0.0053
	(0.0182)	(0.0161)	(0.0152)	(0.0115)	(0.0090)	(0.0084)	(0.0109)	(0.0094)	(0.0085)
EDC	−0.0225	−0.0071	−0.0181	−0.0703***	−0.0409***	−0.0552***	−0.0325***	−0.0153	−0.0243***
	(0.0189)	(0.0187)	(0.0167)	(0.0114)	(0.0094)	(0.0085)	(0.0107)	(0.0098)	(0.0087)
RND	0.0849***	0.0558***	0.0658***						
	(0.0190)	(0.0185)	(0.0168)						
EEF				0.1474***	0.1033***	0.1210***			
				(0.0037)	(0.0035)	(0.0030)			
AEF							0.6448***	0.4378***	0.5224***
							(0.0105)	(0.0097)	(0.0081)
SIZE	0.0324***	0.0318***	0.0324***	0.0212***	0.0255***	0.0246***	−0.0061***	0.0074***	0.0025***
	(0.0014)	(0.0013)	(0.0012)	(0.0007)	(0.0007)	(0.0006)	(0.0008)	(0.0007)	(0.0006)
CFO	−0.0104	0.0011	−0.0035	0.0019	0.0054*	0.0035	−0.0076***	0.0033	−0.0013
	(0.0086)	(0.0069)	(0.0068)	(0.0031)	(0.0032)	(0.0027)	(0.0024)	(0.0028)	(0.0022)
CH	−0.0014	0.0014	0.0007	0.0084***	0.0096***	0.0090***	0.0105***	0.0099***	0.0102***
	(0.0055)	(0.0061)	(0.0054)	(0.0025)	(0.0030)	(0.0023)	(0.0020)	(0.0025)	(0.0019)
LEV	−0.0073***	−0.0032	−0.0046**	0.0017	−0.0009	0.0001	−0.0030***	−0.0029***	−0.0029***
	(0.0027)	(0.0023)	(0.0023)	(0.0012)	(0.0011)	(0.0009)	(0.0008)	(0.0008)	(0.0007)
AGE	−0.0413***	−0.0403***	−0.0383***	−0.0064**	−0.0115***	−0.0087***	−0.0005	−0.0051*	−0.0024
	(0.0057)	(0.0065)	(0.0053)	(0.0032)	(0.0028)	(0.0023)	(0.0027)	(0.0028)	(0.0022)
Intercept	−0.4667***	−0.5426***	−0.8697***	−0.6596***	−0.6695***	−1.0147***	−0.6710***	−0.7318***	−1.0619***
	(0.0291)	(0.0284)	(0.0257)	(0.0191)	(0.0158)	(0.0141)	(0.0140)	(0.0135)	(0.0116)
Firm years	2481	2481	2481	5927	5927	5927	6762	6762	6762
R^2	0.4682	0.4886	0.5589	0.6936	0.7007	0.7816	0.7418	0.7280	0.8071
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors are reported in parentheses.
***p < 0.01,
**p < 0.05, and
*p < 0.1 report the level of significance at various levels.

Table 6. Additional test with additional firm-level variables for Firm-level policy (EU)

Dep. var.	(1) FLX_1	(2) FLX_2	(3) FLX_3	(4) FLX_1	(5) FLX_2	(6) FLX_3	(7) FLX_1	(8) FLX_2	(9) FLX_3
BRX	−0.0627***	−0.0461***	−0.0550***	−0.0698***	−0.0501***	−0.0622***	−0.0519***	−0.0260***	−0.0394***
	(0.0092)	(0.0086)	(0.0075)	(0.0087)	(0.0062)	(0.0050)	(0.0066)	(0.0043)	(0.0032)
CRI	−0.0101	−0.0176**	−0.0154**	−0.0348***	−0.0244***	−0.0313***	−0.0150**	−0.0116***	−0.0140***
	(0.0103)	(0.0086)	(0.0078)	(0.0089)	(0.0041)	(0.0035)	(0.0072)	(0.0035)	(0.0031)
EDC	−0.0293***	−0.0321***	−0.0316***	−0.0514***	−0.0425***	−0.0475***	−0.0268***	−0.0240***	−0.0260***
	(0.0093)	(0.0075)	(0.0069)	(0.0074)	(0.0035)	(0.0031)	(0.0070)	(0.0034)	(0.0030)
RND	0.0417**	0.0511**	0.0469***						
	(0.0186)	(0.0199)	(0.0175)						
EEF				0.1245***	0.0968***	0.1082***			
				(0.0038)	(0.0048)	(0.0035)			
AEF							0.4744***	0.3786***	0.4270***
							(0.0087)	(0.0115)	(0.0082)
SIZE	0.0182***	0.0216***	0.0214***	0.0171***	0.0209***	0.0202***	0.0034***	0.0107***	0.0082***
	(0.0011)	(0.0012)	(0.0010)	(0.0006)	(0.0007)	(0.0005)	(0.0004)	(0.0003)	(0.0002)
CFO	0.0368***	0.0383***	0.0356***	0.0148***	0.0237***	0.0204***	0.0041	0.0019	0.0036
	(0.0074)	(0.0076)	(0.0067)	(0.0036)	(0.0041)	(0.0030)	(0.0027)	(0.0035)	(0.0023)
CH	0.0178**	−0.0042	0.0053	0.0275***	0.0002	0.0103***	0.0243***	0.0056	0.0117***
	(0.0078)	(0.0072)	(0.0068)	(0.0042)	(0.0042)	(0.0034)	(0.0032)	(0.0038)	(0.0027)
LEV	−0.0176***	−0.0100***	−0.0133***	−0.0002	−0.0015	−0.0010	−0.0017***	−0.0028***	−0.0022***
	(0.0031)	(0.0024)	(0.0025)	(0.0009)	(0.0009)	(0.0007)	(0.0007)	(0.0007)	(0.0006)
AGE	0.0020	−0.0020	−0.0029	0.0015	−0.0047***	−0.0044***	0.0025	−0.0057***	−0.0031**
	(0.0032)	(0.0030)	(0.0025)	(0.0025)	(0.0016)	(0.0012)	(0.0021)	(0.0017)	(0.0013)
GDPGR	0.0116	−0.0926*	−0.0556	0.0827***	−0.0393*	0.0073	0.0630***	−0.0582***	−0.0078
	(0.0742)	(0.0547)	(0.0490)	(0.0254)	(0.0201)	(0.0164)	(0.0214)	(0.0170)	(0.0146)
GDPPC	−0.0767	0.0221	−0.0080	−0.0708	0.0038	0.0076	−0.1660***	−0.0552***	−0.0707***
	(0.0598)	(0.0450)	(0.0335)	(0.0554)	(0.0165)	(0.0118)	(0.0444)	(0.0170)	(0.0121)
Intercept	−0.3592***	−0.5342***	−0.8140***	−0.5889***	−0.6568***	−0.9738***	−0.7096***	−0.7137***	−1.0691***
	(0.0185)	(0.0173)	(0.0160)	(0.0163)	(0.0156)	(0.0119)	(0.0130)	(0.0153)	(0.0101)
Firm years	8130	8130	8130	17,063	17,063	17,063	20,150	20,150	20,150
R^2	0.2466	0.2599	0.3520	0.1526	0.3413	0.5099	0.2446	0.4085	0.5957
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors are reported in parentheses.
***p < 0.01,
**p < 0.05, and
*p < 0.1 report the level of significance at various levels.

4.5 Additional robustness checks

We explore the impact of Brexit on firm-level volume flexibility using the Global Industry Classification Standard (GICS) as an alternative. We use the MSCI and S&P definition of GICS (see Panel B of Supplementary Table A2) to classify sub-sectors within the EU and UK goods industry in order to check their relative sensitivity to the risk of Brexit. Our results reveal that the volume flexibility across these categories is not equally sensitive to Brexit uncertainty. There is a significant firm-level difference in the magnitude of the adverse impact of output fluctuation and also firms' response to that fluctuation via the volume flexibility. For example, in Supplementary Table A4, within the UK goods industry, a firm's volume flexibility in energy, materials, consumer discretionary, and consumer staples sectors is significantly and negatively affected by the Brexit. In addition, the other UK sectors affected negatively and significantly by Brexit include automobiles, household goods, food producers, and food and drug retailers. The EU goods industry, on the other hand, was more widely affected by the Brexit than its UK counterpart. However, the depth of the negative impact on volume flexibility is much less than was the case for UK firms Results in Supplementary Table A5 show that the firm's flexibility in five different sectors has been negatively affected by the BRX shocks, but the coefficients only vary between –0.0609 and –0.0295. These five sectors are: materials, industrials, consumer discretionary, consumer staples, and IT. The BRX coefficients for each of these sectors are statistically significant at 99–90% levels of confidence. In Supplementary Table A6 we have shown the effect of Brexit on sales volume and sales growth. The results in the table shows clear negative impact of Brexit on both sales volume and sales growth for both UK and EU goods firms We also have tested the effect of Brexit on volume flexibity for both UK and EU goods firms using shorter time period (data from 2013 to 2018). Results are reported in Supplementary Tables A7 and A8. The results shows similar results that we obtained in our base line regression reported in Tables 1 and 2. In addition, we also have examined dynamic relationship using more firms level variables including investment. The results reported in Supplementary Tables A9 and A10 for UK and EU goods firms respectively are supportive to our earlier findings.

5. Discussion and conclusion

In this paper, we use the process-based volume flexibility measures of Jack and Raturi (2003) to examine the relationship between a major political development, Brexit, and manufacturers' responses to demand uncertainty. We find that the volume flexibility of both the UK and EU goods industry has been significantly and adversely affected by Brexit uncertainty, but the former was noticeably worse off than the latter, confirming our hypotheses 1a and 1b. However, larger firms were found to be more efficient in managing their volume flexibility (as measured by fluctuations in inventory and cost-of-goods-sold) and to remain profitable in the face of demand uncertainty (as measured by sales fluctuations). Both larger and smaller firms in the EU were successful in maintaining profitability by adjusting volume flexibility, but in the UK, this was only true for larger firms The latter might reflect that the EU firms have greater resources at their disposal, making it easier to cope, even if domestic institutions were less than supportive to the goods sector (c.f. Bailey and Tomlinson, 2017). Again, the profits of UK, and to some extent, continental European firms, were adversely affected. These results remain statistically robust with the ROA as an alternative measure of profitability. Our results exhibit a significant and positive association between flexibility and profitability: greater volume flexibility enhanced profitability. We found that, as per our second hypothesis, firms that invested more in R&D, provide training to improve management efficiency, and used innovations to improve asset efficiency coped better with Brexit shocks. In short, this suggests that both incremental and radical innovation may both promote volume flexibility; this is of significance, given that the existing literature suggests that CMEs are stronger in the former and LMEs in the latter (Witt and Jackson, 2016). In other words, within both systems, there are some complementarities that may help. However, based on our dataset, none of these factors could neutralise the negative impact; across Europe, the negative effects will be shared across nations and a wide cross section of firms, whilst in the UK, these effects would more concentrated. This study confirms that Brexit is likely to intensify the imbalances in the

UK economy, leaving orthodox—as adverse to speculation driven—areas of economic activity worse off (c.f. Rosamond, 2019). Indeed, although Brexit's proponents claimed that it would enable the nation to compete better globally, we found that EU goods firms were more outward looking than their UK counterparts. The effects of the Covid-19 may further exacerbate these tendencies, leading to further divergence in the fortunes of goods firms between the EU and their UK counterparts; in turn, this may encourage further policy divergence, given variations in the relative national influence of different sectors.

The study provides additional insights on the comparative effects of institutions. Existing theoretical work suggests that continental European firms will be more long-termist, and, accordingly, more asset and employment heavy (Walker *et al.*, 2019). In contrast, UK firms are likely to be more closely orientated to short-term returns; an intensification of this emphasis has led to downsizing and the breakup of firms (ibid.). These different orientations may help explain why continental European goods firms coped better. Nonetheless, UK firms tend to spend more on R&D; this may reflect the UK's advantage in "blue sky" rather than incremental innovation, in turn a product of institutional incentives and capital availability (Schmidt and Kwon, 2020). Indeed, this, as well as employee efficiency and assets efficiency, seemingly contributed to mitigating the observed negative effects of Brexit. Institutions operate at supranational, national and subnational levels (Wood and Allen, 2020). Although the effects of the former are often underestimated, it is evident that Brexit has resulted in a much more powerful shock on the UK goods industry than the preceding financial crisis; the prospect of losing coverage of European institutions seems particularly adverse for the goods sector. This is possibly because, despite their strengths in specific areas, UK national institutions are less than supportive of manufacturing (Walker *et al.*, 2019). European institutions and associated rules may have mitigated these negative effects; hence, the prospect of losing them may have posed particularly severe challenges for the goods industry. Hence, Brexit may have the effect of accentuating the negative effects of existing UK institutions on the goods sector, even if it is possible that within other areas of the economy, such as financial services, it may hold some advantages (O'Reilly *et al.*, 2016). Indeed, rather than providing space for fresh departures, Brexit may have contributed to reinforcing the UK's existing trajectory, associated with a decline in the goods sector, albeit with some persistent advantages in R&D-intensive areas of activity.

This raises important policy questions. The first is whether Brexit may encourage UK based firms to take their local customers and suppliers more seriously, moving away from arms-length contracting to much closer relations (c.f. Jackson and Deeg, 2019). In other words, even if the scope of customers and suppliers may have diminished, it may help promote inward orientated development (Hinds, 2020). In other words, greater barriers to trade with Europe might have protectionist consequences, as indigenous firms face less competition and have incentives to secure supplies locally, leading to benefits down supply chains; closer proximity to suppliers may facilitate a return to just in time inventory systems On the one hand, we have seen that firms who are invest in managerial capabilities and R&D may cope better, and, indeed, it is possible that they may benefit most from such opportunities. On the other hand, manufacturing across Europe has over the decades become ever more capital intensive, and this limits opportunities to substitute suppliers with those closer to home. Moreover, Brexit's protectionist effects are about trade with Europe; removing British firms from the constraints of European regulators has gone hand in hand with the embracing of globalization, even tempered with an imperial-nostalgic embracing of the Anglosphere (Dent, 2020). Indeed, it is perhaps significant that some of the most vociferous proponents of "British" manufacturing have been those firms that have outsourced production to the Far East either generally (eg Dyson) or have become more reliant on Chinese supply chains (eg JCB).

Moreover, given we found that UK firms were already more inward looking than their European counterparts, the scope for further advantages from the promotion of inward orientated growth may be limited. Secondly, there is the question of unforeseen risks emerging as a result of Brexit disruptions to trade (Connolly and Judge, 2018). Whilst our study focuses on firm level outcomes, we accorded only limited attention to coping strategies to disruptions to trade and supplies. A spectacular recent fire at a chemical manufacturer in the British Midlands (2021), which was widely reported in the international press, may have at least been exacerbated by

a possible large stockpiling of raw materials to cope with Brexit delays. Although the policy focus to date has been on providing immediate assistance to firms and ways of easing logistics bottlenecks, such events might suggest that policy attention should also consider the unforeseen consequences from such coping strategies. Thirdly, there is the extent to which firms can and should be compensated for and/or supported through Brexit disruptions. Previous survey evidence suggests that UK SMEs fear that this may be seen as suggesting they are riskier outlets for investment, starving the of capital (Brown *et al.*, 2018; Salder, 2019); government measures to facilitate access to credit may help firms make the necessary investments in R&D and managerial skills that may mitigate Brexit's effects.

As with any scholarly endeavour, this study has certain limitations. Above all, it may simply be too soon to reach any definitive conclusions as to Brexit's consequences, and a replication of this study five years onwards may provide rather different results; indeed, documenting such changes over time may be a worthwhile endeavour. Secondly, although institutions may impact on the ability of firms to cope, institutional arrangements are themselves subject to change, and, indeed, political developments may help impel the latter. The rise of populism in the UK and elsewhere will have significant consequences for institutions and what they do. Populism's funders may be investing in it to suit their financial interests, but in turn, this will have impacts on other firms across the economy. Again, firms that support Brexit may do so for very specific reasons, for example, to increase the relative advantages of outsourcing production to China vis-à-vis their European competitors that do not. In turn, this may reshape the contours of the UK goods industry. We do not investigate the consequences of those goods firms that may have invested in Brexit with the intention of winning from it, and how they anticipate doing so, but this may be an important factor in mitigating Brexit's consequences. Again, this is beyond the scope of the study, but may represent important factors in helping explain why some goods firms may cope with Brexit than others. In short, these reflections make a further case for longitudinal research on the consequences of unforeseen or at least poorly prepared for systemic shocks (c.f. Phan and Wood, 2020), and in taking greater account of politics in exploring the relations between institutional dynamics and firm level practices (c.f. Mildenberger, 2020).

Moreover, as the literature on comparative capitalism alerts us, certain sets of national institutional configurations may be more beneficial to specific industries than others (Hall and Soskice, 2001; Crouch *et al.*, 2009; Butzbach *et al.*, 2020). The LME model is particularly conducive to certain areas of industry (eg financial services, pharmaceutics and tech), whilst the CME model is generally held to be more supportive to firms in the goods industry (Crouch *et al.*, 2009; Butzbach *et al.*, 2020). UK goods firms may lose out even more as a result of post-Brexit deregulation, and/or benefit from less competition from continental European competitors on the home market, which may, in turn, may at least partially recompense for more difficult access to European markets. Other sectors are likely to fare very differently, and indeed, a comparison of the effects of Brexit across the economy as a whole would help shed light on whether this event will contribute to the diversification or the narrowing of the UK economy, with theoretical implications in terms of how we understand the LME model. This would represent an important avenue for future research. Furthermore, a comprehensive dynamic analysis including further interactions of profitability, innovation and business strategies with Brexit would shed more light on the eventual effect of Brexit. Future research could take this opportunity to exapand the insight on Brexit.

Again, Brexit is only one of a number of major systemic shocks that Britian has undergone in recent years: others would include the 2008- financial crisis, and, indeed, the 2019- Covid-19 pandemic. A comparative exploration of the effects of these shocks on the UK goods industry would help shed light on its relative comparative advantages and disadvantages, especially as these other events lack the same protectionist consequences as Brexit. Again, we have looked at European firms as a composite category. A comparison of the relative fortunes of goods firms from CMEs in relationship to those from more peripheral European economies would help shed further light on the relative advantages and supports the CME model confers on indigenous firms when confronted with disruptions in accessing key overseas markets.

Supplementary data

Supplementary materials are available at *Industrial and Corporate Change* online.

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