The impact of the Digital Markets Act on innovation

Helping or hindering innovation and growth in the EU?

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1 Executive summary

The European Commission is planning a Digital Markets Act (DMA). Oxera's research has found that the Commission's proposals—so far as they can be discerned from the consultation process—risk reducing innovation overall. In turn, this will lead to lower economic growth and harm European consumers.

The proposed DMA includes an ex ante regulation tool. The scope of this tool would be limited to large platforms with 'significant network effects acting as gatekeepers'. This report assesses the potential consequences of this regulatory tool.

The Commission's reasons for proposing ex ante regulation

The Commission's main concerns, as expressed in the Inception Impact Assessment (IIA) for the proposed ex ante regulation, appear to be that:

1. the existence of large online 'platform ecosystems' makes it difficult for smaller digital platforms to bring their innovations to consumers because these 'platform ecosystems' are 'incontestable'; and

2. because the large platforms determine 'the parameters of future innovation, consumer choice and competition', European platforms are hampered in their ability to grow, which leads to a risk of 'reduced benefits from social gains deriving from innovation'.

At this stage of the consultation, the Commission has not been clear about which practices might be affected. Examples of such practices set out in the IIA include certain forms of differentiating among downstream competitors by platforms and 'acceptance of supplementary commercial conditions' that 'have no connection with the underlying contractual relationship'. However, we note that these are only two examples; other practices could be included, such as imposing restrictions on lines of business that would prevent the largest platforms from entering some new markets, or obligations to share with rivals data or details of algorithms. These restrictions would apply only to the platforms that are found to be 'gatekeepers' (a concept that the Commission has yet to formally define).

Ex ante regulation is likely to reduce, not increase, innovation

As a package, the Commission's ex ante regulation proposals would directly and indirectly reduce the ability and/or incentives of global platforms to provide innovative products to consumers. For example, prohibitions on bundling or adjacent market entry would directly reduce the ability of global platforms to innovate by offering new products and/or services to consumers. Similarly, obligations to share data with competitors might reduce these platforms' incentives to innovate due to the reduced gains from their innovations.

The potential costs of this lost innovation do not appear to have been considered in the IIA. Indeed, the Commission appears to expect positive impacts on innovation as a result of 'increased competition brought by alternative online platforms'. The implicit assumption seems to be that these alternative online platforms will bring significant innovation and this will compensate for any reduced innovation by larger platforms.

However, this is not likely to be the case, for the following reasons.

- In some markets, the global platforms will be potential entrants. The literature suggests that entrants often bring 'drastic' or transformative technologies or innovations to new markets. Thus, restrictions on adjacent market entry by global platforms may deprive consumers of significant benefits from innovation.

- Smaller platforms, which are motivated to innovate in the hope of becoming the 'next big thing', would face lower incentives to innovate if they anticipate that their success will be accompanied by significant regulation and a reduction in the value of the 'prize' of success. This is captured in the literature through the trade-off between appropriability and contestability.

- To the extent that ex ante regulation aims to replace innovation by global platforms with innovation by smaller local rivals, it fails to take account of the positive influence of market size on innovation incentives. Firms' innovation efforts are driven, in part, by access to larger global markets.

- While small firms can and do innovate, sometimes providing important drastic innovations, it is far from certain that, at a practical level, they can fill any void left if global platforms were to cut back on their innovation efforts. Indeed, the Commission itself has acknowledged this in the context of several mergers.

Therefore, the proposed regulations are likely to reduce overall innovation by platforms operating in Europe. This will harm consumers in the EU because innovation brings significant benefits: first, it is the *only* source of growth in output per worker over the long run, which in turn is *the* driver of long-run consumer income growth; second, numerous innovations have proved to be transformative by providing important social benefits.

The benefits of innovation to society

Innovation provides clear benefits to society:

- the economics literature stresses that innovation is the only driver of long-term economic growth in output per worker. Less innovation therefore means lower economic growth, which would harm the long-term interests of EU consumers, businesses, and other stakeholders;

- tangible social benefits are provided over and above general economic progress, generating crucial advances and improvements across society that we often take for granted. Policies that undermine innovation therefore also risk limiting our ability to improve society overall.

Innovation strategy and asymmetries between firms

The literature does not, in general, show that smaller firms are disincentivised from innovation by the presence of global platforms. Theoretical models of competition between incumbents and entrants tend to show that incumbents have incentives to pursue incremental innovations that improve current products or processes, allowing them to increase sales and profits over their existing volumes. By contrast, potential entrants, lacking a large base of existing sales in the relevant market, have stronger incentives to pursue disruptive innovations that will make current products and production processes obsolete.

Consumers benefit from both incremental and disruptive innovations; an incremental innovation benefit, when spread over a large existing customer

base, can be just as valuable in welfare terms as a drastic innovation by a market entrant.

While, in some markets, the global platforms are in the position of the incumbent, in many others, they are potential entrants and are more likely to enter such new markets via disruptive innovation. If ex ante regulation deters large platforms from entering new markets, this would deny consumers in these markets the benefits of potentially significant and ground-breaking innovation. In other markets where the global platforms are the incumbents, reduced incremental innovation as a result of ex ante regulation would lead to lower consumer welfare unless there is a very large increase in innovation by non-regulated new entrants to compensate for the loss. However, the threat of future regulation would also reduce the incentives of non-regulated entrants to engage in significant innovation. The IIA does not consider these trade-offs.

Drastic innovation is incentivised by the prospect of winning a large 'prize' in terms of market leadership. As we discuss below, the measures proposed in the ex ante regulation would lead to a smaller prize for successful market disruptors, and so lower levels of drastic innovation and economic growth.

Innovation and competition

Innovation is an inherently risky activity. Some R&D projects will lead to new products or production processes, while others will not. Some new products will receive a positive reception from the market and 'take off' (e.g. online shopping), while others will struggle (e.g. Google Glass or the Amazon Fire Phone). In order to take the risk of investing in an R&D project, a firm must believe that it has a good enough chance of at least recouping its upfront investments.

The economics literature suggests a complex relationship between competition and innovation. While rivalry and competition spur firms to innovate, firms do so because innovation will allow them to differentiate from or get ahead of their rivals and thus attract more sales. The literature suggests that innovation will be promoted to the extent that:

1. future sales in the market are 'contestable'—it is possible for an innovator to compete for the future sales in the market;
2. the value of an innovation is 'appropriable'—an innovator can capture a sufficient proportion of the value of their innovation to justify their initial investment in the innovation.

This creates a policy trade-off, as measures to increase the contestability of sales in the future are also likely to reduce the perceived appropriability of the value of future innovations by potential innovators.

This trade-off does not appear to be recognised in the IIA, as the Commission focuses on contestability and does not consider the likely impact of reducing appropriability.

Moreover, ex ante regulation targeted at global platforms can be expected to affect the incentives of their smaller rivals. Smaller firms innovate, in part, in the hope of becoming the 'next big thing'. If they anticipate that this will come with additional burdensome regulation, the value of that prize will fall and less effort will be expended to innovate. If this effect outweighs any increase in contestability of the markets where these small firms might innovate, then ex ante regulation would discourage innovation by all firms—large and small.

Innovation and market size

In addition to ignoring the potential effects of reducing appropriability, the IIA does not consider the impact of market size on incentives for innovation.

Market size has a positive effect on innovation. It is easier to recoup the fixed costs of R&D projects if one is selling into a larger market, as these costs can be spread over more units. This observation offers more reason to question the Commission's expectation that innovation by global platforms can be replaced by innovation by smaller rivals. While the EU is a large market, the rest of the world is far larger.[1] The EU market alone may not provide local digital platforms with sufficient incentive to innovate. The result could be that European consumers and businesses are denied the benefits of some innovations, whereby the innovation either does not happen at all, or happens outside the EU and cannot be rolled out in the EU due to ex ante regulation.

While the Commission might expect that ex ante regulation of global platforms will give EU firms space to develop the next big innovation that will go on to be successful globally, such regulation may well reduce the likelihood of this outcome. As we explained above, regulation may create enough uncertainty about the appropriability of such an innovation that incentives for EU firms to innovate would be lower.

Lessons from the economics literature on mergers and innovation

The above considerations demonstrate that small firms have the ability and incentive to undertake innovation—indeed, they might be the source of important innovations in some instances. However, at a practical level, it is far from certain that smaller rivals to large firms would systematically fill the void resulting from the latter's reduced innovation. Evidence of this comes from the literature around mergers. When two firms merge, if nothing else were to change (i.e. there are no synergies), we might expect a reduction in their innovation efforts. This is because if either firm successfully innovates, the new product will cannibalise the sales made by their merging partner. The economics literature suggests that other firms in the market may respond by increasing their innovation efforts, but not by enough to compensate for the lost innovation by the merging parties. In this case, overall, innovation would fall.

These models have been influential in recent European Commission merger decisions, and have formed part of the reasoning for clearing mergers, but only conditional on the divestment of important R&D facilities, in order to preserve innovation competition.

There are clear parallels between a situation in which innovation by large firms is reduced due to them merging, and a situation where innovation by large firms is reduced by ex ante regulation. The Commission's reasoning in merger decisions reveals concern that increased innovation by smaller rivals would not compensate for innovation lost as a result of the merger. This appears to be inconsistent with the IIA, where the Commission suggests that holding back the largest platforms will be more than outweighed by smaller platforms innovating more.

[1] The EU represents around 16% of global GDP (see https://www.statista.com/statistics/253512/share-of-the-eu-in-the-inflation-adjusted-global-gross-domestic-product/#:~:text=In%202018%2C%20the%20share%20of,to%20an%20estimated%2016.28%20percent Accessed 16 November 2020).

Conclusions

Innovation is the only source of long-term growth in output per worker, and as such it is crucial for the economic welfare of EU citizens. The relationship between innovation and competition is complex; rivalry between firms is essential for innovation, but so is the prospect that firms will earn a return on their innovative efforts. The economics literature describes this complex relationship through the concepts of contestability and appropriability.

The proposals to target global platforms with ex ante regulation are focused on contestability, to the exclusion of their potential impact on appropriability and market size. They also ignore the potential trade-offs between these innovation drivers. This is likely to lead to the unintended consequence of reduced innovation overall—to the detriment of European consumers and businesses.

2 Introduction

We first set out the context of this report and the Commission's proposals. We then offer some preliminary comments on what appears to be a crucial assumption for the Commission which, although outside the scope of this report, merits some question. Finally, we outline the structure of the report.

2.1 The Commission proposals

As part of the Digital Markets Act (DMA), the European Commission has proposed a series of measures. These include an ex ante regulation package and a New Competition Tool (NCT) that would allow it to intervene in markets, imposing behavioural or structural remedies, even if there is no alleged breach of Articles 101 or 102 TFEU.

The precise form of these regulations remains unknown, but the Inception Impact Assessments (IIAs), published on 2 June 2020, provide a key source of information. The IIA for the ex ante regulation contains some proposals which, if implemented, would represent improvements on the status quo. For example, given that digital commerce (by its very nature) crosses borders, it is appropriate for the Commission to be concerned about the possibility of regulatory fragmentation, and to highlight the need for the EU to safeguard the functioning of the digital single market. To that end, a dedicated regulatory body at the EU level could reduce the transaction costs of operating digital platforms across multiple jurisdictions.

In other areas, the IIA highlights concerns that the presence of large online platforms in the digital arena may lead to slower innovation:[2]

> Many innovative digital firms and start-ups find it difficult to bring innovative solutions, including innovative alternatives to these large online platforms, to the consumer, in particular in view of the existence of an increasing number of 'online platform ecosystems' that these large online platforms operate.

According to the IIA, the Commission appears to believe that the presence and size of the large online platforms hampers smaller potential rivals from innovating, bringing their product to market, and scaling their offering.[3]

> A small number of large online platforms increasingly determines the parameters for future innovations, consumer choice and competition. Consequently, Europe's estimated 10 000 online platforms are potentially hampered in scaling broadly and thereby contributing to the EU's technological sovereignty, as they are increasingly faced with incontestable online platform ecosystems. This leads to a risk of reduced benefits from social gains deriving from innovation.

The Commission's concerns around innovation and large digital platforms appear to be that:

1. the existence of large online 'platform ecosystems' makes it difficult for smaller digital platforms to bring their innovations to consumers because these 'platform ecosystems' are 'incontestable'; and

2. the large platforms determine 'the parameters of future innovation, consumer choice and competition', thus potentially European platforms are

[2] European Commission (2020), p. 2.
[3] Ibid.

'hampered' in 'scaling broadly', leading to a risk of 'reduced benefits from social gains deriving from innovation'.

2.2 Preliminary comments

The IIA appears to be built upon assumptions that may well not hold.

First, although not the focus of our report, we note that the Commission has so far not provided any evidential support for its view that online platform ecosystems are incontestable.

In the economics literature, Evans and Schmalensee (2002) point out that economic models describing innovation as a patent race have given the misleading impression that the new economy consists of stable monopolies.[4]

> While it is true that network effects tend to reinforce leadership positions, in many high-technology industries there are multiple, sequential races for market leadership. Major innovations occur repeatedly, and switching costs and lock-in do not prevent displacement of category leaders by better products […] It is not atypical for a fringe firm that invests heavily to displace the leader by leapfrogging the leader's technology.

The authors go on to discuss how the erstwhile market leaders in word-processing, spreadsheets, personal finance software and high-end desktop publishing have lost out to challengers. Other examples of successfully contested digital technologies are described in Box 2.1.

[4] Evans and Schmalensee (2002), p. 10.

Box 2.1 Successfully contested digital markets

A prominent and timely example of a successfully contested digital market with network effects is videoconferencing software, which is a digital platform and one that can be part of an ecosystem. It will also be the subject of network effects, as a particular piece of videoconferencing software will be more desirable the more other people are using it.

One of the first software platforms to enable videoconferencing was Skype, released in 2003. Skype was so successful that the word was included as a verb in several English dictionaries. Eventually, in 2011 Microsoft acquired the platform and incorporated it into its suite of products, rebranding its own messaging and videoconferencing service (Lync) as 'Skype for Business'. This gave the brand a presence in both the consumer and business segments of the market. Prior to the challenge from Zoom in the business user segment, Skype also faced competition in the consumer market segment from mobile device videoconferencing offered by WhatsApp, Apple Facetime and others.

After Zoom was launched in 2013, it relatively quickly established a significant market share, reaching 40m users by 2015.[5] As remote working became necessary in 2020 due to the COVID-19 pandemic, Zoom saw 300m daily meeting participants.[6] Although comparisons are difficult due to firms reporting different metrics, the available data appears to show that Zoom's popularity during the pandemic has been at least as high as that of Microsoft, even when users of Microsoft's newer product, Teams, are also taken into account.[7]

The lesson from Zoom's entry is that digital platforms with network effects are contestable if an entrant innovates with a better product. Here the contestability might have been assisted by the ease with which consumers can multi-home (i.e., use more than one platform). Intuitively, multi-homing makes markets more contestable because it reduces the risks associated for consumers and businesses with trying a new platform.

Source: Oxera.

Second, the Commission's assumption that innovation would not be harmed, or even might increase, as a result of the ex ante regulations measures ignores several important trade-offs. Our report focuses on exploring these trade-offs and how they relate to the likely impact of the ex ante regulation on EU consumer welfare and long-term economic growth per capita.

2.3 Structure of this report

This report surveys the economics literature on the drivers of innovation, to examine whether restricting the business lines and behaviours of large firms (beyond existing digital regulations) is likely to lead to more or less innovation.

- Section 3 briefly discusses the benefits of innovation and highlights particular innovations that have made dramatic improvements to safety, social equality, and business models.
- Section 4 reviews the literature on innovation as a tool of strategic competition when there are asymmetries between the firms in terms of size and incumbency.

[5] See https://www.businessofapps.com/data/zoom-statistics/ accessed 16 November 2020.
[6] See https://www.businessofapps.com/data/zoom-statistics/ accessed 16 November 2020. Daily meeting participants and daily active users are two different measures of usage for online meeting software. Daily active users counts the number of people who used the software at least once in a given day, while meeting participants counts the number of participants in meetings over the day. The latter measure is typically larger because an active user is likely to take part in more than one meeting.
[7] Skype and Teams report 40m and 75m daily active users respectively, while Teams had 200m meeting participants on one day in April 2020 (see https://uk.reuters.com/article/uk-zoom-video-commn-encryption/zoom-says-it-has-300-million-daily-meeting-participants-not-users-idUKKBN22C1IX, and https://uk.reuters.com/article/uk-zoom-video-commn-encryption/zoom-says-it-has-300-million-daily-meeting-participants-not-users-idUKKBN22C1IX both accessed 16 November 2020). Converting Skype's 40m daily active users into daily participants at the same rate as Teams (75m daily active users and 200m daily meeting participants) would suggest approximately 106m daily participants for Skype. This would put the combined Microsoft suite of meeting software on a par with Zoom in terms of size. By comparison, Google Meet reports approximately 100m daily meeting participants (see. https://www.theverge.com/2020/4/29/21240942/google-meet-free-zoom-response-microsoft-teams-features accessed 16 November 2020).

- Section 5 reviews the literature on the economic drivers of innovation, and draws out the trade-offs in competition policy related to innovation.
- Section 6 reviews the influence of market size on innovation decisions and outcomes.
- Section 7 considers the evidence from mergers where attention has been paid to whether other firms can fill the void created when large incumbent firms may reduce their innovation efforts.
- Section 8 surveys the emerging experimental literature on innovation and competition.
- Section 9 concludes.

3 The benefits of innovation

Innovation plays a central role in modern economies. Technological progress not only fuels economic growth by increasing productivity, but can also contribute to a more inclusive and safer society. The economics literature is virtually unanimous on the biggest benefit of innovation—that it is the only driver of per-capita economic growth in the long term.

3.1 Innovation drives economic growth over the long term

Almost all introductions to macroeconomics discuss the importance of growth as a factor affecting individual levels of income. By increasing the size of the 'pie' to be distributed among individuals in an economy, growth raises the average income per capita and contributes to substantial reductions in the world's poverty rates.[8] Early macroeconomic models, seeking to identify the source of long-term economic growth, traced it back to technological progress (innovation). For instance, Solow (1956) and Swan (1956) demonstrated that there would be no long-term growth in output per worker without technological progress.[9] However, while these models explain that growth comes from innovation, they do not explain what causes innovation.

Given the importance of innovation to explain long-term growth, economists directed their efforts towards models that capture explicitly the drivers of innovation. This strand of the literature is called 'endogenous growth theory'.

3.2 Endogenous growth theory

Endogenous growth models explore the relationship between innovation and growth in detail. In these models (such as Romer, 1990), R&D activity by firms takes place in a dedicated market for ideas that rewards the leader of a patent race with significant ex post profits for the invention. As a result, the growth rate of the economy remains positive as long as it does not run out of ideas. In other words, innovation benefits the economy as a whole by fuelling growth over the long term.

For an economy, expenditure on R&D has the same quality as an investment in capital. It represents forgone consumption today that leads to more or better consumption tomorrow. Through this insight, the social return on innovation can be measured and compared to its optimal level to see whether actual R&D investment is too high or too low (see Box 3.1). This analysis shows that consumers derive significant benefits from innovation, but would be even better off if innovation efforts were to increase.

[8] For an empirical study of the evolution of world incomes and poverty rates, see Sala-i-Martin (2006).
[9] In the model, capital per worker depreciates as machines wear out, but increases as the economy's output is invested in capital rather than consumed. Eventually, capital per worker reaches a steady state where investments in capital just match depreciation. Output per worker is driven by capital per worker, so it also comes to a steady state at this point. Technological progress and the population growth rate explain why modern economies continue to experience growth even after reaching a steady state. These two elements are 'exogenous' in these models, meaning that they are determined outside the model, which takes their values as given.

Box 3.1 Social returns to R&D activity

Jones and Williams, in their 1998 paper, measure the social return to R&D, which they define as the additional unit of future consumption induced by an additional unit of R&D investment. The existence of this social return to R&D is generated by the intertemporal allocation of resources. As the authors explain, if instead of consuming one unit of output in the current time period it is invested in R&D, then the social return to R&D corresponds to the additional units of consumption generated in the next period by that R&D investment.

The social rate of return to R&D can be used to evaluate whether R&D investment levels are optimal. R&D investments are optimal when the social rate of return is equal to the real interest rate. Jones and Williams found that R&D investments in the USA were suboptimal and calculated that optimal investment in research should be at a level more than four times higher than actual investment.

Source: Jones and Williams (1998).

3.3 Examples of benefits from innovation

It is easy to take for granted the way that innovations have contributed to the transformation of society. Below are examples of market-driven innovations that have brought about other important social benefits. While innovation increases macroeconomic output, it also has the potential to change the way we live our lives for the better. In particular, we reflect on the wider impacts of:

1. the washing machine;
2. the three-point seatbelt;
3. the flat-pack furniture business model;
4. voice-recognition technology.

3.3.1 The washing machine

One historical innovation that played a significant role in transforming society is the washing machine. Along with other household appliances, the washing machine significantly reduced the workload and drudgery of household chores. This has the effect of liberating the time spent (i.e. labour hours) on domestic housework towards other work (such as the labour market).

The first automated washing machine, the Bendix, was introduced in 1937.[10] It is estimated that the washing machine reduced the time required to wash a 17kg load of laundry from 4 hours to 41 minutes—a sixfold reduction.[11] The washing machine was one part of a broader automation of household tasks. Estimates suggest that the washing machine and similar inventions led to the time spent on domestic production by an average household in the USA falling from 58 hours a week in the 1900s to 18 hours a week in 1975.[12]

Some economists have found that the significant time reduction required for domestic household production played a key role in the upward trend in female labour market participation observed in the USA after the 1940s.[13] The increased female labour force participation in the economy provided the conditions for other important social transformations in the USA, such as increases in female education levels and in women's earnings relative to those of men.[14]

[10] https://speedqueeninvestor.com/history-of-the-washing-machine
[11] Greenwood et al. (2005), p. 112.
[12] Ibid., p. 113.
[13] See ibid., and Goldin (2006).
[14] Goldin (2006).

3.3.2 Three-point seatbelt

The three-point seatbelt is one of the key innovations that improved automobile safety.[15] The iteration of the seatbelt installed in all modern-day vehicles was invented in 1959 by Nils Bohlin while working at Volvo. With more than 300m motor vehicles in use in the EU in 2018,[16] the safety-enhancing seatbelt is an important innovation which has saved lives.

Volvo estimates that the three-point seatbelt has saved over 1m lives since its introduction in 1959.[17] According to the European Transport Safety Council, the use of seatbelts is estimated to reduce the probability of fatality in traffic accidents by approximately 50%.[18] In a 2008 working document, the European Commission considered the non-use of seatbelts as one of the three main 'killers' on the road, estimating that non-use of seatbelts resulted in 17% of road deaths.[19]

3.3.3 Flatpack furniture

Flatpack furniture is furniture sold unassembled and in flat parts, as opposed to being sold as a finished product.[20] The consumer assembles the furniture after purchase, typically without the need for special tools.[21] The flatpack furniture innovation introduced a low-cost option into the market so that functional furniture was not the preserve of the wealthy.

The flatpack business model achieves cost savings because the compact flatpack design allows a larger number of products to be stacked efficiently in a given space. This generates significant cost savings in transportation, distribution, and storage of flatpack products.[22] Flatpack also allows the outsourcing of the furniture assembly costs from the manufacturer's supply chain onto the consumer.[23] Behavioural economists also find that consumers value their purchases more because they assembled them themselves. This phenomenon has been termed the 'IKEA effect'.[24]

[15] The three-point seatbelt is a restraint on the upper torso that functions by preventing occupants from being thrown about the interior of the car or thrown out of the car in the event of a vehicle accident. If worn properly, it also spreads the stopping force across the occupant's pelvis and rib cage—two of the more sturdy parts of the body—which in turn minimises the impact on other parts of the body.
[16] Estimates according to the European Automobile Manufacturers' association. https://www.acea.be/statistics/tag/category/key-figures, accessed 27 July 2020.
[17] https://www.media.volvocars.com/uk/en-gb/media/pressreleases/20505, accessed 27 July 2020.
[18] European Transport Safety Council (2006), p. 19.
[19] European Commission (2008).
[20] Flatpack furniture is also referred to as ready-to-assemble (or RTA), knock-down, self-assembly and kit furniture.
[21] Although flatpack furniture is commonly associated with IKEA, records of flatpack furniture designs date back as early as the 1850s. Many consider Michael Thonet's No. 14 bentwood chair built in 1859 as one of the early forms of the flatpack furniture concept. The chair was manufactured and transported in separate parts before being assembled in store. Another early form of flatpack furniture was Louise Brigham's 'Box Furniture' design in 1909. Louise designed furniture that could be assembled entirely from skeletons of packing crates. In 1951, Erie Sauder, the founder of Sauder Woodworking Company, also designed a table that could 'snap together' without either hardware or glue. https://www.sauder.com/about/about-sauder, accessed 27 July 2020.
[22] Spinney, Reimer and Pinch (2017), chapter 7.
[23] In Kuwait, IKEA provides the option to assemble the furniture for the customer at a rate of 5% of the purchase value.
[24] Norton et al. (2012).

Box 3.2 Flatpack furniture and IKEA

The most successful of the flatpack furniture manufacturers is IKEA. In 2019, IKEA operated 433 stores worldwide and made over €40 billion in retail sales.[25] This represented more than 5% of the global furniture market in 2019.[26]

While IKEA did not invent the concept of flatpack furniture, it has become the brand most associated with this product in most consumers' minds. It has supplemented the original innovation with several complementary innovations of its own, and built a brand around the combined package. So the value of the original innovation has been enhanced by a relative latecomer to the market.

Source: Oxera.

3.3.4 Voice-recognition technology

A more recent innovation which not only offers productivity improvements but also generates social benefits by promoting inclusivity is voice-recognition technology. First developed in 1952, this technology has improved significantly with the advances in software technology and computing power.[27] It allows people to interact with computers using voice commands rather than traditional keyboards, mice and monitors, which frequently require users to see and read text. This technology is now preinstalled in all modern smartphones and smart speakers, and is increasingly prevalent in consumer products, home appliances and the workplace.[28]

Voice-recognition technology, by bringing about convenience to our daily lives and improving the user experience of various products, has the potential to generate productivity and welfare improvements for society. In addition, it fosters the added social benefit of promoting inclusivity for people who are physically disabled, visually impaired, or illiterate.[29] [30] For example, products with voice/speech recognition can enhance the daily lives of visually impaired people by allowing them access to online information and media,[31] and supporting their learning and development.[32]

[25] Inter IKEA Group Financial Summary FY19. https://weu-sc93-prd-858086-cdn-endpoint.azureedge.net/-/media/interikea/igi/financial-reports/inter-ikea-group-financial-summary-fy19.pdf?rev=5ddb623c142144ac810f6d31a5a5e472, accessed 17 November 2020.
[26] The global furniture market size was estimated to be USD 609.7 billion (or around 544.5 billion Euros based on 1 USD being approximately worth 0.8931 EUR in 2019, see https://www.exchangerates.org.uk/USD-EUR-spot-exchange-rates-history-2019.html). https://www.gminsights.com/industry-analysis/furniture-market, accessed 17 November 2020.
[27] The 'Audrey' system developed in 1952 by Bell Labs is considered to be the first speech-recognition system. It could only recognise digits. https://www.pcworld.com/article/243060/speech_recognition_through_the_decades_how_we_ended_up_with_siri.html, accessed 27 July 2020.
[28] For example, Microsoft has integrated its speech-recognition system (Cortona) into Microsoft Teams. https://techcrunch.com/2018/03/12/microsoft-teams-will-integrate-with-cortana-add-transcription-and-translation-features/, accessed 27 July 2020.
[29] Estimates put the number of blind or partially sighted people in Europe over 30m, see: http://www.euroblind.org/about-blindness-and-partial-sight/facts-and-figures#:~:text=Statistics,sighted%20persons%20as%20blind%20persons, accessed 27 August 2020.
[30] The EU's adult illiteracy rate of approximately 0.87% in 2016 translates into a relatively large minority given the EU's large population. See https://fred.stlouisfed.org/series/SEADTLITRZSEUU, accessed 27 August 2020.
[31] https://www.rnib.org.uk/about-us/media-centre/latest-media-releases/RNIB-teaches-Alexa-to-give-sight-loss-information, accessed 27 August 2020.
[32] For example, Bouck et al. (2011) observed an increase in efficiency and independence in the completion of computational problems by visually impaired high school students when using calculators with voice input, speech output functions.

4 Innovation strategy and asymmetries between firms

In this section, we focus on models that explicitly consider asymmetries in size and incumbency between rival firms and how that affects innovation strategies. There are two results from this literature that are relevant to the issues being considered in respect of the proposed ex ante regulations:

1. market leadership may confer some advantages in innovation races, but these advantages are not insuperable and innovation races might still be won by smaller rivals (section 4.1); and

2. entrants and incumbents tend to pursue different innovation projects, with entrants typically targeting drastic innovations, while incumbents typically target incremental innovations (section 4.2).

Before expanding on these points, it is important to note that the relevant asymmetries in the innovation literature refer to the different positions of the firms in the market where the innovation project is being considered. So, while a new entrant in a market may be larger than the incumbent firms in terms of certain measures of size (e.g. market capitalisation), it is entirely possible that this entrant has a smaller customer base in this market.

The large global platforms that are likely to be within the scope of ex ante regulations will be incumbents in some markets, but there are many other markets where they are (potential) entrants. These are often the markets where large digital platforms are at their most innovative as innovation is their means of entry.

4.1 The advantage of market leadership

The literature suggests that whether entrants or incumbents drive innovation in a market depends on a number of factors, including the degree of uncertainty involved in the discovery and innovation process. A paper by Gilbert and Newbery (1982) shows that an incumbent market leader can be motivated to maintain its market position through pre-emptive innovation. Under certain conditions, this means the incumbent would be willing to outbid potential entrants to achieve an innovation earlier. The incentive to outbid comes from the drop in the incumbent's profits as a result of entry being larger than the increase in profits earned by a successful entrant. Because entrants know that the incumbent can outbid them if they start spending resources on development, they are discouraged from innovating.[33]

While the implication of Gilbert and Newbery's stylised model is that innovation comes from incumbent firms, their results are vulnerable to small changes in their assumptions. Specifically, Reinganum (1983) shows that adding an element of uncertainty to the process of discovery changes Gilbert and Newbery's results so that entrants drive innovation, both by making discoveries themselves and by forcing incumbents to innovate more.[34]

Uncertainty drives the difference in results because it fundamentally changes the pay-offs for the incumbent. Under certainty, the incumbent's optimal

[33] The incumbent might even find it optimal not to use the new technology once they develop it, merely acquiring the patent to prevent rivals from doing so—which Gilbert and Newbery call 'sleeping patents'. This strategy of entry deterrence serves to preserve the incumbent's profits, but can also produce potential social benefits. This pre-emptive strategy can reduce the need for an incumbent to invest in excess capital stock as an alternative means of entry deterrence and thereby reduces wasteful capacity investments.
[34] Gilbert and Newbery (1982) consider that the time to patent discovery is deterministic and is a decreasing function of R&D expenditure. They do briefly consider an extension to stochastic discovery, but this is accompanied with some restrictive assumptions.

innovation strategy is to spend marginally more on innovation than a potential entrant. This guarantees success for the incumbent in the innovation contest. There is no benefit to the incumbent from increasing investment any further as success is already guaranteed. Investing any less would not be optimal as it would allow the entrant to innovate first, which would lead to substantially lower profits for the incumbent.

Reinganum's model avoids this 'cliff edge' feature of Gilbert and Newbery's model. If the incumbent reduces innovation expenditure, this simply increases the probability that the entrant innovates first, and, at the same time increases the probability that the innovation is delayed. During that delay, the incumbent continues to earn substantial profits while the entrant earns nothing. So the incumbent has a stronger incentive to cut back on innovation effort than the entrant.[35]

In digital markets, there is a great deal of uncertainty as to whether an innovation will be successful, especially from the perspective of achieving success in the market. This suggests that Reinganum's results may be more relevant. In reviewing some of the historic digital conflicts between different products, Evans and Schmalensee (2002) stress that there was often no certainty among industry analysts as to which product would win out.

Other economists have found that as long as rivals have a hope of 'leapfrogging' the current leader, and becoming the favourite to win the overall race for discovery, they will stay in the race.[36] Such a result is referred to as an 'intermediate' equilibrium because it lies between the extremes found by other authors (e.g. Gilbert & Newbery and Reinganum), which show either that leaders' positions are very difficult to challenge or that innovation comes from entrants. Leapfrogging is possible if the race involves several stages of discovery, or if a leader cannot be sure about the extent of its lead over a follower.

In a paper that finds a counterintuitive link between market structure and innovation, Etro (2004) shows that low barriers to entry can make a market leader's position *more* persistent. In his model, innovation efforts are 'strategic complements', meaning that if one firm reduces innovation effort, rivals find it best to reduce their efforts as well.[37] An incumbent takes into account how rivals respond to its actions. In a market without the possibility of entry, incumbents have an incentive to reduce their innovation effort, knowing that rivals already in the market will follow suit. This extends the period before innovation makes the incumbent's existing technology obsolete. In contrast, in markets where entry is possible, new entrants will exploit any opportunity presented by low innovation in an industry. As a result, the incumbent no longer has an incentive to reduce their innovation effort. Higher innovation

[35] Reinganum also highlights that incremental innovations are likely to be more deterministic in nature and so incumbents are likely to put more effort into these innovation projects, while radical innovations are likely to be more stochastic in nature and so will be where entrants target their efforts.
[36] Fudenberg et al. (1983).
[37] Game theory makes a distinction between games of *strategic substitutes* and *strategic complements*. The terms were coined by Bulow et al. (1985). In a strategic interaction (referred to as a 'game' in game theory), players choose their 'strategic variable', which could be price, quantity, advertising spending, or R&D investment. If one agent's decision to increase (decrease) their strategic variable leads other agents to increase (decrease) their strategic variable as well, the game is one of 'strategic complements'. If one agent's decision to increase (decrease) their strategic variable leads other agents to decrease (increase) their strategic variable, the game is one of 'strategic substitutes'. Normally interactions where rival firms compete on price are games of strategic complements (price cuts by one firm lead to price cuts by rivals); and interactions where rivals compete by choosing quantity are games of strategic substitutes. Rivals increasing their innovation effort in response to the market leader increasing theirs suggests that, in Etro's model, innovation investments are strategic complements.

effort from the incumbent means they are more likely to make the next big discovery and thus retain their market-leading position.

4.2 Different innovation targets

Some parts of the literature allow firms to choose between pursuing incremental and drastic innovations (see Box 4.1). Such an addition to economic models is useful as firms do not just choose what resources to put into their innovation efforts, they also choose which research projects to pursue. A frequent finding in this literature is that incumbents have stronger incentives than entrants to engage in incremental innovation as this will increase the profitability of the large number of units they are already selling. By contrast, entrants have stronger incentives to pursue drastic innovations that will render current products and production techniques obsolete. If an entrant is the first to develop such an innovation, they will likely displace the incumbent.

Box 4.1 Types of innovation

The literature makes several distinctions between different types of innovation. Some innovations lead to a better product and are referred to as product innovations; other innovations are to the production process and are referred to as process innovations. The distinction is not always clear cut as some process innovations might be sold as a product (albeit to other firms). For example, Amazon's innovation in developing the Amazon website was a process innovation in retailing on the internet in a way that consumers wanted to buy. In opening its website up to third-party retailers through the marketplace, Amazon is effectively taking this process innovation and selling it as a product to other retailers.

Some innovations are incremental, in that they make only small improvements on the existing technology; other innovations are drastic, in that they render the existing technology obsolete. A drastic product innovation will make the old product so undesirable as to be virtually unused—smart phones or colour televisions might be an example. A drastic process innovation lowers marginal cost so far that the monopoly price with the innovation is less than the marginal cost was without the innovation.

It is possible to have any combination of these two types of innovation, such as 'drastic product innovation' or 'incremental process innovation', as shown in Table 4.1

Source: Oxera.

Table 4.1 Innovation combinations

	Product Innovation	Process Innovation
Incremental innovation	Incremental product innovation	Incremental process innovation
Drastic innovation	Drastic product innovation	Drastic process innovation

Source: Oxera.

Specifically, this pattern whereby incumbents direct their research effort to incremental innovation and potential entrants direct their efforts towards drastic innovation can be found in the theoretical models of Acemoglu and Cao (2015) and Cabral (2018). Acemoglu and Cao further show that free entry might reduce incumbents' incentives for incremental innovation, as it brings forward the point at which the incumbent is displaced by another firm as the market leader. This makes the overall effect of free entry on innovation ambiguous. Cabral finds that greater asymmetry between large and small firms decreases incremental innovation, but increases the rate of drastic innovation. Higher market concentration increases the 'prize' won by a potential entrant who develops the drastic innovation that allows it to displace the current incumbent. This increases the innovation effort of potential entrants and increases the rate at which incumbents are toppled.

This theoretical prediction that market leaders may have relatively stronger incentives for incremental innovation while entrants have relatively stronger incentives for drastic innovation has received partial empirical support.[38] Akcigit and Kerr (2018) use Census Bureau and patent data for US firms to test whether firm size affects innovation direction. They are able to distinguish 'external innovation' aimed at creating new products and 'internal innovation' aimed at improving existing products. This distinction does not map exactly to the distinction between incremental and drastic innovation, but there are overlaps.[39] They find that 'the relative rate of major inventions is higher in small firms' and this difference is the outcome of the firms' different innovation choices, rather than differences in capabilities.

The pattern of leaders pursuing improvements to current technologies while challengers pursue more drastic changes is not confined to firms. Similar observations have been made about the innovation strategies of rival countries and cities by Brezis et al. (1993) and Brezis and Krugman (1997). Technological leaders are slow to recognise the opportunities offered by a new disruptive technology. Since such technologies are initially not as productive as the dominant technology of the time, high-wage countries will not tend to switch labour resources into the new technology. By contrast, low-wage countries will find it optimal to do so, and eventually supplant today's technological leader.

[38] The support is only partial because the distinction between drastic and incremental innovation is one that has been made by economists and is not recorded in patent data. It would be impossible for an economist to go through a large patent dataset and manually assign patents to groups according to whether they represented incremental or drastic advances.
[39] In particular, note that entrants are perfectly capable of developing incremental innovations, but by definition cannot develop internal innovations since they do not have any existing products to improve.

5 Innovation and competition

In this section we first highlight some of the early theoretical debates over the role of firm size and innovation between Joseph Schumpeter and the Nobel Prize-winning economist Kenneth Arrow (section 5.1). We then consider the empirical literature that attempted to shed light on the theoretical debates and the measurement issues that plagued these attempts (section 5.2). Finally, we consider the implications for competition policy that come from this debate (section 5.3).

5.1 History and evolution of the debate

The interaction of innovation decisions with competition is a complex one. The prices and sales volumes needed to make innovation worthwhile require firms to be able to differentiate from and get ahead of their rivals, at least temporarily, increasing demand for their own brands. However, actual or potential competition is also essential to incentivise innovation. To put this simply, in order for innovation to lead to differentiation, and so increase demand, there must be (potential) rivals away from which to differentiate.

This creates a key trade-off in terms of innovation and competition policy that is absent from the Commission's IIA for the ex ante regulation. Measures to make it easier for small rivals to compete with technologically advanced innovative firms may also reduce firms' abilities to extract value tomorrow from the innovations they are considering today. This could disincentivise innovation. This trade-off has long been recognised in competition policy and intellectual property law, but there is no consideration of it in the IIA for the ex ante regulation.

The arguments among economists as to whether competition drives innovation have often been described as an argument between the followers of Arrow and those of Schumpeter. Arrow is presented as having argued that competition was the driver of innovation, while Schumpeter is supposed to have emphasised that innovation requires size and is driven by large firms taking turns in a gale of creative destruction. These schools of thought have become known as the Arrowvian and Schumpeterian views of innovation, but the positions of these two authors were somewhat more nuanced than these simple characterisations would suggest.

Arrow (1962) compares the incentives for innovation with the social benefits of innovation. This comparison is conducted on the assumption that either (a) the industry in question is served by a monopoly or (b) it is currently served by competitive firms. Arrow finds that the incentive to innovate is stronger in a competitive industry than it is in a monopolistic industry because the monopolist's innovative incentives are dulled by the monopoly profits it was already earning. For a monopolist, the incentive to innovate is the difference between the monopoly profit it earns with the innovation and the monopoly profit it is currently earning without the innovation. A competitive firm is not currently making any economic profit, so the total profit resulting from the innovation represents its incentive to innovate. The way in which monopoly profits reduce a monopolist's incentive to innovate is referred to in the rest of the literature as the 'Arrow replacement effect'.

By contrast, for Schumpeter, competition is not about prices but about the development of new products and new production processes—in short, innovation. Such innovations are matters of life and death for the firms involved as they seek to survive through the process of creative destruction that is going

on around them, as revolutionary products, production processes and business models overturn whatever preceded them. Next to this, the static price competition that distinguishes competitive from less competitive industries is, to Schumpeter, trivial.

There are some subtleties in the positions of both authors that are frequently overlooked. For example, Arrow's definition of competition is relatively broad and the definition of monopoly is relatively narrow.[40]

> In the monopolistic situation, it will be assumed that only the monopoly itself can invent. Thus a monopoly is understood here to mean barriers to entry; a situation of temporary monopoly, due perhaps to a previous innovation, which does not prevent the entrance of new firms with innovations of their own, is to be regarded as more nearly competitive than monopolistic for the purpose of this analysis.

Similarly, as regards Schumpeter, while his argument is frequently presented as being that large firms drive innovation, this should not be read as saying that competition is detrimental to innovation. Schumpeter's argument would be better understood as being that innovation *is* competition (and vice versa). Successful innovators will grow in size and set rather than take prices (at the expense of less innovative rivals). This competition through innovation makes more and better goods available to workers for a lower price (in terms of hours of their labour). It is this competition in innovation that has been responsible for the sharp increase in living standards that capitalism has achieved, not static price competition.

Note that Arrow's results are not inconsistent with large firms being responsible for innovation. In Arrow's model, once a firm innovates in a competitive environment, if the innovation is drastic, the firm enjoys significant profits and becomes a large firm. This lack of any inconsistency between Arrow and Schumpeter was pointed out in Shapiro (2012). Shapiro argued that what really mattered most for innovation and competition were that the *future* sales were contestable (contestability); and that the benefits of innovation could be appropriated by the innovator (appropriability).[41] The replacement effect highlighted by Arrow accords well with the concept of contestability as, for a given level of post-innovation sales, a firm with fewer ex ante sales will have more to gain through innovation. The concept of appropriability captures neatly what Schumpeter meant when he said that large firms were the source of innovation—if severe ex post competition brought about by rapid imitation means even a successful innovator earns little profit, it will not have an incentive to engage in innovation.

5.2 The empirical literature

The work of Arrow and Schumpeter and the perceived difference as to whether competition spurs or hinders innovation led to empirical research to try to determine whether innovation would be higher or lower in more competitive environments.

The early results of this literature are mixed. For example, Scherer (1967) finds a positive correlation between industry concentration and innovation

[40] Arrow (1962), p. 619.
[41] In the context of mergers, Shapiro also argued that synergies between the merging parties that could bring down the cost of innovation were important.

(measured by the employment of engineers and scientists).[42] However, Nickell (1996) shows that more competitors and lower 'rents' (i.e. economic profits) are associated with higher total factor productivity growth in UK manufacturing.

Blundell et al. (1999) find that both market share and product market rivalry tend to be associated with higher levels of observable innovation, suggesting that large firms have incentives to engage in innovation *and* that competition leads to more innovation. This finding appears supportive of the general picture emerging from the theoretical literature that both rivalry and the potential to differentiate from or get ahead of rivals are important drivers of innovation.

In his concluding remarks, Nickell (1996) suggests (but is unable to test) that competition works to promote innovation not by making individual firms more efficient, but by allowing for multiple production methodologies and selecting the best. This is a view of competition as an evolutionary process; such an evolutionary process would be similar to some interpretations of the Schumpeterian view of the role of innovation and competition.

Aghion et al. (2005) unites an empirical approach with a theoretical approach. Empirically, they find an 'inverted-U shape' to the innovation achieved within each industry and the level of competition within that industry.[43] So that at first innovation increases in competition when the industry is not particularly competitive, but then innovation begins to reduce with competition as the industry becomes more competitive. They then build a theoretical model to explain this empirical finding.

Their theoretical model divides innovation between catch-up innovation by firms that are technologically behind and innovation motivated by an 'escape from competition' by firms that are technologically neck-and-neck with their rivals. In a competitive market, the incentives to catch up are relatively small and the incentives to differentiate away from a technologically equal rival through innovation are relatively large. When there is a lack of competition in the market, the opposite holds. Crucial to generating the inverted-u relationship between competition and innovation is a 'composition effect', which means that:

- firms in uncompetitive industries spend most of their time technologically neck-and-neck such that increases in competition lead to increases in innovation incentives;[44] but
- firms in competitive industries spend most of their time 'unlevelled' (i.e. with a technological leader and follower(s)) so that there is a technological leader and follower, meaning that increases in competition reduce innovation incentives.[45]

[42] However, that correlation is greatly reduced when including industry dummies, suggesting that innovation is driven more by technological opportunity than by concentration. Scherer also does not include firm-level fixed effects, which may affect results by controlling for unobserved variations in the innovativeness of particular firms.
[43] They measure the level of competition within an industry by taking the average of the Lerner index for all the firms in the industry; and the level of innovation is measured by a citation-weighted patent count for each firm averaged across all firms in the industry.
[44] An uncompetitive industry sees strong innovation incentives for the laggard when there is a technological leader and weak innovation incentives when the firms are neck-and-neck; as a result, firms in such an industry will be neck-and-neck most of the time.
[45] A competitive industry sees strong innovation incentives when the firms are technologically neck-and-neck and weak innovation incentives when there is a technological leader, so the industry will have a technological leader most of the time.

This theoretical model employed in multiple Aghion papers relies on the assumption of step-by-step innovation where technological followers must catch up with the technological leader before attempting to overtake.[46] This rules out the possibility of 'leapfrogging', where a follower is able to discover the 'next big thing' without first replicating the discoveries of the current technological leader. In reality, leapfrogging is possible, is observed, and is indeed crucial to the creative destruction process that Schumpeter focused on.

The empirical research agenda has had difficulty overcoming some of the inherent measurement issues for both the degree of competition and innovation outcomes. These measurement issues may explain some of the differences in empirical results. Measurements that might be used to estimate differences in competition and innovation are likely to differ systematically across industries and over time in terms of how well they assess competitive pressure and innovation. This makes it difficult to draw inferences about the influence of levels of competition on innovation through cross-industry comparisons or comparisons over time (see Box 5.1).

Box 5.1 Measuring innovation and competition

Empirical work on the relationship between innovation and the level of competition requires that some way be found to measure both, which is not as easy as it may appear. First, as Holmes and Schmitz (2010) point out, using industry indices of competition such as the average Lerner index in a market to measure the level of competition can be misleading since this is a static measure and subject to contentious market definitions. Indeed, Vives (2008), building a theoretical model to explain the impact of competition on innovation, used three different measures of competition: the degree of product substitutability; the number of competitors; and the size of the market and cost of entry. Innovation effort tends to respond differently to different measures of competition. For example, innovation effort increases in the degree of product substitutability, but decreases in the number of competitors.

Second, while it is relatively easy to measure innovation inputs (such as R&D expenditure), it is difficult to measure innovation outputs. Schmookler (1962) measured innovation through patents. However, he acknowledged that this approach was subject to valid criticisms, in particular the underlying assumption that the ratio of patents to inventions and the average importance of each invention were constant over time. Schmookler (1962) was concerned with examining technological progress over time within industries; when comparing technological progress in different industries, we would need these ratios to be constant across industries—an even more improbable assumption. It is possible to control for varying degrees of importance of different inventions by weighting patents according to the number of citations, as Aghion et al. (2005) do. However, the problem of the ratio of patents to inventions potentially differing across industries remains. Differences in the number of patents filed in different industries may reflect differing extents to which firms in the industries rely on patents to protect their inventions, rather than genuine differences in the level of innovation in each field. For example, innovations in some industries are easier to patent than in others.

In addition to measurement problems, Aghion et al. (2018) raise the issue of the endogeneity problem where, in real-world data, the degree of competition may be influenced by the rate of innovation as much as the rate of innovation is influenced by the degree of competition. They therefore deploy an experimental design instead (as discussed in section 8)

Source: Oxera.

5.3 Implications for competition policy

As described above, innovation incentives are driven by the extent to which an innovator can appropriate the value of its innovations (appropriability) and the extent to which future sales in a market are contestable (contestability). Below we show how there is a trade-off between these two drivers of innovation. While some authors do express concerns about the possibilities for

[46] Phillipe Aghion, with a range of co-authors, has conducted a great deal of research into the relationship between competition and innovation. The theoretical model described here is common to many of the papers he has co-authored. It was first developed in Aghion et al. (1997), but was also used to explain the empirical results in Aghion et al. (2005) and the experimental results in Aghion et al. (2018).

anticompetitive conduct by large digital firms, they do not suggest resolution through blanket prohibitions of business practices beyond existing competition law.

As Shapiro (2012) stresses, it is, in part, the prospect of appropriation that spurs innovation. At the same time, there is a recognition that the competitive structure of markets affects innovation, and Shapiro points out that an absence of sufficient contestability undermines the pressure for incumbents or the opportunity for potential entrants to innovate. Federico et al. (2020) go further, saying that 'greater rivalry' *means* 'greater contestability of future sales'.

This creates a trade-off between appropriability and contestability from the perspective of competition policy: unless policies are crafted carefully, measures to improve contestability are likely to undermine the appropriability of existing innovations. Such an undermining will be observed as a negative signal about the likely appropriability of future innovations by incumbents and potential entrants alike. This trade-off between appropriability and contestability leads to a balancing act for policymakers, as described by Segal and Whinston (2007). Carefully crafted packages of policies can minimise the trade-off by combining measures to improve contestability with other measures designed to improve appropriability.

Evans and Schmalensee (2002) make a similar point. They stress that competition in many digital industries centres on investment in intellectual property, to develop a product that will confer market leadership (at least for a while). Static price/output competition is seen as less important.[47] Encouraging entry may spur innovation as it allows firms to become profitable early (increases contestability), but it similarly stifles innovation when these firms realise that they will be on the wrong side of such measures once they succeed (reduces appropriability).

Another problem, as Evans and Schmalensee point out, is that in dynamic markets, conventional tests used by competition agencies to detect market power or assess anticompetitive effects of certain business practices are less effective. Conventional tests for market power revolve around defining the market to include all the sufficiently close substitutes and examining information such as market shares. However, these approaches ignore the far more important source of competitive constraint in dynamic markets, which is the potentially disruptive innovations being pursued by rivals. Similarly, innovation in digital markets frequently involves integrating previously separate products and features. For example, spellcheckers and word processors were once sold separately; the modern smartphone represents the integration of a mobile phone, a personal digital assistant, an MP3 player and a digital camera.

Successful innovation may result in firms becoming large as their innovation allows them to differentiate themselves from their rivals. Jean Tirole, in his 2014 Nobel Prize lecture, pointed out that an accepted principle in competition policy is that there is nothing inherently wrong with firms becoming large (Tirole, 2015). Quite the contrary, size and market leadership may very well be the consequence of competition on the merits by offering low prices and high quality, or being innovative. These may be the rewards to successful market competition. If not clearly linked to abusive conduct, punishing firms simply for being large may stifle incentives for future competition on the merits. However,

[47] Note the similarities with the Schumpeterian view of competition as the process of creative destruction and how competition through innovation is more important than static price competition between firms.

by imposing prohibitions on business conduct exclusively on large firms, this is exactly what the ex ante regulation proposals are doing.

In more recent contributions to the debate, Gilbert (2020) provides a valuable synthesis of the literature on competition and innovation in the context of high-tech markets. Central to his thesis is the argument that US competition policy needs to move away from being price-centric and towards being innovation-centric. He makes several recommendations that would represent a substantial tightening of existing antitrust enforcement in the USA. There is no discussion of using per se prohibitions. Gilbert also argues that breaking up big tech cannot substitute for diligent antitrust enforcement. Federico et al. (2020) take a similar view, advocating various reforms to competition rules, but stopping short of per se prohibitions along the lines of those that might result from the proposed ex ante regulations.

Similarly, Federico et al. (2020) express concerns that exclusionary conduct by a digital incumbent might make entry impossible for an innovative potential rival. This would reduce innovation. However, such exclusionary conduct is not defined through a list of practices that can be prohibited, but as conduct that does not constitute competition on the merits—a standard competition policy description of exclusionary conduct which would require an effects-based analysis to establish.

The trade-off between appropriability and contestability that is featured in the economics literature on competition and innovation goes unacknowledged in the Commission's IIA for the ex ante regulation proposals. One interpretation of these proposals is that they are an attempt to increase contestability. However, the overall impact on contestability remains open to question. Contestability of numerous markets will actually decrease from the perspective of firms that are within the scope of the ex ante regulation.

6 Innovation and market size

This section highlights the impact of market size on innovation. First, we discuss the literature, which is conclusive that larger markets spur more innovative effort (section 6.1). We then discuss the implications of this result for ex ante regulation and particularly for the Commission's expectation that local innovation will replace innovation from large global platforms (section 6.2). In light of the observations from the literature, the Commission's expectation seems unlikely because of the smaller size of the European market when compared to the rest of the world.

6.1 The economics literature on market size and innovation

Broadly speaking, the larger the market in which an innovator plans to sell its products, the larger the number of units it will expect to sell. Intuitively, this allows the fixed cost of innovation to be spread over more units and makes more innovation projects look profitable in expectation.

In the theoretical literature, Vives (2008) establishes a relationship between market size and innovation when exploring the relationship between competition and innovation. He finds that the effect of market size is consistent across different states of competition. In a market with no entry, adding competitors would reduce the residual demand for each firm and decrease investments in R&D. So increases in market size will increase the residual demand for all firms for a given number of competitors, and so increase investments in R&D. In a market with free entry, increasing the market size would result in higher R&D investments per firm.

The finding that market size drives innovation is part of a broader pattern of innovation being driven by demand. Empirical support for this broad point can be found in Schmookler (1962), who studies the relationship between innovation and demand (proxied using the number of patents and output respectively—see Box 5.1). Schmookler finds that innovation follows demand. Comparing the number of patents on a specific type of railway car equipment with the production of that same equipment, he finds surges in output *precede* an increase in patents. Although radical innovations can create markets and thereby *lead* demand, incremental innovations and the associated incentive to invest in R&D typically *respond to* demand. This also suggests that larger markets should provide additional incentives for innovation.

Greater economic integration of separate economies (e.g. through trade) has also been shown to increase innovation through a market-expanding effect.[48] Under the framework of Rivera-Batiz and Romer (1991), an idea developed within one economy can also be commercialised in the other and patents filed in one country can be used in the other. As a result, opening trade doubles the size of the market for the goods invented and, with it, the magnitude of expected profits from innovation. Thus, access to a larger international market incentivises firms to invest more in R&D, makes the R&D sector more productive, and contributes to higher economic growth.

6.2 Implications for ex ante regulation

The ex ante regulation proposals—in targeting global firms in the hope that their innovation will be replaced by innovation from local firms—is failing to account for the influence of market size on innovation incentives. Where

[48] Rivera-Batiz and Romer (1991).

European firms are developing the ‘next big thing’ and are likely to get there before the global technology platforms, the ex ante regulation proposals are not likely to make a difference.[49] For all other innovations, these proposals might impede rollout of such innovations in the EU to the detriment of European consumers and businesses. The large global platforms may be blocked from rolling out some of their innovations, for example due to restrictions in the ex ante regulations on lines of business, while the European market is not large enough to incentivise local firms to develop similar innovations as quickly. This would mean innovation rollout was delayed in the EU to the detriment of European consumers, businesses and economic development.

[49] Furthermore, for the reasons outlined above, what difference they make is likely to be negative, as innovators know that part of the cost of a really successful innovation might be that they fall within the scope of the DMA at some point in the future.

7 Evidence from the economics literature on mergers and innovation

In this section we consider the evidence from the economics literature on mergers and innovation (section 7.1) and how that literature has affected merger control decisions by the European Commission (section 7.2). The relevance for our assessment of ex ante regulation comes from the clear parallels between situations in which firms' innovation is reduced due to their merging and situations where it is reduced by ex ante regulation.

The literature (and past decisional practice) tends to suggest that rivals will not increase their innovation efforts by enough to compensate, should merging parties decrease theirs. This has been the basis for making merger clearances subject to divestment requirements in the past.

7.1 The relevant literature

The economics literature in general and the arguments presented above show that small firms have the ability and incentive to undertake innovation. Indeed, in some instances they might be the source of important drastic innovations. However, at a practical level, it is far from certain that rivals to large firms would systematically fill any void resulting from reduced innovation by global platforms in the EU.

The economics literature highlights that mergers raise competition concerns because they reduce the number of firms active in the market. This raises traditional concerns about prices, but also, for similar reasons, there may be concerns that innovation incentives would be muted (Katz and Shelanski, 2005).

The merging parties might reduce their innovation efforts because a successful innovation improving one of their products will reduce demand for their other products (Federico et al., 2017, 2018).[50] Because innovation is a strategic substitute in these models, the innovation of rivals that are not part of the merger will increase.[51] However, the models show that the innovation efforts do not increase by enough to compensate for the lost innovation from the merging parties, and aggregate innovation falls absent efficiencies or synergies. Where there are merger-specific synergies, they may in fact lead to an increase in innovation effort by the merging parties, or at least ameliorate any reduction (Federico et al., 2018 2018; Motta and Tarantino, 2018).[52]

7.2 Merger decisions

Two key recent decisions in this context are the agrochemical mergers between Dow and DuPont in 2017 and between Bayer and Monsanto in 2018.[53] In *Dow/DuPont*, the innovation concerns were based on the existence of overlap in pipeline products, but also the importance of the parties as

[50] Effectively the Arrow replacement effect discussed above becomes stronger for the merging parties after the merger and reduces their incentive to innovate.
[51] See footnote 37 for the difference between strategic substitutes and strategic complements.
[52] Denicolo and Polo (2018) and Bourreau, et al. (2019) point to two assumptions made by Federico et al. (2018) that may be critical in their conclusion that overall innovation efforts fall as a result of a merger. First, the probability of failure as a function of R&D efforts needs to take a particular functional form (log-convex). This is not necessarily an unrealistic assumption to make, but it is also not guaranteed to hold. Second, Federico et al. (2018) assume that investment in R&D affects the probability of success but not the value of the innovation. In particular, Bourreau et al. (2019) suggest that relaxing this assumption can lead the impact of the merger on innovation outcomes to be more ambiguous.
[53] Innovation concerns had been raised in previous decisions, but these normally concerned pipeline products at a sufficient stage of development that they could be treated as existing products for the purposes of merger control.

innovators in specific innovation areas. There was also evidence of R&D investment suppression as part of the post-merger integration plans. Importantly, the Commission concluded that there are barriers to entry in R&D. The merger was cleared subject to divestment of certain products, together with the global R&D facilities of DuPont's pesticide business.

In *Bayer/Monsanto*, the Commission found that, absent the remedies, the merger would have significantly reduced competition on price and innovation and strengthened Monsanto's dominant position in certain markets where Bayer was an important challenger. As in *Dow/DuPont*, the finding on innovation concerns was based on a detailed analysis of patent data. The merger was also cleared subject to significant divestments, including R&D capabilities.

The Commission's reasoning in merger decisions reveals a concern that increased innovation by rivals would not compensate for innovation lost as a result of a merger. This appears to be inconsistent with the IIA, where it suggests that holding back the largest platforms will be more than outweighed by smaller platforms innovating more.

8 The experimental literature

In this section, we describe the value added by experiments (section 8.1), and some of the results from the experimental literature that has been produced to date (section 8.2).

8.1 The value added from experiments

Data used to measure either competition or innovation is likely to vary systematically across industries for reasons unconnected with the underlying levels of innovation and competition in those industries. There may also be endogeneity issues since in addition to the level of competition influencing the level of innovation, the level of innovation may influence the level of competition. (See Box 5.1 for further discussion of these issues.)

To deal with this empirical challenge, there is a small literature conducting experiments to identify the effect of competition on innovation. Well-designed experiments allow the researcher to control the initial conditions and so identify more reliably how competition drives innovation. At a high level, economic experiments are often highly stylised games played by research subjects who may be drawn from university students (undergraduate or postgraduate) or business leaders (the former is more common than the latter for cost and availability reasons). The choices made by the research subjects, the possible outcomes of these choices, and the real financial rewards that the experimental subjects receive depending on the experimental outcome are all set by the researcher and designed to mimic some real-life situation that is of interest. For example, the experiments in Aghion et al. (2018) had students play a game which was effectively based on the Aghion et al. (1997) game theory model of competition and innovation.

However, the additional clarity that comes from stylised games is not costless. Some experiments lack what is called *external validity*, meaning that their results may hold reliably in laboratory environments but do not apply in the real world. A lack of external validity is usually a result of over-simplification of the economic environment that the experiment is seeking to mimic. However, some simplification is necessary as there is a limit to the amount of complexity that can be communicated to experimental subjects over a 1–2-hour experiment. The implication is that, to the extent that additional context improves the degree to which the experiment represents real-world situations without hindering the participant's understanding, they should be included in experiments in order to improve external validity (Nieboer, 2020).

Some economists (Bravo-Biosca, 2020) have advocated for 'field experiments' in this area, which would involve trialling a policy on a small group of firms selected at random and comparing the resulting innovation outputs to a 'control group' on which the policy was not trialled. Field experiments present some advantages—for instance, they are conducted on the actual individuals whom the proposed policy will affect in the environment where the policy will operate. However, they can be expensive, and policymakers are usually the only people in a position to conduct such experiments.

8.2 The experimental literature

The experimental literature to date broadly finds that aggregate innovation effort tends to increase with the competitive nature of the environment. In particular, Isaac and Reynolds (1988, 1992) find that rivalry in terms of the number of firms tends to increase innovation efforts, as does closer rivalry between a fixed number of firms. Similarly, Aghion et al. (2018) finds that,

generally, innovation effort increases with the degree of competition (measured by the ease of collusion when firms are neck-and-neck).

Harris and Vickers' (1987) theoretical paper predicts that once the gap between technological leaders and followers grows wide enough, followers effectively drop out of the race for discovery and leaders cut back on their innovation effort. Designing an experiment to test the theoretical results of Harris and Vickers (1987), Zizzo (2002) finds only limited support for their theoretical conclusions and no evidence of these two particular effects in his experiment.

9 Conclusions

Innovation is the only source of long-term growth in output per worker, and so is crucial for the economic welfare of EU citizens. The relationship between innovation and competition is complex. Rivalry between firms is essential for innovation, but so is the promise that innovation will be rewarded through the ability to differentiate away from rivals and (potentially) establish a temporary degree of market leadership. The economics literature describes this complex relationship through the concepts of contestability and appropriability.

The proposals for ex ante regulations are focused on contestability to the exclusion of their potential impact on appropriability and ignoring the potential trade-offs between these different innovation drivers. This is likely to lead to unintended consequences.

First, there is value to the variety that comes from the different innovation strategies of incumbents and entrants. Entrants tend to pursue drastic innovations, while incumbents tend to pursue incremental innovations. In markets where global platforms are potential entrants, a reduction in their innovation means forgone or delayed drastic innovation which increases in incremental innovation by smaller rivals may not compensate. On the other hand, when global platforms are incumbents, even small incremental innovation may create a large amount of value when rolled out to their large number of users. Reduced incremental innovation could only be compensated by smaller rivals if there were a large increase in drastic innovation efforts, but this is not a likely consequence of ex ante regulation, for the reasons set out below.

Second, imposing burdensome regulations on large technology platforms may increase the contestability of the markets where such firms are incumbents.[54] However, smaller firms will understand that, should they ever be as successful as the large platforms, they will become subject to similar regulation. This will reduce the value of being so successful and so reduce the appropriability of innovation. This will have a negative effect on innovation. This trade-off is not considered in the Commission's IIA.

Third, if the ex ante regulation aims to replace innovation by global technology platforms with innovation by smaller local rivals, this ignores the influence of market size on innovation incentives. Larger markets unambiguously increase the strength of innovation incentives, so local firms innovating for the European market would have smaller innovation incentives than global firms innovating for a global market. Innovations will be rolled out more slowly within the EU to the detriment of European consumers and businesses. The Commission may hope that European firms will develop the proverbial 'next big thing' and innovate for a global market, but it is not clear that ex ante regulation will promote this, partly for the reasons set out above.

Finally, given that the proposed regulations will make it more difficult for large technology platforms to innovate in various ways,[55] it seems uncontroversial that innovation from large technology platforms will fall. However, the Commission's IIA expects an increase in innovation as a likely economic impact. This could only happen if rival technology firms outside the scope of

[54] Additional regulations on the large technology platforms limiting their scope to innovate by combining product features or entering new markets will actually reduce the contestability of various markets from their perspective.
[55] Such as by entering adjacent markets with an innovative product; or combining features previously seen in two different products into one product.

the ex ante regulations increased their innovation outputs by enough to compensate. However, in previous merger decisions, the Commission has expected that innovation from rivals would not increase by enough to compensate should innovation by merging parties fall. This has been part of the reasoning for clearing mergers only subject to the divestment of R&D facilities. The Commission's IIA does not address the tension between these two positions.

The proposals for the ex ante regulation of large digital platforms are likely to lead to unintended consequences for innovation. This is largely because trade-offs between contestability and appropriability that have been a feature of competition policy to date have not been considered in the context of the ex ante regulation. This report brings those insights from the economics literature into the debate.

A1 Bibliography

Acemoglu, D. and Cao, D. (2015), 'Innovation by entrants and incumbents', *Journal of Economic Theory*, **157**, pp. 255–294.

Aghion, P., Bechtold, S., Cassar, L. and Herz, H. (2018), 'The causal effects of competition on innovation: Experimental evidence', *The Journal of Law, Economics, and Organization*, **34**:2, pp. 162–195.

Aghion, P., Bloom, N., Blundell, R., Griffith, R. and Howitt, P. (2005), 'Competition and innovation: An inverted-U relationship', *The Quarterly Journal of Economics*, **120**:2, pp. 701–728.

Aghion, P., Harris, C. and Vickers, J. (1997), 'Competition and growth with step-by-step innovation: An example', *European Economic Review*, **41**:3–5, pp. 771–782.

Akcigit, U. and Kerr, W.R. (2018), 'Growth through heterogeneous innovations', *Journal of Political Economy*, **126**:4, pp. 1374–1443.

Arrow, K.J. (1962), 'Economic welfare and the allocation of resources for invention', in *The Rate and Direction of Inventive Activity: Economic and Social Factors*, Edited by Universities-National Bureau Committee for Economic Research, Committee on Economic Growth of the Social Science Research Council, Princeton University Press, pp. 609–626.

Blundell, R., Griffith, R. and Van Reenen, J. (1999), 'Market share, market value and innovation in a panel of British manufacturing firms', *The Review of Economic Studies*, **66**:3, pp. 529–554.

Bouck, E.C., Flanagan, S., Joshi, G.S., Sheikh, W. and Schleppenbach, D. (2011), 'Speaking math—A voice input, speech output calculator for students with visual impairments', *Journal of Special Education Technology*, **26**:4, pp. 1–14.

Bourreau, M., Jullien, B. and Lefouili, Y. (2019), 'Mergers and Demand-Enhancing Innovation' *mimeo*.

Bravo-Biosca, A. (2020), 'Experimental Innovation Policy', *Innovation Policy and the Economy* **20**, pp. 191-232.

Brezis, E., Krugman, P. and Tsiddon, D. (1993), 'Leapfrogging in International Competition: A Theory of Cycles in National Technological Leadership', *American Economic Review*, **83**:5, pp. 1211–1219.

Brezis, E.S. and Krugman, P.R. (1997), 'Technology and the life cycle of cities', *Journal of Economic Growth*, **2**:4, pp. 369–383.

Bulow, J., Geanakopolos, J., and Klemperer, P., 'Multimarket Oligopoly: Strategic Substitutes and Complements', *Journal of Political Economy* **93**(3), pp. 488-511.

Cabral, L. (2018), 'Standing on the Shoulders of Dwarfs: Dominant Firms and Innovation Incentives', *CEPR*, Discussion Paper No. DP13115.

Denicolò, V. and Polo, M. (2018), 'Duplicative research, mergers and innovation', *Economics Letters*, 166, pp. 56–59.

Etro, F. (2004), 'Innovation by leaders', *The Economic Journal*, **114**:495, pp. 281–303.

European Commission (2008), Staff Working Document SEC (2008) 350.

European Commission (2020), 'Inception Impact Assessment of the ex ante regulatory instrument'.

European Transport Safety Council (2006), 'Raising Compliance with Road Safety Law: 1st Road Safety PIN Report'.

Evans, D.S. and Schmalensee, R. (2002), 'Some economic aspects of antitrust analysis in dynamically competitive industries', *Innovation Policy and the Economy*, **2**, pp. 1–49.

Federico, G., Langus, G. and Valletti, T. (2017), 'A simple model of mergers and innovation', *Economics Letters*, 157, pp. 136–140.

Federico, G., Langus, G. and Valletti, T. (2018), 'Horizontal mergers and product innovation', *International Journal of Industrial Organization*, 59, pp. 1–23.

Federico, G., Morton, F.S. and Shapiro, C. (2020), 'Antitrust and innovation: Welcoming and protecting disruption', *Innovation Policy and the Economy*, **20**:1, pp. 125–190.

Fudenberg, D., Gilbert, R., Stiglitz, J. and Tirole, J. (1983), 'Preemption, leapfrogging and competition in patent races', *European Economic Review*, **22**:1, pp. 3–31.

Gilbert, R.J. (2020), *Innovation Matters: Competition Policy for the High-Technology Economy*, MIT Press.

Gilbert, R.J. and Newbery, D.M. (1982), 'Preemptive patenting and the persistence of monopoly', *The American Economic Review*, pp. 514–526.

Goldin, C. (2006), 'The quiet revolution that transformed women's employment, education, and family', *American Economic Review*, **96**:2, pp. 1–21.

Greenwood, J., Seshadri, A. and Yorukoglu, M. (2005), 'Engines of liberation', *The Review of Economic Studies*, **72**:1, pp. 109–133.

Harris, C. and Vickers, J. (1987), 'Racing with uncertainty', *The Review of Economic Studies*, **54**:1, pp. 1–21.

Holmes, T.J. and Schmitz Jr, J.A. (2010), 'Competition and productivity: a review of evidence', *Annual Review of Economics*, **2**:1, pp. 619–642.

Isaac, R.M. and Reynolds, S.S. (1988), 'Appropriability and market structure in a stochastic invention model', *The Quarterly Journal of Economics*, **103**:4, pp. 647–671.

Isaac, R.M. and Reynolds, S.S. (1992), 'Schumpeterian competition in experimental markets', *Journal of Economic Behavior & Organization*, **17**:1, pp. 59–100.

Jones, C.I. and Williams, J.C. (1998), 'Measuring the social return to R&D', *The Quarterly Journal of Economics*, **113**:4, pp. 1119–1135.

Katz, M.L. and Shelanski, H.A. (2005), 'Merger policy and innovation: Must enforcement change to account for technological change?', *Innovation Policy and the Economy*, 5, pp. 109–165.

Motta, M. and Tarantino, E. (2018), 'The Effect of Horizontal Mergers, When Firms Compete in Prices and Investments', *mimeo*.

Nickell, S.J. (1996), 'Competition and corporate performance', *Journal of political economy*, **104**:4, pp. 724–746.

Nieboer, J. (2020), 'Using online experiments for behaviourally informed consumer policy', *FCA Occasional Paper*, 51.

Norton, M.I., Mochon, D. and Ariely, D. (2012), 'The IKEA effect: When labor leads to love', *Journal of Consumer Psychology*, **22**:3, pp. 453–460.

Reinganum, J.F. (1983), 'Uncertain innovation and the persistence of monopoly', *The American Economic Review*, **73**:4, pp. 741–748.

Rivera-Batiz, L.A. and Romer, P.M., (1991), 'Economic integration and endogenous growth', *The Quarterly Journal of Economics*, **106**:2, pp. 531–555.

Romer, P.M. (1990), 'Endogenous technological change', *Journal of Political Economy*, **98**:5, Part 2, pp. S71–S102.

Sala-i-Martin, X. (2006), 'The world distribution of income: falling poverty and… convergence, period', *The Quarterly Journal of Economics*, **121**:2, pp. 351–397.

Scherer, F.M. (1967), 'Market structure and the employment of scientists and engineers', *The American Economic Review*, **57**:3, pp. 524–531.

Schmookler, J. (1962), 'Economic sources of inventive activity', *Journal of Economic History*, pp. 1–20.

Schumpeter, J.A. (1942), *Capitalism, socialism and democracy*, Harper & Brothers.

Segal, I. and Whinston, M.D. (2007), 'Antitrust in innovative industries', *American Economic Review*, **97**:5, pp. 1703–1730.

Shapiro, C. (2012), 'Competition and Innovation: Did Arrow Hit the Bull's Eye?', in in Josh Lerner and Scott Stern (eds.) *The Rate and Direction of Inventive Activity Revisited*, University of Chicago Press, pp. 361-410.

Solow, R.M. (1956), 'A contribution to the theory of economic growth', *The Quarterly Journal of Economics*, 70:1, pp. 65–94.

Spinney, J., Reimer, S. and Pinch, P. (2017), *Mobilising Design*, Taylor & Francis.

Swan, T.W. (1956), 'Economic growth and capital accumulation', *Economic Record*, **32**:2, pp. 334–361.

Tirole, J. (2015), 'Market failures and public policy', *American Economic Review*, **105**:6, pp. 1665–82.

Vives, X. (2008), 'Innovation and competitive pressure', *The Journal of Industrial Economics*, **56**:3, pp. 419–469.

Zizzo, D.J. (2002), 'Racing with uncertainty: a patent race experiment', *International Journal of Industrial Organization*, **20**:6, pp. 877–902.

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