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Product market competition, creative destruction and innovation

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Abstract

We examine the economic analysis of the relationship between innovation and product market competition. First, we give a brief tour of the intellectual history of the area. Second, we examine how the Aghion-Howitt framework has influenced the development of the literature theoretically and (especially) empirically, with an emphasis on the "inverted U": the idea that innovation rises and then eventually falls as the intensity of competition increases. Thirdly, we look at recent applications and development of the framework in the areas of competition policy, international trade and structural Industrial Organization.

Keywords: Competition, Innovation, Creative Destruction

JEL Classification: O31, L13, O32, B20, L40

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1 Introduction

Is product market competition conducive to innovation and growth, or does it dampen incentives for research and development (R&D)? This is one of the longest standing questions in social science, and is a central feature of the legacy of Aghion and Howitt (1992), which brought key elements of industrial organization (IO) into modern macro growth models. Some prominent inventors and entrepreneurs (e.g. Thiel, 2014) have argued that tough competition discourages innovation and thus inhibits productivity growth by reducing the expected returns from innovation. This is often taken as the main message from Schumpeter (1943), who argued that the static efficiency gains (e.g. lower prices) from competition were outweighed by dynamic efficiency losses, as all innovation rents would be dissolved when price was equal to marginal cost. By contrast, competition authorities generally argue that competition is beneficial not just because of static gains of prices, but also for innovation, because it encourages new entry and forces incumbent firms to innovate in order to stay ahead of rivals.

As we will see, there are theoretical arguments that predict both positive and negative effects of competition on innovation. The empirical evidence has also been mixed. So what weight should policy makers place on rewarding successful innovation through allowing monopoly power versus enhancing the competitive pressures markets place on firms to push forward the frontier? Is there a trade-off, or can these policies be used as complementary mechanisms?

One recurring theme is that competition can mean different things. Observable indicators of within market competition (such as the number of firms, levels of concentration, price-cost margins, etc.) are endogenous outcomes of more primitive objects such as elasticities of substitution (consumer preferences) and barriers to market entry. Of course, these primitive objects themselves can change through technological innovation and government policy.

We structure our paper as follows. Section 2 gives an intellectual history of these issues leading to Aghion and Howitt's development of endogenous growth theory. We then explain the key insights of the approach to "step by step" innovation models and the "Inverted U" relationship. Next, in Section 3 we examine some applications of the approach in competition policy, trade policy and structural IO models. The final section offers some conclusions.

2 Intellectual History

2.1 Theoretical underpinnings

Smith to Arrow-Debreu

Economists since Adam Smith (1776) have generally seen competition as an important driver of growth and prosperity. Standard models, such as Arrow and Debreu (1954), formalize this result regarding the efficient allocation of finite resources in producing the first Welfare Theorem.

One extension of the idea of allocative efficiency is how aggregate productivity can be depressed by misallocation of output across firms. When firms have heterogeneous levels of productivity due, for example to different levels of managerial capability (Bloom and Van Reenen, 2007), tougher competition results in a Darwinian process by which inefficient firms shrink and die and high productivity firms survive and grow. Market frictions that inhibit this process generally result in lower aggregate productivity. The importance of misallocation is at the centre of modern macroeconomics (e.g. Hsieh and Klenow, 2009).

In addition to these "between firm" reallocation effects, a subterranean "folk wisdom" amongst economists is that competition improves productive efficiency *within* firms. Leibenstein (1966) labelled this "X-efficiency" and this was encapsulated by Sir John Hicks' quip "the best of all monopoly profits is a quiet life." This idea has been formalised in various ways, perhaps most simply by recognising that firms generally do not maximize shareholder value due to the principal-agent problem between the owners and managers of a firm. Firms are subject to agency problems, because it is not possible for the (usually dispersed) owners of corporations to fully observe managerial effort and performance, nor to implement first-best contracts in order to elicit this optimal effort. Competition can act to push managerial effort, not least because the CEO will be more fearful of the firm going bankrupt (Hart, 1983; Schmidt, 1997).[1]

Schumpeter

Schumpeter (1943) emphasised the importance of innovation and entrepreneurialism to capitalism and was sceptical of formal equilibrium models, which initially make his contributions hard to parse into modern economics. His emphasis was that competition can

[1] Another way may be through managerial career concerns and for the labor market to provide incentives (Holmstrom, 1982). Note that managerial incentives actually have an ambiguous relationship to product market competition. The Raith (2003) model shows this most clearly measuring competition by consumer price sensitivity in the context of a circular city Hotelling model. Greater competition means that an increase in managerial effort shifts more market share, which increases effort. But it also means less rents for any given level of effort, which has the opposite effect. This is exactly like the standard trade-off between competition lowering average innovation rents, but increasing the marginal return to research effort.

lower incentives to innovate, with the main mechanism through reducing the *ex post* profits of innovators.[2] Since there is a cost to performing R&D, the reward must be some temporary profit advantage. When competition immediately drives the innovation quasi-rents to zero – for example, from instant diffusion – there is no incentive to perform R&D. In our terms, the non-rivalrous and non-excludability of R&D means that it will be under-supplied in a decentralized competitive economy.

Policy makers have long recognized this. The patent system grants temporary monopoly property rights to an innovator precisely to enable her to obtain some stream of rewards (in return for publishing the patent to allow future inventors to build on the knowledge). There are often calls to abolish the patent on a particular product to restore competition – a recent example being around pharmaceuticals such as vaccines. In addition, after the innovation is produced then the first best is to supply it at marginal costs. However, abolishing Intellectual Property rights could clearly reduce innovation incentives.[3]

Arrow

A key contribution of Arrow (1962) was to show how Schumpeter's intuition could be overturned. Arrow compared innovation incentives for an industry characterized by monopoly to one with perfect competition. Who will invest the most in cost-reducing R&D? Agents' decisions depend on comparing the profits earned post-innovation to pre-innovation. Let us say the competitive firm becomes a monopolist if she innovates, so that the post-innovation rents are the same in both cases. But the monopolist by definition is earning a stream of pre-innovation rents, so he will have less incrementally new profits than the competitive firm, so will have less incentive to invest in R&D.

The monopolist's disincentive to replace his own stream of rents by innovating has come to be called the Arrow replacement effect and works in direct opposition to the Schumpeterian incentive.

Industrial Organisation literature through early 1990s

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[2] He also argued that competition cut the ability to invest in R&D *ex ante* through firms having less financial resources to invest. This assumes imperfect competition in the financial markets. Otherwise, a firm with a profitable idea could simply borrow the money to finance the innovation or allow a venture capitalist to take an equity stake. This theme was later pursued by Arrow (1962), but given space constraints we will focus only on product market frictions in this paper.

[3] Some argue (e.g. Boldrin and Levine, 2009) that there are many other ways to protect innovation without patents (e.g. secrecy, lead-times, holding on to key personnel, etc.) and their harms outweigh their benefits. These mechanisms are important – and much more important in some industries than others (e.g. Cohen and Levine, 1989). We are skeptical, however, that wholesale abolition is called for. For example, it is hard to believe that the bio-pharmaceutical industry could flourish with any patents.

In the early 1990s, the IO literature started incorporating these incentives into formal models and examining new ones. One way to look at this was in models of entry with spatial competition. In stage two, there is a game in the product market, say with product differentiation generating imperfect horizontal competition. At Stage 1, there is a decision to pay a sunk cost to enter and at Stage 2 a "short run" pricing game a la Hotelling (1929) and Salop (1979). Competition depends on (i) the endogenous number of firms and (ii) the degree of product substitutability, which is governed by consumers' preferences and represented by the slope of the Hotelling "umbrellas" (actual or psychic transport costs). If consumers begin perceiving that products are more substitutable (increased competition), there are lower markups for any given number of firms in the market, and so fewer firms can be sustained in the market. If we regard the sum of sunk costs to enter as R&D, there will be lower aggregate R&D as the market is less attractive. Dasgupta and Stiglitz (1980) described this effect by saying, "ex post competition drives out ex ante competition", and this is the essence of the Schumpeterian effect of competition.[4]

Gilbert and Newbery (1982) emphasize another positive reason why monopolists may innovate more. They consider R&D incentives for a non-drastic innovation – one where the successful innovators costs are not so low that they can charge the monopoly price and still drive all other firms out of the market. They compare an incumbent monopolist with a potential new entrant. Arrow's replacement effect would give the entrant the strongest R&D incentives. However, if the monopolist innovates he stays a monopolist. By contrast, if the entrant innovates she enters the market as a duopolist. Since joint profits under duopoly will be lower than monopoly profits (unless there is perfect collusion), the monopolist will "bid more" for the innovation. This is a pre-emption incentive that Gilbert and Newbery (1982) labelled the (private) "efficiency effect". Several papers put the replacement and efficiency effects into more general IO theory models (see Chapters 8 and 10 of Tirole, 1989).

Endogenous Growth Theory

In the late 1980s and early 1990s, these innovation models were firmly in the realm of micro-theory (see the Reinganum (1989) for a good overview). The revolution of Aghion and Howitt (1991) was to bring some of their insights into macro growth models.

[4] Note that there will generally be an inefficiently high level of R&D in these models. There is actually inefficiently high entry as firms compete for market share through business stealing and do not internalize the loss of rivals' profits from the sunk cost of entry. In more general models, these business stealing effects need to be weighed against the knowledge externalities of R&D which have been found to be empirically large. Most empirical assessments have found that the knowledge spillovers dominate, implying under-investment in innovation from society's perspective (e.g. Bloom, Schankerman and Van Reenen, 2013).

One issue with early endogenous growth models was that they all predicted that increases in competition discouraged innovation by reducing the returns to R&D. Some models, such as Romer (1990), had a relatively simple supply side - monopolistic competition with Constant Elasticity of Substitution preferences and symmetric firms. Although this simplifies the analysis so that a representative agent approach could be used, it leaves no role for firm heterogeneity, creative destruction and therefore the issue of strategic competition. The prediction that competition discourages reflects Schumpeter's early intuition of competition reducing the rents from a sunk cost investment like R&D entry costs. The same effect is also at play in Aghion-Howitt (1992), but the paper did open a rich seam of empirical and theoretical work linking Industrial Organization (IO) and growth through endogenous innovation.

2.2 Confronting theory with empirical evidence

2.2.1 Empirical Approaches to the innovation-market structure relationship

Initial attempts

The very early empirical evidence was based case studies of particular firms or industries. As useful as these can be for developing theories and intuitions, it was not until after the Second World War that this area, along with the economic profession, turned to more systematic quantitative evidence. Scherer was an early pioneer in studying the empirical link between competition and innovation, primarily establishing a positive relationship between firm size and concentration on the one hand and patenting activity on the other (Scherer, 1965a, and 1965b). Cohen and Levin (1989) provide a comprehensive survey of this early econometric literature, concluding that although some factors, such as technological opportunity and appropriability, had clear positive effects on innovation, the role of market structure remained deeply ambiguous.

The Modern Literature

The advent of new panel data on innovations, new econometric methods and more powerful computers allowed the burgeoning of a rich micro-empirical literature investigating the predictions of endogenous growth theory, heavily influenced by Aghion and Howitt's work.
Blundell, Griffith and Van Reenen (1995, 1999), henceforth BGVR, were among the first to use firm level panel data on innovations to advance this literature. They tackled two related issues - could the correlation between market structure and innovation be interpreted *causally*, and if so, *why* would market structure enable firms to be more innovative?

They found three main results. First, their measures of industrywide competition had a strong positive association with innovation - e.g. industries that became more open to imports and/or less concentrated subsequently had larger numbers of directly measured innovations and patents. Second, within an industry, higher market share firms also tended to be more innovative. They argued that this could be explained by the greater incentives high market share firms has to innovate (as in Gilbert and Newbery, 1982). Their third result was testing this hypothesis by examining the heterogeneous response in the stock market (as a measure of the firm's value) to innovation events. They showed that changes in a firm's innovation or patenting boosted stock market values, especially if these were "surprise" innovations (an idea that has been taken up in the event studies of Kogan et al, 2017). Most importantly, they established that the magnitude of the innovation-induced increase in value was much greater for firms that already had high market share.

A crucial part of BGVR was assembling new firm level panel data on innovation and new econometric methods - a fixed effects estimator that exploited pre-sample data to control for unobserved heterogeneity in dynamic count data models.

Innovation Data

One key issue in this literature is how to measure innovative output. BGVR used data on commercialised innovations collected by the Science Policy Research Unit (Pavitt et al, 1987) and linked it with accounting data on publicly listed UK firms. The SPRU data were based on expert surveys identifying over 4,000 of the most "technologically important and commercially successful" innovations in the UK since the Second World War, as well as the names of the firms who first produced and used them. These data provided a long time series and were instrumental in enabling the burgeoning of a new body of empirical innovation work (see Geroski, 1995).[5] In addition, BGVR matched in the more conventional patents data from the US Patents Office.

Patents data and R&D expenditures are the other main measures of innovation, in addition to total factor productivity (TFP) - a residual measure of the amount of growth that cannot be explained by other factors. Each of these measures have strengths and weaknesses.

R&D expenditure is an input, not an output. In addition, it tends to focus on formal activities in labs rather than the more informal search for innovations. Moreover, in many countries and

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[5] The Community Innovation Survey (CIS, https://ec.europa.eu/eurostat/web/microdata/community-innovation-survey) run by Eurostat also attempts to measure innovations directly. Survey questions are a mix between innovation that is "new to the firm" (diffusion) and "new to the economy" (our definition of innovation), however.

time periods it has not been mandatory for firms to report R&D spending. For example, in the UK prior to 1990 it is generally not reported, even by publicly listed firms. In the US, R&D is well reported for publicly listed firms, but not privately listed ones. Administrative data sources are better in this respect, although they are typically only samples and access is often hard for researchers.

Patenting activity, innovation counts and TFP are all output measures. Patents are a very heterogeneous measure of innovation (see Griliches, 1990); a patent can represent a fundamentally new technology worth billions, or an incremental improvement in an existing technology worth little. The advantage of R&D is that it is measured in dollars, so has a natural value attached to it. Various solutions to the problem of valuing patents have been implemented include citation-weighting (assuming that more valuable patents are more often cited), family size (taking out protection in more countries signals greater value), renewals and/or using stock market data (e.g. Pakes, 1986).

TFP is a measure of technological progress (and thus implemented innovative activity).[6] However, for most firms TFP growth is not pushing the technological frontier forward, but rather reflects diffusion of innovations to the firm, not new to the world. In addition, it may reflect other things than technology, such as managerial efficiency improvement. Moreover, this assumes that TFP is perfectly measured. In reality, there are a large number of problems with measuring outputs and inputs. The lack of firm-specific output price measures means that TFP reflects price-cost markups as well as technical efficiency (Hall, 1988; Klette and Griliches, 1996; de Loecker, 2011). Mismeasurement of input prices and quality also cause biases (e.g. de Loecker et al, 2016). Despite these issues, huge progress has been made in recent years in better TFP measurement and production function estimation (see de Loecker and Syverson, 2021, for a review). And TFP has the advantage of being in principle measured on a cardinal scale like R&D, but more available across a wider spectrum of firms.

Econometrics of Innovation

The modern empirical literature tried to tackle a number of empirical challenges. Prior work had largely used cross sectional data to establish correlations between innovation on the one

[6] TFP reflects the adoption of various technologies which are sometimes measured directly – Information and Communication Technologies, robots, new drugs, artificial intelligence, etc. The "intangible capital" approach treats these as other forms of capital, which in principle can be measured in the same way as tangible capital through the Perpetual Inventory Method (see Haskel and Westlake, 2017). But these are mostly about diffusion rather than innovation per se, which is the focus of this paper.

hand and market structure on the other. However, this relationship is inherently dynamic and nonlinear. A successful innovation will likely lead to firm growth and an increase in the firm's market share; this growth in market share will change a firm's ability and incentives to innovate.

BGVR adapted the panel data literature on estimating non-linear count data models with firm fixed effects when such dynamic feedback effects are important. The firm fixed effects try to capture the unobserved heterogeneity, such as the vastly different technological opportunities and appropriability conditions facing firms. Failing to control for these firm capabilities could lead to spurious associations between firms' innovative performance and their market position. Richer panel data allowed researchers to control for other, potentially confounding, firm and industry characteristics that affect innovation and firm performance. Policy variation and better econometric methods helped to identify the causal impact of competition on innovation.

2.2.2 Bringing the theory and empirical evidence closer together

At the start of the 21st Century, the advances in empirical evidence seemed at face value to contradict the theoretical literature. Theories of industrial organisation (e.g. Salop, 1979 and Dixit and Stiglitz, 1977), and endogenous growth theories (e.g. Romer, 1990, Aghion and Howitt, 1992 and Grossman and Helpman, 1991) predicted that increased product market competition would reduce the returns to entry and innovation, and so discourage it. However, the empirical literature like BGVR pointed to net positive effects. In addition, although some theories also pointed in that direction, such as Arrow's replacement effect, these were not incorporated into canonical models.

The inverted-U model: Theory

In an attempt to reconcile this empirical evidence with standard theory Aghion, Bloom, Blundell, Griffith, and Howitt (2005, henceforth, ABBGH) developed a model of the "Inverted U" relationship. This idea built on work by Aghion, Harris and Vickers (1997) and Aghion, Harris, Howitt and Vickers (2001). The model extends endogenous growth theory by allowing both current technological leaders and their followers to innovate. It assumes that innovations by leaders and followers all occur step-by-step, that is an innovator cannot move too far ahead of the lagging firm, due for example, to knowledge spillovers. If a firm that is already at the technology frontier in an industry innovates, the follower will automatically learn to copy the leader's previous technology.[7]

This assumption means that there are two kinds of sectors in the economy: (i) *levelled* (or *neck-and-neck*) sectors where both firms are at technological par with one another, (ii) *unlevelled* sectors, where the *leader* is one-step ahead of its competitor.[8] The model implies that innovation incentives depend not only on post-innovation rents (which is how they had previously been modelled in the endogenous growth models where all innovations are made by outsiders), but on the *difference* between post-innovation and pre-innovation rents. More competition will foster innovation and growth when it increases the *incremental profits* from innovating - i.e. when it reduces a firm's pre-innovation rents by more than its post-innovation rents.

The role of innovation in this model is that it allows firms to escape competition, to move one-step ahead in technology terms from its rival. This incentive to escape competition is likely to be most powerful when firms are operating at similar technological levels: in this case, firms have incentives to compete *for the market* to escape competition *in the market.*

By contrast, where innovation is made by firms that are using inferior technologies (laggard firms), their pre-innovation profits are low and increased product market competition does not have much of an impact on these. What increased product market competition does is reduce their post-innovation rents - a rent dissipation effect - which disincentives them from innovating.

On average, an increase in competition thus has an ambiguous effect. The model captures the Arrow replacement effect (escape competition) as well as classical rent dissipation (Schumpeterian effect).

The inverted-U arises because the fraction of sectors with neck-and-neck competitors is itself endogenous, and depends upon equilibrium innovation intensities in the different types of sectors. When competition (as measured by consumer price sensitivity) is low, a larger equilibrium fraction of sectors involves neck-and-neck competing incumbents, so that overall

[7] The basic model has a duopoly structure, but it can be generalized in order to think of the follower as a group of firms.

[8] Aghion et al. (2001) analyse the more general case where the leader can move any number of steps ahead, but this provides no closed-form solution for the equilibrium R&D levels and the steady-state industry structure. Thus it cannot formally establish qualitative results such as the existence of an inverted-U relationship between competition and innovation or characterize the relationship between competition and the distribution of technological gaps. More recent work has tackled this by numerical simulation methods (e.g. Aghion, Bergeaud and Van Reenen, 2021).

the escape-competition effect is more likely to dominate the Schumpeterian effect. On the other hand, when competition is high, the Schumpeterian effect is more likely to dominate, because a larger fraction of sectors in equilibrium have innovation being performed by laggard firms with low initial profits.

Putting this together with the effect of competition on the equilibrium industry structure, ABBGH establish an inverted-U relationship - if the degree of competition is very low to begin with, an increase in competition results in a faster average innovation rate, whereas if it is high to begin with then an increase in competition results in a slower average innovation rate.

This arises because when there is not much competition, the incentive for neck-and-neck firms to innovate is low, so the industry will be slow to leave the levelled state (which happen when one of the neck-and-neck firms innovate). The overall innovation rate will be highest when the sector is unlevelled, so the industry will be quick to leave the unlevelled state (meaning the lagging firm innovates). As a result, the industry will spend most of the time in the levelled state, where the escape-competition effect dominates, meaning that starting from a low degree of competition, an increase in competition should result in a faster average innovation rate.

On the other hand, when competition is initially very high there is relatively little incentive for the laggard in an unlevelled state to innovate. Thus, the industry will be relatively slow to leave the unlevelled state. Meanwhile, firms in the levelled state face a large incremental profit giving them a relatively large incentive to innovate, so that the industry will be relatively quick to leave the levelled state. As a result, the industry will spend most of the time in the unlevelled state where the Schumpeterian effect is at work on the laggard, while the leader never innovates, so if the degree of competition is very high to begin with, an increase in competition should result in a slower average innovation rate.

The reason that the escape-competition effect dominates when competition is low, whereas the Schumpeterian effect on laggards dominates when competition is high, is this “composition effect” of competition on the steady-state distribution of technology gaps across sectors.

The inverted-U model: Evidence

Figure 1: Empirical Inverted U relationship

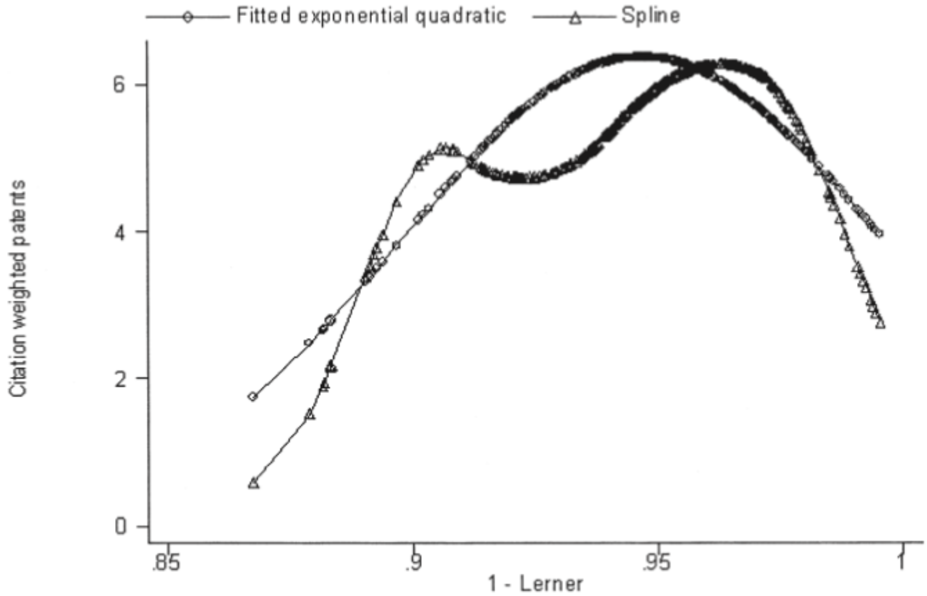

FIGURE II
Innovation and Competition: Exponential Quadratic and the Semiparametric Specifications with Year and Industry Effects

Source: ABBGH (2005)

ABBGH provided empirical support for these predictions using non-parametric estimates of the relationship between patents and the Lerner Index (the estimated price cost margin at the industry level) for UK firms. Figure 1 shows the basic relationship in the raw data, using both an exponential quadratic curve and a nonparametric spline fitted to the data. The horizontal axis is one minus the Lerner, so is increasing in competition. A value of 0.9 implies a price-cost margin of 10%, whereas a value of one is when price equals marginal cost (perfect competition). Each circle or triangle represents an industry year observation. As industry competition rises from 0.87, cite-weighted patents increase, but eventually plateau at around 0.95 and then decrease when competition becomes very high.

A concern about this correlation is the endogeneity of the market power measure. To tackle this issue ABBGH instrument the Lerner Index with three sets of policy instrument: (i) the Thatcher-era privatizations, (ii) the EU Single Market Programme, and (iii) Monopoly and Merger Commission investigations that resulted in structural or behavioural remedies being imposed on the industry. They include industry and time effects, so the instruments identify the impact of competition using the differential timing of the introduction of policy changes across industries. The basic relationship that is shown in Figure 1 in the raw data holds up to this extended analysis. Further, as predicted by the theory, more neck-and-neck industries show a higher level of innovation activity for any level of product market competition, and the inverted-U curve is steeper for more neck-and-neck industries. The authors show robustness of the results to alternative measures of technology (e.g. R&D expenditure instead of patents) and competition (e.g. the Herfindahl Index instead of the inverse Lerner Index). We discuss some policy implications of these findings in Section 3.1 below.

Direct extensions of the Inverted-U model

ABBGH spawned a literature that proposed both complementary and contradictory theoretical models, and that provide both empirical support for the inverted-U and evidence that seems to question the robustness of the relationship.

Papers that extend the approach include Aghion et al (2009), who study the impact of foreign entry as a form of competition, and show that the impact on domestic incumbent firms depends on the technology distance between the firms. Aghion et al (2008) and Griffith and McCartney (2014) consider the mitigating impact of labor market institutions. Haruyama (2006) adds three additional reasons that complement ABBGH and reinforce the inverted U, these relate to cross industry R&D spillovers, the cumulative aspects of technological progress, and rent protection activities by firms. Hashmi (2013) finds a negative relationship between competition and innovation using US data. The model in ABBGH uses the assumption that the technology gap between the leading firm and the laggard can be only one-step. Hashmi relaxes that assumption and shows that this generates richer dynamics and means that the relationship between competition and innovation can be positive, negative or an inverted U depending on how close or far competitors are in technology space (what AABGH call the degree of neck-and-neckness of the industry); to quote that article: *"The reconciliation of the empirical results between the U.K. and the U.S. samples depends on the assumption that the U.K. industries are more neck-and-neck than the U.S. industries. This is just one possible explanation for the different empirical results. The different results could also be attributed to differences in the data sets and the samples."*

Beneito, Rochina-Barrachina and Sanchis (2017) find a positive relationship between competition and innovation using Spanish data. They extend the ABBGH model to accommodate the possibility that inefficient firms face the threat of exit when competition intensifies, and this generates a model in which the effect can be positive or an inverted U. In sectors where there is a laggard firm that uses non-frontier technology (unlevelled sectors in

ABBGH) then the threat of exit means that these laggard firms have an incentive to innovate to avoid bankruptcy, and this offsets the negative Schumpeterian effects. De Bondt, Raymond, and Vandekerckhove (2012) provide an excellent discussion of the literature, and highlight earlier work by Kamien and Schwartz (1976) that showed an inverted U relationship, and which is not well acknowledged in the literature.[9]

In conclusion, a number of papers provide empirical support for the inverted U,[10] and while others show empirical evidence that questions the robustness of the relationship[11], our sense is that the inverted U relationship has held up reasonably well. On average, though the relationship between innovation and competition tends to be more positive than negative.

3 Some Applications and Developments

This body of work has wide-ranging implications for policy and future research in economics. We discuss three of these – competition policy, international trade and structural models.

3.1 Competition Policy

Competition policy (often referred to as anti-trust policy in the US) refers to the set of laws, regulations and policies that governments put in place to guard against the unnecessary creation and abuse of market power. Primary among these is merger policy, where competition authorities investigate whether a proposed Merger and Acquisition (M&A) is against the public interest. However, policies over collusion and abuse of an existing dominant position are also important.

Economic thinking is deeply embedded in competition policy, with consumer welfare having been generally adopted as the standard criteria for whether or not a merger is harmful. The standard test is whether a proposed merger is likely to lead to a significant reduction in

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[9] In that model, firms compete in R&D to win a patent. The firm trades off the cost of accelerating research effort with the payoff from successful innovation; increased competition increases the risk of someone else getting the patent first; leading to an inverted U relationship.

[10] These include Aghion and Braun (2008) for South Africa, Lambertini et al (2017), Pender and Woerter (2014) with Swiss data, Polder and Veldhuizen (2011) for the Netherlands, and Askenazy and Irac (2013) using French data.

[11] These include Hashmi (2013), Tingvall and Poldahl (2006) with Swedish data, Michiyuki and Shunsuke (2013) for Japan, and Correa (2012) who provide an econometric investigation of the parametric version of the model estimated by ABBGH and show evidence of a structural break that coincides with the establishment of the US Court of Appeals for the Federal Circuit in 1982. The find a positive relationship between competition and innovation in the period prior to 1982 and no relationship after 1982, and argue that the empirical results in ABBGH are driven by misspecification.

competition often interpreted as when there is likely to be an increase in (quality-adjusted) prices.

Innovation considerations are increasingly discussed in competition cases. For example, the European Commission blocked a merger of the agricultural chemicals division of Dow and DuPont largely on innovation grounds (European Commission, 2016). Gilbert and Green (2015) surveyed US merger cases in high tech sectors and found that since 2000, most challenges by US antitrust enforcers to mergers have included allegations of harm to innovation. The Department of Justice (DoJ) raised innovation concerns in US vs. Microsoft (as did the European Commission's DG-COMP) and in its recent action against Google. The Federal Trade Commission (FTC) filed a complaint that Facebook harmed innovation by acquiring Instagram and WhatsApp. Gilbert, Riis and Riis (2021) discuss these in more detail and show how elements of the "Inverted U" approach can be generalized in merger analysis.

Nevertheless, judges frequently complain that standard economics is of limited practical use. Traditionally, Schumpeterian "dynamic considerations" are set against the traditional static considerations of antitrust. Under this view, a horizontal merger may create monopoly power and so generate static consumer losses, but a more concentrated market could support greater innovation. These may be through the incentive effects discussed earlier, through relieving financial constraints that hold back R&D (which has high sunk/fixed costs and much uncertainty) or through reducing duplicative research. Thus, merging parties could in principle appeal to the dynamic efficiency benefits that will ultimately more than offset the static deadweight losses.

As we have seen, however, these arguments are likely to be fragile in a generic sense, as there are as many reasons why a more competitive market could stimulate greater innovation (e.g. Arrow's replacement effect). Indeed, the argument could be turned on its head. Even if a merger reduced prices due to (say large short-run) merger-related marginal cost synergies, the innovation losses in the longer-run from a reduction in competition could outweigh these static gains.

What does the inverted-U model imply for policy? What it clearly does *not* imply is that competition policy should be lax on firms with market power. It does suggest that at high levels of competition it might be important to weigh up potential dynamic efficiency losses versus static efficiency gains from tough anti-trust policy - i.e. focus more on competition *for the market* than competition *in the market* - although this range is not nearly as large as previous theory suggested.

The prior of most competition authorities, at least in Europe, is that competition is beneficial for innovation/dynamic efficiency. For example, Kai-Uwe Kuhn the former Chief Economist of the EU's DG-COMP, has argued that the most controversial merger cases (those that go to Phase II after the Commission has issued a Statement of Objection) are by their nature in less competitive markets (Kuhn et al, 2012). Hence, they will usually be on the upwards sloping region of the inverted U, meaning a negative innovation effect from the reduction in competition.

The empirical evidence on using natural experiments from anti-trust policy changes on innovation is thin. Watzinger et al (2020) find substantial increases in innovation following the US government's break-up of AT&T into the "Baby Bells". By contrast, a recent paper by Kang (2020) examining all prosecuted US cartel cases finds that innovation was higher when the cartels operated than when they were suppressed (but argues that the effects are via relaxing financial constraints rather than product market effects).

The Aghion-Howitt perspective also implies that it might be important to consider the impact of market liberalization and tough anti-trust policy on industries that lag behind the technological frontier. This is not to suggest that these industries should be protected, but that complementary institutions and policies may be required to cope with the displacement of workers. The results also suggest that in industries where firms are currently well matched technologically, anti-trust might be particularly effective at spurring innovation, as these firms seek to escape competition. In industries where firms lag behind the technological frontier other policies might be need to facilitate innovations aimed at catching up with the frontier. These policies could increase the fraction of industries where there is neck-and-neck competition and in this way encourage aggregate innovation.

A final implication is that patent policy is a necessary complement to competition policy. Patents ensure that an innovative firm is rewarded, while competition policies ensure that firms that do not innovate earn little rents. It is important though, that patent policies do not make it difficult for frontier firms to lock their positions in, as this generates too few neck-and-neck industries and aggregate innovation is thereby reduced.

Although it has always been there, the issue of innovation is rising up the agenda of competition authorities. This is primarily because of the growth of the importance of dynamic high tech sectors where innovation (rather than price) is the key mode of competition. This is most obvious in digital sectors, which have become dominated by the GAFAMs (Google, Amazon, Facebook, Apple and Microsoft). These multinationals have achieved stratospheric market valuations and come to dominate increasing numbers of sectors. Part of the reason for their dominance are a number of powerful network effects, which gives their core markets a "winner takes all" flavour. For example, Google dominates in search in large part because of data. When someone uses Google to search, it helps improve the quality of the underlying algorithm. In addition, the better this search algorithm the more people will use it. It is hard for rivals to break into this market, because the data Google amasses on search means that other engines struggle to be as attractive, even if sponsored by deep financial pockets – e.g. Microsoft's Bing). The product itself is free, but the value is monetized through advertising.

There are many competition concerns with the GAFAMs. A major one is that the dominant platforms cement their power through reducing future competition by stifling rival innovation (see Tirole, 2020, for a comprehensive overview). One strategy is to try to kill off a promising start up through business strategies such as degrading interoperability between the dominant firm's platform and that of the entrant. This was at the heart of the European Commission's landmark case against Microsoft in 2004 (see Kuhn and Van Reenen, 2009; Genakos et al, 2018). Ultimately, this is about degrading a rival's ability to innovate by restricting access to some essential facility such as a platform or core data.

If a rival cannot be thwarted through these raising its costs, an alternative tactic may simply be to buy up the competitor. In the 1990s, start-ups would aim to have an exit strategy by eventually doing an IPO. Today, venture capitalists are more likely to state that the "exit strategy" is not to become the next Amazon or Microsoft via an IPO, but rather to be acquired by a tech titan. This may have benefits to the smaller firm, but it deprives the consumer from competition with an alternative provider.

Such acquisitions can be even worse than simply reducing competition. Cunningham et al (2021) describe the phenomenon of "killer acquisitions" where a dominant firm takes over a smaller firm and kills off its nascent technological innovation. They show this happens in parts of the pharmaceutical industry, where a new drug in a biotech's pipeline would threaten a drug maker's inferior current product. Rather than spend the additional R&D resources to take the drug to market (e.g. Phase III trials, marketing, etc.), Big Pharma may prefer to simply continue enjoying their rents from the current branded product.

The key problem is that a dominant firm may use its power to reduce the ability and incentives of rivals to innovate. In principle, competition authorities could act on this, but in practice, it is difficult. For example, consider a merger investigation. The standard practice is to look at the *current* market shares of the merging parties to assess the risk to competition. GAFAM acquisitions of start-ups are based on their future potential, not current size. When Facebook took over Instagram and WhatsApp, they were relatively small platforms, which did not add much to Facebook's market share, whatever the market definition. However, clearly Instagram and WhatsApp had the potential to grow and potentially threaten Facebook's dominance. Blocking the acquisition would have to be based on the risks to future competition. This is particularly difficult in the US where the DoJ and FTC have to convince a judge that there is a greater than 50% chance of competition being harmed. The parties can easily argue that the empirical evidence for this is thin.

As Tirole (2020) and de Loecker, Obermeier and Van Reenen (2021) argue, the standard of proof in such cases should be shifted more to the dominant firm to provide greater assurance that the takeover will *not* reduce innovation. The Furman Report (2019) suggests many similar reforms for the UK Competition and Markets Authority (CMA) in judging M&A as well as the creation of a specialist regulator for the digital sector. The European Commission's proposed Digital Services Act (DSA) and Digital Markets Act (DMA) is along similar lines.

All these considerations of competition policy are rooted in Aghion and Howitt's emphasis that future innovative incentives should be front and centre of decision-making.

3.2 International Trade

Static Effects of trade on Productivity and Diffusion

There is a vast literature examining the impact of competition on productivity (of which innovation effects are a subset). The survey by Van Reenen (2011) argues that on average positive effects of competition on productivity are uncovered although there is certainly a large degree of heterogeneity. Part of the impact is through reallocation on the extensive and intensive margins. Syverson (2004), for example, shows that productivity is higher in the concrete industry in locations with greater competition, because lower productivity establishments shrink and exit. However, part of the impact is through changes within firms whereby an increase in competition causes an incumbent firm to upgrade its productivity (Backus, 2020). This is a theoretically more ambiguous effect because, like the inverted U, there can be positive Arrow-like escape competition effects, as managers work harder to avoid losing rents, but negative Schumpeterian-like effects from lower rents. The empirical work suggests positive effects on average. Holmes and Schmitz (2010) survey the evidence and discuss many interesting case studies, such as the opening of the Great Lakes. They stress how competition forced many incumbents to move to more efficient management practices. The importance of competition for improving management has also been demonstrated econometrically by Bloom and Van Reenen (2007), Bloom, Propper, Seiler and Van Reenen (2015) and Bloom, Sadun and Van Reenen (2016) using explicit measures of management.

This literature is fundamentally static, however, rather than examining innovation *per se*. We next turn to this.

Dynamic Innovation Effects

Changes in the patterns of international trade offers some sharp changes to competition. However, the impact of trade is complex because it may operate on multiple margins (see Shu and Steinwender, 2018 and Melitz and Redding, this volume, for a longer discussion). Much of the literature has focused on the positive impacts of exports on innovation. A reduction in the barriers to exporting effectively increases the effective market size faced by a firm, and a wide class of models implies that larger markets will encourage innovation. For example, if there are fixed costs of R&D, a larger market means that these fixed costs can be spread across a wider number of units. Several papers have shown positive effects of growth of export market size on innovation (e.g. Aghion et al., 2018; Aghion, Bergeaud and Van Reenen, 2021; Aw, Roberts and Xu, 2011).

Direct product market shocks are clearer when barriers to imports (e.g. tariffs) in a firm's product market fall. In this case, a firm faces increased competition from foreign exporters. Although entry into a firm's input markets may have a clear benefit in terms of a wider variety, higher quality and lower cost of inputs, the Aghion-Howitt perspective suggests that product market competition may have more ambiguous effects (e.g. the "inverted U" discussed above). The early firm-level work by Blundell et al (1995, 1999) found positive correlations between innovation and import penetration in the firm's industry, even after controlling for fixed effects. Although suggestive, there could be other factors driving the relationship: an unobserved shock to domestic growth expectations could boost both innovation and imports, for example.

Much recent work has used the rise of China as a prospective exogenous quasi-experiment. The growth of China is clearly due to policy decisions starting with Deng Xiaoping in the early 1980s, to open up China's economy, in order to make the country the "workshop of the world". This accelerated with China's accession to the World Trade Organization in December 2001, causing an enormous growth in Chinese goods imports into Western countries.

The impact of the "China Shock" (Autor, Dorn and Hanson, 2013) on US labor markets has been extensively discussed. Bloom, Draca and Van Reenen (2016) examined the impact of Chinese imports on technical change in 12 European countries since the mid-1990s. They found that although firms more exposed to the China shock reduced employment, they increased their innovation as measured by raw or cite-weighted patent counts. They also found increases in adoption of IT and in TFP. Moreover, the falls in jobs were much stronger in low-tech firms, implying that China stimulated technological upgrading both within firms and through reallocation towards more innovative firms. This positive mean impact of import competition on innovation emerged from simple correlations of the long-differenced growth in patents and Chinese import penetration, as well as an identification strategy using the industry specific removal of quotas as part of WTO Accession (specifically, the abolition of the Multi-Fiber Agreement which China gained access to when it joined the WTO).

By contrast, Autor, Dorn, Hanson and Shu (2020) looked at US data and found negative effects of Chinese imports on US firm patents. The identification strategy of Autor et al (2020) was different to Bloom et al (2016), and used increases in Chinese imports in European industries as an exogenous shift to those in the US. Nevertheless, Bloom, Romer, Terry and Van Reenen (2021) show that replicating the same Autor et al (2020) IV strategy on the European data continued to produce positive effects.[12]

Autor et al (2020) and Bloom et al (2021) both suggest that the "Inverted U" approach of ABBGH offers a reconciliation between the differing results in the EU compared to the US. European markets were generally less competitive than US manufacturing markets in the 1990s, due to greater regulation and fragmentation (e.g., the Single Market was still being built). Hence, the China shock moved countries along the upward sloping part of the inverted U. By contrast, in the more competitive markets of North America, we may be on the downward sloping part of the inverted U, so even higher competition causes the Schumpeterian effect to outweigh the "escape competition" effect.[13]

3.3 Structural IO Approaches

Introduction to Structural Models

As noted earlier, an advantage of the Aghion-Howitt creative destruction approach to endogenous growth compared with Romer-style expanding variety approaches, is that firm

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[12] Bloom et al (2021) develop the theoretical underpinnings through a "trapped factor" model, where the resources (like skilled labor) displaced within a firm by Chinese competition are redeployed into innovation activities. They embed this in a macro endogenous growth model to show the large impacts of China on Western aggregate innovation. Quispe (2020) also finds positive effects of China's WTO accession on quality upgrading in Peru.

[13] This explanation chimes with our contrast between the UK findings in ABBGH and the US work of Hashmi (2013) discussed earlier.

heterogeneity is at its centre (e.g. in the decisions of entrants vs. incumbents). This makes it a natural framework for thinking about innovation and market structure.

The Aghion-Howitt framework is, in some ways, a marriage between IO, where imperfect competition and firm heterogeneity has always been central, and macro, which focuses on the need to explicitly aggregate in order to understand general equilibrium outcomes such as growth.

There is a growing body of structural IO work, which has been influenced by Aghion-Howitt, but draws more on modern IO approaches that explicitly estimate models of innovative conduct in specific industries. This contrasts with the more "reduced form" work on innovation and market structure described above, which is less wedded to estimating structural parameters from a specific model of conduct.

The advantages of taking a structural approach is that the behaviour of players in the game can be characterized explicitly and deep parameters are in principle identified. It is therefore possible to conduct more credible counterfactual exercises (e.g. what would have happened were a merger banned) explicitly examining changes in (partial) equilibrium objects such as price and innovation. Importantly, it is also possible to explicitly quantify social welfare under different policies and changes in market structures.

The disadvantages of a structural approach is that one will usually have to take a narrower focus on a specific industry in order to institutionally justify the modelling assumptions. Thus, it is hard to generalize. Secondly, stronger assumptions typically have to be made, particularly around functional forms, in order to recover parameters. Third, the models and estimation techniques are quite complex, making it harder to assess the credibility of the identifying assumptions.

Static structural IO models of short-run price and quantity games are common (for surveys see Pakes, 2021 and Ackerberg et al, 2007). However, these mostly take as given the level of productivity and the number/quality of brands/products. R&D investments are designed to explicitly enhance these primitives and taken at an earlier stage. Structural dynamic models of investment will be strategic given the imperfect competition in the later stage of the game. Estimating these dynamic games poses many tricky issues, especially since multiple equilibria are endemic.

Some structural IO papers on innovation and competition[14]

[14] Our review is partial by necessity and we leave out many good papers. For example, Yang (2020) studies the incentives to innovate in a vertical relationship, such as System-on-a-Chip vendors selling technology to cell phone manufacturers. Empirically, the benefits of a hypothetical merger between Qualcomm and a smartphone

Goettler and Gordon (2011) estimate a dynamic oligopoly game of the PC micro-processing industry where there was competition between leader INTEL and AMD over several decades. They incorporate the durable nature of the good by making demand and price-setting dynamic. They perform a counterfactual analysis of innovation under an Intel monopoly and find that Intel would innovate by about 4% more in the absence of AMD. Consumer surplus, however, is overall higher with AMD competing because prices are lower. They emphasise that this depends crucially on the durable nature of the good. Product upgrades are necessary to stimulate demand, and they happen only if consumers value quality highly and are relatively price insensitive. Nonetheless, their bottom line is that they find that monopoly outperforms duopoly in terms of innovation.

Goettler and Gordon (2011) use a full solution concept, which requires explicitly characterizing the entire game.[15] Bajari, Benkard, and Levin (2007) propose a two-step approach to estimating dynamic investment models, which enables a researcher to relax some of the functional form assumptions (essentially, by taking a semi-parametric approach to estimating the R&D policy correspondence rule). This does not require solving for the full equilibrium. Hashmi and Van Biesebroeck (2014) implement this two-step approach in the global automobile industry. They model car quality for the average consumer, which is determined by the dynamic control variable, innovation (proxied by patents). Innovation as a function of market structure is not easy to characterize, but they do find that after entry although incumbent innovation falls, aggregate innovation rises. Thus, their conclusions are consistent with Blundell et al (1999) that although high market share is followed by more innovation, higher aggregate competition leads to higher aggregate innovation.

A disadvantage of the previous two papers is that they analyze the innovation decisions of a few incumbent firms. Igami (2017) goes beyond this to incorporate both incumbents and entrants (up to more than two dozens of firms)[16] and focuses on the incumbent-entrant heterogeneity in innovation incentives.[17] His context is the Hard-Disk Drive (HDD) manufacturing industry between 1981 and 1998. He finds that despite cost advantages and pre-

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manufacturer, who can then coordinate R&D incentives and reduce double marginalization, exceed the harms from foreclosing entry or increasing costs for other smartphone makers.

[15] This is also true in the approach of Benkard (2004) on aircraft.

[16] Aw, Roberts, and Xu (2011) study the Korean electric motor industry which is characterized by *many* firms and apply a monopolistic competition framework. This mutes strategic interactions between incumbents and entrants.

[17] Methodologically, he builds on Aguirregabiria, and Mira (2007) who study entry games (static and dynamic respectively) with incomplete information.

emptive incentives, incumbents innovate less than entrants because of the Arrow replacement effect – they do not want to cannibalize their own products.

Igami and Uetake (2020) look again at the HDD industry using data that are more recent 1996-2016, which was a period of rapid consolidation leading eventually to only three global players. Given this context, they focus on the impact of consolidation on innovation and whether competition authorities were too lax in allowing so many mergers. Unlike Igami (2017), they explicitly endogenize mergers and the evolution of technology at the frontier (i.e. Kryder's Law[18], which was kept exogenous in the earlier paper). Their estimates suggest that innovation and competition is more like a rise to a plateau than an inverted U. Their counterfactual analysis suggests aggregate innovation increases when the industry moves from monopoly to duopoly and from duopoly to triopoly. After this, it is less clear with a lot of heterogeneity across time and space. They conclude that the current competition authority "rule of thumb" which is not to allow further consolidation beyond three players is roughly right.

Another interesting recent paper is Bhattacharya (2021), who examined the US Navy's Small Business Innovation Research (SBIR) program. He considers this as a three stage game. Firms bid for R&D procurement contracts. The Navy puts out a request for solutions to an innovation problem. Firms compete and a subset are awarded a Phase I contract to develop a White Paper. Of those who innovate in this way, a subset of the players then progress to a Phase II where they try to develop a workable prototype. Finally, the Navy selects no more than one of these to produce the new product in a Phase III military contract for production, which is where the serious money is.

Bhattacharya (2021) observes the Phase II and III contracts (monies paid by Navy and some contract characteristics), and the identity of the successful firms at each stage. He builds a model where firms must decide how much R&D effort to supply at Phase I and Phase II motivated by the (small) prospect of a prize in the Phase III. Effort at Phase I increases the chances of stochastically discovering an innovation (of heterogeneous value) and progressing in the contest. Greater effort at Phase II will reduce the cost of producing the innovation. The Navy awards Phase III to the firm with the highest surplus (innovation value minus production

[18] Kryder's Law is an engineering regularity that says the recording density (and therefore storage capacity) of HDDs doubles approximately every 12 months, just like Moore's Law, which says the circuit density (and therefore processing speeds) of semiconductor chips doubles every 18–24 months.

costs), but pays only a fraction of this surplus to the firm. This generates the classic hold-up problem which means firms do “too little” R&D. The business stealing effect, however, also generates the possibility that there may be “too much” R&D. So there remains the classic Aghion-Howitt trade-off and which dominates is an empirical issue.

Bhattacharya (2021) structurally estimates the dynamic sequential contest and then simulates counterfactual policies. He finds that increasing competition, for example by allowing more firms to enter Phase II would increase both the quality of innovation and social welfare, as would be allowing the Phase III winner to keep more of the surplus. However, this does not happen in practice, and he argues that this is because the narrow interests of the Navy dictate a greater emphasis on cost containment than is socially optimal.[19]

Conclusions on structural models

Structural estimation of IO models of innovation and competition is a growing area, but the complexity of the problem has meant that progress has not been speedy. Overall, our take on the current literature is that, although there are certainly many differences between industries, increasing entry from monopoly (i.e. very low competition) does seem to increase aggregate innovation, but at some point, these gains flatten out. This is compatible with falling innovation for incumbents, which is compensated with the innovation of entrants. What is not clear is the point at which these aggregate gains may go into reverse (as in the downward part of the inverted U).

These models, and the development of more structural dynamic IO models with endogenous investment is an exciting area of frontier research and we expect to see many more papers in the next decade (see also Pakes, 2021 survey). An issue here is to ground the complex models in institutional reality and well identified causal parameters in a transparent way.

4 Conclusions

Aghion and Howitt’s work combined the insights of the IO literature on market structure and innovation into macro growth theory. Thus, it became a powerful way to link micro insights into growth policies.

[19] See Howell et al (2021) for a causal evaluation of a reform to the US Air Force’s SBIR program.

The evolution of the work in this area is clear. By the start of the 21st Century the econometric and data tools for the analysis of innovation and market structure had become well developed, allowing for estimation of the dynamic, nonlinear effects of competition with unobserved heterogeneity. However, this work (e.g. Blundell et al, 1999) strongly suggested the competition had a positive impact on innovation, rather than the negative impact the Schumpeter had highlighted that operated through the dissipation of innovative rents. AAGBH incorporated the insight from Arrow, that the pre-existing rents of a monopolistic incumbent created a disincentive to innovate, because these would be replaced by a new stream of innovation rents. When both insights were combined the impact was ambiguous. When put in an equilibrium step-by-step model some clear predictions could be made relating to the "Inverted U" and the impact of competition in levelled and unlevelled sectors. The relationship has held up reasonably well over time, although on average the positive effect of competition still seems to dominate empirically (see our discussion of applications in competition policy and international trade).

Where should research go from here? One can never write the music of the future, because if so, it would already be written. However, here are some suggestions.

First, the weight of the economy has shifted towards high tech, innovative sectors. Hence, understanding the dynamics of these sectors has become ever more important. Innovation requires *ex post* rewards, as this helps drive private sector incentives, i.e. we want firms to compete *for the market* of the future. But as well as allowing deserved rewards for innovation, a wise policymaker should seek to reduce artificial barriers that protect dominant firms from reducing the ability of rivals to innovate to catch up or replace the leader, as this reduces dynamic competition for the market. Some of these barriers are created by the government through regulation, trade barriers, etc. But some may be created by the incumbents who quite rationally, wish to reduce their chanced of being displaced (so stifle competition for the market). Strategies such as takeovers of potential future rivals, raising rival costs through reducing compatibility or other business practices and/or lobbying activities to protect market power are commonly used. We need to build institutions and develop policies (especially around competition authorities) that reduce the ability of incumbents to implement these strategies, even if they have achieved their success through legitimate innovation (see Van Reenen, 2018). This is a broader point than just market structure. Increasing inequality is a feature of many modern capitalist societies, and we need to ensure incumbents do not use their wealth and power to lock themselves and their descendants into elite positions (Case and Deaton, 2020).

Second, on a more methodological point, the use of quasi-experiments to better identify the impact of competition on innovation (and other outcomes) should be exploited more in this literature. One of the strengths of ABBGH was to pioneer this approach.

Finally, a critique of the general literature is that the models are relatively simple and applied to the economy as a whole. Focusing on more specific markets, as is accomplished in a typical structural IO paper, allows a richer description of the environment and institutions. This makes the modelling potentially more credible. Our sense is that this area will also grow in the coming decades.

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