Financialisation As An Enabler Or Inhibitor Of Innovation? The Case Of UK Biotech

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Financialisation as an enabler or inhibitor of innovation? The case of UK biotech

Pauline Gleadle*, Stuart Parris^,
Alan Shipman* and Roberto Simonetti*

* IKD, Open University, UK
^ Canterbury Christ Church University, UK

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Abstract:

This paper discusses the structural changes occurring in the Pharmaceutical and Biotechnology industries the basis for a case study to explore the existence of a relationship between financialisation and innovation . The paper specifically examines the extent to which structural change can be identified as an outcome of 'financialisation', and/or a test of the effectiveness of financialisation, especially in the UK and US. It focuses on the problem of financial resources transfer within the new industry structure, from large developers and marketers of drugs to small independent innovators. The industry's structural change permits a exploration of two related hypotheses. First, that the old vertically integrated structure was due (at least in part) to financial market imperfections, which made it more efficient to transfer financial resources within one company structure than between companies via financial transactions. Second, that the industry's vertical disintegration results (at least in part) from improvements in the efficiency of financial mediation, making market-based financial transfer more efficient than intra-firm transfer. However, in contrast to the theoretical expectations we find our case study of the biopharmaceutical industry highlights that the impact of financialisation has been to focus the transfer of financial resources towards opportunities with short-term near market opportunities, instead of focusing on long-term innovation projects.

Keywords: financialisation, biotechnology, cost of capital, private equity, innovation

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Contact Details: FINNOV-Enquiries@open.ac.uk
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Introduction

The pharmaceutical industry in the UK, Europe and US has undergone significant structural change, usually characterised as vertical disintegration of the research and development (R&D) process. A 'blockbuster model', in which large companies conducted all stages of the production process from early-stage R&D through later-stage clinical trials to volume production and marketing has given way to a more disaggregated model, in which the large companies concentrate on later-stage development, mass production, marketing and distribution, while specialist players focus on discovery and early-stage development. 'Big Pharma' has shifted from fully enclosing the R&D process to outsourcing its early stages, monitoring the progress of independent research on a variety of compounds but only mobilising resources for their commercial development when their potential has been proven elsewhere.

This structural change has been traced to the blockbuster discovery model encountering a falling productivity of R&D, as its ratio of costs to outcomes (drug approvals) has rapidly increased (Bunnage, 2011). Intensive R&D spending was economically worthwhile for as long as it yielded at least a few products that would generate very large sales over a long period, offsetting the many products that absorbed R&D expense but attained low or no sales. In-house R&D ceases to be profitable when it generates fewer marketable compounds and/or these fail to generate large sales value, owing to limited demand or rapid onset of generic competition. As a result, major Pharmaceutical players ('Big Pharma') have looked to alternative innovation models, including outsourcing core activities such as R&D and clinical activity (Chataway et al, 2007). Another widely used strategy by big Pharma has been the targeted acquisitions of small biotech companies with the expectation of being able exploit promising early stage innovations occurring in this sector. The result of the emergence of biotechnology SME has been a complex interaction and cooperation between a number of different players, from SME to multinational pharmaceuticals (Henderson et al, 1999).

This structural change has been extensively researched from the perspective of transaction-cost and resource-based theories of the firm. For example, Pisano (2006) cites various features of the industry's new, more dispersed structure that may have deterred biotech innovation, including the lack of means or incentives for information-sharing between firms researching similar areas, and the loss of human and knowledge resources due to high attrition rates of firms and research teams. Gopalakrishnan et al (2008) find that, to obtain the necessary flow of equity finance from Big Pharma partners, Small Biotech firms may have to yield up significant management control to these (even if they hold only a minority equity stake) and offer substantial access to R&D outputs. Among the key problems identified in these studies is that of property rights transfer: ensuring that Pharma companies can acquire and efficiently develop successful early-stage products from Biotechs, while paying these a sufficient reward that they retain both the means and incentive to go on developing new early-stage products.

This paper investigates the extent to which the structural change in the biopharmaceutical industry can be identified as an outcome of 'financialisation', and/or a test of the effectiveness of financialisation, especially in the UK and US. It focuses on the problem of *financial resources transfer* within the new industry

structure, from large developers and marketers of drugs to small independent innovators. The industry's structural change permits a test of two related hypotheses. First, that the old vertically integrated structure was due (at least in part) to financial market imperfections, which made it more efficient to transfer financial resources within one company structure than between companies via financial transactions. Second, that the industry's vertical disintegration results (at least in part) from improvements in the efficiency of financial mediation, making market-based financial transfer more efficient than intra-firm transfer.

Our focus in this paper is on financialisation and its impact on innovation. In order to explore these linkages, we define first what we mean by financialisation. We employ a composite definition of the term, drawing on a range of sources which we argue are particularly relevant to financialisation and its effect upon innovation. Specifically, firstly we define financialisation as encompassing the growing power of financial markets over companies in particular through greater pressure to maximise share prices and shareholder value. Secondly, financialisation is argued to involve a shift of profitability from 'real' operations to the 'financial' both within companies and for the economy as a whole. Thirdly, we define financialisation as involving a shift from equity towards debt in the composition of firms' financing. Finally, we argue that for the purposes of our definition, financialisation leads to a relocation of risk and return as investment is moved out of the 'real' portfolios of diversified multi-product firms and into the 'financial' portfolios of institutional investors chasing growth in companies with narrowly defined core competences.

Section 1 discusses the evolution of the pharmaceutical industry to its present structure, and the reasons for this. Section 2 examines the 'financialisation' aspect of this restructuring, and its implications for financing of small innovating firms. Section 3 examines the record of private equity and venture capital as a vehicle for financing the industry's vertically separated early-stage research, and section 4 looks at evidence for the public equity markets' adaptation to this financing need. Section 5 concludes.

1 Industry restructuring and the Bio-Pharma financing challenge

Big Pharma companies are generally highly profitable and cash-rich, because they focus on relatively mature products whose costs have been reduced by mass production and outsourcing and whose revenues are still held up by patent protection. However, they have limited opportunities for profitably re-investing in their own operations, since the highest returns are associated with new drug discovery that now takes place out-of-house. Small Biotech companies offer potentially high returns on investment, but they are generally unprofitable and cash-constrained in the years leading up to a major commercialisable discovery.

Biotechs and other small firms, while effective for early-stage R&D in particular areas, are generally unable or unwilling to follow their successful products through to later-stage development and production. Their preferred approach is generally to license or sell the proprietary rights to a Big Pharma company, channelling the proceeds back into early-stage work on other products, or to be acquired by a Big Pharma company, selling themselves as a unit in the process of selling the rights to

new product. The principal reason for small innovators not bringing their products to market (and relying on Big Pharma to do so) is the high cost of later-stage development, especially the large-scale clinical trials that are needed before a new product reaches the market, and of marketing and distributing new products after approval. Clinical trials absorb 35% of the industry's total R&D expenditure, compared with 23% for discovery; and 45% of Development expenditure compared with 20% for manufacturing and controls (Nikisch et al 2009: 313).

This has led to the rise of small (often privately-held) biotech companies which (a) develop early-stage products with the aim of selling them to large pharma companies when proven and/or (b) carry out early-stage research on contracts from larger companies. Cases of small biotech firms following-through an innovation and growing into large pharma companies are extremely rare: such a transition would require successful management of growth, internationalisation, and acquisition of Big Pharma's capabilities of mass-production, mass-distribution, marketing and regulatory compliance, and would still leave the new large player competitively vulnerable because of its specialisation on one product. So the industry configuration has remained one of a few large, diversified Pharma companies and a large number of small, innovation-focused biotechs, the second group sustaining itself through the sale of research outputs to the first.

Much of the new biotechnology related knowledge originates from university research, which is often commercialised through spin out activity. Biotechnology SMEs play an important role, acting as innovators for the pharmaceutical industry. 'Big pharma' has become the integrator of these lower order functions, taking the "role of licenser and marketer of brought-in therapeutic treatments (Cooke, 2003). Florida and Kenney (1998) observed these dynamic interplays of small and large firms, universities, and formal and informal knowledge exchanges. They suggest it represents a "new model of innovation which integrates components of entrepreneurial-driven versus corporate-led dichotomy posed by neo-Schumpeterian theory" p.126. This positions biotechnology firms in the middle of relationships between R&D centres and multi-national pharmaceutical firms

Biotech firms' greater uncertainty, of financial performance and return on R&D, means that their costs of capital (measured by required return on equity) are typically 20% or more, compared to 10% for Big Pharma firms; and innovating firms can only achieve such returns by generating new products that can achieve high-volume sales under patent (Nikisch et al 2009). Innovative SME companies generally encounter high capital costs because of the high risk of failure and generally low collateral value (Fazzari et al. 1988; Hall, 2002). This is particularly true for biotech companies whose comparatively high capital costs can be related to the high pre-production costs and low success rate of new drug discovery. For example, although biotechnology firms are businesses, they are science intensive and often active in the development of "basic biomedical science" (Pisano, 2006. p.2). There is high technical uncertainty in translating basic science into commercial products and services. In addition to the usual activities associated with commercial activity, biotechnology firms frequently need to resolve scientific issues in order to demonstrate the feasibility or efficacy of the firm's product or processes (McKelvey et al, 2004; Pisano, 2006). Biotechnology firm R&D may deal with scientific issues that are fundamentally unknown and this significantly increases the level of risk (Pisano, 2006).

These risks mean biotech companies will face a higher cost of capital than large Pharmaceutical firms. As the productivity of the Pharmaceutical sector has declined in recent years (Pammolli et al. 2011) biopharmaceutical industry survival and growth is therefore dependent on an efficient transfer of financial resources from Big Pharma to Small Biotech, repaid by an efficient transfer of marketable innovations from Biotechs' early-stage research to Pharma's later-stage testing and commercialisation.. This reinforces an interdependency in which Big Pharma must invest in Small Biotechs to achieve innovation, and Small Biotechs must access Big Pharma's marketing and distribution capability to generate returns on their innovation.

Under the old vertically integrated structure, financial transfer was conducted within Big Pharma firms. When early-stage drug development costs were relatively low, these firms could maintain a range of potential new compounds at the top of their new-product 'pipeline', and then use internal selection procedures to screen-out the unviable candidates and channel resources to develop the rest. Big Pharma firms have, for a number of reasons, ceased to be able or willing to pursue large numbers of early-stage drug discovery programmes in-house. These reasons include increasing cost of the drug discovery process, the increased complexity and risk of developing new molecular entities that satifisy the large returns required for the blockbuster model and the difficulties with finding efficacious drugs that satisfy the regulatory burden[1] (Chataway et al. 2007; Cockburn, 2007; Tait, 2007; Pammolli et al. 2011)

The level of uncertainty in the drug discovery process requires a mechanism to the reduce risk of failure (Pisano, 2006). In general, radical innovation tends to be more associated with micro and small firms rather than with medium to larger sized enterprises (Acs and Audretsch 1990). Given the complexity of the innovation process in Pharmaceuticals an increasing amount of basic research has been conducted within research institutions and universities. This gave rise to increasing numbers of biotech companies emerging as small start-up companies, set up by researchers and/or spun-off from university departments. As SMEs biotechnology firms are able to operate in a variety of relationships to reduce risk of the innovation process, via the development of various collaborations, strategic agreements and licensing arrangements with academic institutions, other biotechnology firms and large corporate firms to share the risk of research and development, whilst simultaneously gaining access to important competence and resource (Mckelvey et al, 2004). Similarly a biotech is able to reduce the risk of the innovation process by trading intellectual property assets according to their strategic plans, thereby reducing the burden of significant manufacturing or marketing costs (Pisano, 2006). One advantage of research conducted in the small company setting, is that it is possible to assemble the company around a specific scientific problem recruiting specialist expertise and developing a company culture needed to pursue new discoveries, and enable the pioneers to effectively manage the risk associated with new innovation and so obtain the best price for successful early-stage innovations.

[1] The regulatory structure is also cited by Tait (2007) as one of the major reasons for the continued existence of a Big Pharma

2: Financialisation as cause or consequence of restructuring

The aspect of financialisation most conducive to innovation and growth from the point of view of the economy as a whole, involves the conversion of enterprises and new technologies into tradable revenue streams. By such means, financial markets can price innovations efficiently, channelling funds to innovating companies at lower cost than would be achieved by non-market allocation. This role of financialisation in efficiently reallocating capital becomes especially important during times of rapid technological change. Hence, advocates of financialisation and shareholder value argue that the shift to major new technologies will be faster and more efficient if powerful financial markets exist which can shift capital from high-profit low-growth corporations to new firms needing funding to pursue innovation. Indeed, Jensen (1986) argues that the stock market with value-driven investors acts as an effective mechanism forcing mature corporations to distribute free cash flows so that investors can channel them to whatever new areas offer the highest return. This account corresponds with Arrighi's (2010) view of financialisation at the current late stage of a long upswing enabling profits to be redistributed from mature technologies and reassigned to new ones. Accordingly, two very different strands of analysis represented by Jensen (1986) and Arrighi (2010) extend the definition of financialisation so as to include the transfer of profit from the corporate into the financial sector and as enabling the reallocation of investment into new technological areas.

We explore these ideas as to financialisation's potential for reallocating funds towards innovation with respect to investment in the UK in biotechnology and pharmaceuticals. This is because the biotechnology industry, built on long term programmes of public research in R&D, theoretically would be expected to provide significant investment potential for the commercialisation of research, thereby providing one channel through which capital from mature industries could be allocated to new industries via financial intermediaries.

As result of the new industry structure, four 'post-blockbuster' channels for financial re-allocation appear to operate in the Bio-Pharma industry:

(1) *Relational*: Big Pharma companies acquire equity stakes in and/or form strategic alliances with Biotechs, channelling funds to them and receiving research outputs from them
(2) *Bank-based*: Big Pharma companies channel funds into commercial banks, which lend to early-stage Biotechs before they approach the bond or equity markets
(3) *Private financial market*: Big Pharma companies channel funds to private equity groups, which invest in early-stage Biotech
(4) *Public financial market*: Big Pharma companies channel funds (via dividends or buybacks) to stock-market investors, who invest in early-stage Biotech via equity or bond-holding

Route (1) still involves direct company-to-company financial flows, and could be regarded as a modification of the old vertical integration. The long-term strategic partnerships between biotech pioneer Genentech and the pharma giants Lilly and Roche (which took majority shareholding) are early examples of the relational approach. But their success has not been widely replicated, and other a number of

conditions regarding financial and social-capital transfer appear to be necessary for relational approaches to work (Gopalakrishnan et al 2008).

Route (2) involves intermediation by commercial banks, which are a potential source of debt finance for companies whose small size or high risk prevents them from raising capital on bond or equity markets. However, while all almost firms use commercial banks for financial transactions and financing of working capital, earlier studies suggest it is comparatively rare for Biotechs and other small innovation-based companies to borrow large sums for fixed-capital investment. Indeed, debt is generally low across both the Pharma and Biotech sectors, so that their capital costs are principally costs of equity (Harrington 2009). And the observed tendency for large mature firms to favour a shift in capital structure towards debt is greater than for smaller firms using new technologies. Cornell and Shapiro (1988) argue that this is due to a combination of factors including the greater volatility in earnings of small firms so raising their cost of debt and the lower tax liabilities of small companies such that the tax breaks associated with debt are less attractive. Additionally, smaller firms' likelihood of financial distress which raises relatively their cost of debt plus the fact that borrowing can be viewed as a sign of weakness both contribute to driving smaller companies to seek equity rather than debt financing. This paper therefore concentrates on the final two routes, involving private and public equity markets.

Routes (3) and (4) involve different forms financial-market intermediation. Private equity partnerships operate in a similar way to investment banks, borrowing on wholesale markets to finance equity holdings in non-financial firms. So route (3) can be regarded as a modification of (2), which addresses some of the drawbacks of conventional bank lending to small biotech firms. Private equity investors tend to operate on a 3-5 year time horizon, which may be much longer than that of commercial banks geared to working-capital finance. They tend to acquire expertise in a targeted range of industries, and build up a portfolio of equity participations that spread risks while staying within the areas of industry expertise. They aim for trade sale or flotation (IPO) of the equity stake as the usual means of exit. And they aim to make profit mainly by capital gain on equity stakes, incurring less tax than would apply to equivalent gross profit paid as dividends or interest.

Route (4) is the most controversial, since (for economic efficiency) it requires the return of capital to shareholders and their re-investment of that capital in new innovative businesses. The return of capital (by Big Pharma and big companies in general) has generally been viewed as a negative development, especially when conducted through share buybacks (Lazonick and Tulum 2011, Lazonick 2008). To be viewed as a mechanism for efficient capital re-allocation, the increased return of capital by Big Pharma would have to result in increased channelling of equity or debt capital into small innovative businesses, by private or institutional investors. Such direct channelling would be difficult to observe; so the most available test of such efficiency would be the extent to which increased return of capital by mature corporations has been matched by increased fund-raising by newer innovation-based firms, via the relational, private-equity or public-equity route.

3 Private equity, venture capital and financial transfer from Big Pharma to Biotech

We turn first to the role of private equity and venture capital in the funding of the UK biotech industry. At the centre of the biotechnology-pharmaceutical interaction, the venture capitalist is an important agent in the interactions and relationships developed by a biotechnology firm. The venture capitalist operates to "facilitate commercialisation" of new knowledge, by providing finance and the strategic knowledge of how to reach the pharmaceutical market (Cooke, 2003). Niosi (2003, p.749) sees the commercialisation of biotechnology through spinout firms, as a process involving a sequence of milestones and collaborations where the venture capitalist plays a key role,

> *"The sequence starts with obtaining patents. These will signal to the financial community the value of the new firm. Patenting is followed by venture capital, entry into the stock market under the guidance of the venture capital firm, and the organisation of a major alliance followed by the launching of the firm's products in overseas markets, usually with the help of large international corporate partners."*

Niosi (2003) classes venture capitalists as external factors involved in the transition of a biotechnology firm from a collection of scientific knowledge assets, to a functioning firm that can demonstrate its potential to the wider financial community. However, in this role the VC can also help support internal firm capabilities by bringing external resources and competences into the biotechnology firm.

Trends of venture capital investment in UK biotech have fluctuated over recent years. Data from the British Venture Capital Association (BVCA) members' survey indicates that biotech has received a significant share of the total technology investment, and a sizeable share of biotech investment has been directed towards early stage opportunities over recent years (see Table 1). However, the size of biotech investment is insignificant compared to the overall investment total – indicating the low priority of biotechnology and technology investment generally to venture capitalists in the UK. As the capital investment required to develop biotechnology related products is large, frequently cited at $1bn, even if the lowest estimates of approximately $59m (Subbaraman, 2011) are taken into consideration, the extremely high risk of failure of any individual drug in development indicates the amount of venture capital contributed to biotechnology is low. For instance in the UK, drug development costs are estimated to be £50-150m (DTI, 2003) with a 1% probability of success.

Table 1 here

Another key problem of the role of venture capital in financing biotech is identified by Lazonick and Tulum (2010) related to the speculative behaviour of investors. Lazonick and Tulum observe the apparent paradox of investors committing funds to an industry where historically the performance of biotech companies has been low compared to other sectors. The authors note that much of the investment activity is driven by speculative behaviour, whereby the investor can extract value from the company after an IPO, even if the companies has little likelihood obtaining revenue

from a product in the short-term. Despite the high cash burn of the biotech industry, investors provide capital to firms speculating the expectations of rising share prices. (Lazonick, 2008). In fact most of biopharmaceutical firms reaching IPO in the US were at the time product-less firms and reliant on the speculative behaviour of the stock market to secure investment. Cash is frequently invested on the basis of management 'narratives' particularly when the company has yet to generate any product and so the stakeholder network of biotech firms is particularly fragile (Froud et al. 2006 Haslam et al. 2011). In the longer term this model of investment is unsuitable for companies that will typically require 10-15 years of development time, it puts the potential innovation, in this case new therapies and treatments, at higher risk and higher cost. As frequently the innovation is from publicly funded laboratories, the authors criticise the role of venture capitalists for obtaining short-term speculative returns from publicly funded research.

The ability of investors to raise funds for private equity and venture capital could be presented as one potential beneficiary of financialisation, whereby capital is efficiently re-allocated via a series of intermediaries, fund managers and investors to support the next generation of promising entrepreneurial and innovative companies and industry leaders. However, as the industry developed, observers have noted a distinction in types of venture capital, with a tendency for investors to move towards larger, lower risk investments (involving investments in larger more established companies). One result of the movement of investors towards later stage investment is that although the UK private equity investment sector is the largest in Europe, investment for early stage opportunities has declined. One reason for the difficulties increasing the flow of investment to UK start ups is that the UK market is observed as being 'thin' whereby a low flow of finance and a low supply of high quality opportunities have not created a sufficient environment for the development of a thick (or deep) market for early stage funding (NESTA, 2009).

A further potentially major source of funding is the pension fund sector. Venture capital and private equity form one of several non-traditional asset classes that enable pension funds to diversify and further improve their risk-return combination.
It's been widely argued that institutional investors, including pension funds, were forced into a "search for yield" in the years before the 2008 crash (and the 2001 dot-com crash), taking greater risks in pursuit of higher returns. Factors promoting the search included low yields on government debt (enabled by the 'Greenspan put' in the US and similarly accommodative monetary policy in the UK); the large inflow of East Asian - especially Chinese - saving (which kept long bond yields low even when the US and UK raised short-term interest rates); and the run-up in share prices as the risk premium on equities declined (Blanchard 1993, Turner, 2009 Altman, 2010).
Evidence of a "search for yield" in the US is provided by Healey & Rozenov (2004), who show that across the period 1991-2001 the largest 200 defined-benefit funds (DB) reduced the share of domestic equities in their portfolios by 1.5 percentage points, and that of domestic bonds by almost 8 points.

However, it has been observed that as pension funds raised their exposure to private equity and expanded their share of total private-equity funding, the allocation of this funding became more risk-averse. Private equity's investment in buying-out and restructuring mature companies grew faster than its investment in venture capital and early-stage expansion (various papers by William Lazonick). Before 1991, public-

sector pension funds were heavier on fixed income and lighter on equities than those from the private sector (Healey & Rozenov 2004).

Whilst the relaxation of the regulation of pension funds in the US is widely documented as increasing the supply of investment for venture capital fund raising (for instance see Gompers, 1998 or Jeng and Wells, 2000), less empirical work has considered the implication of different funding sources on the performance of venture capital funds. Gompers (1998) prior to the dotcom crash, raised the question of whether the flow of funding into the industry was too large, giving rise to increasingly large deal valuations and with larger funds increasing pursuing later stage opportunities, moving away from early stage deals. Likewise Jeng and Wells (2000) note that the level of private pension funds in a country is a significant determinant of the amount of venture capital investment, although perhaps more important is the liquidity of markets, such that having active IPO activity, strong stock markets and M&A activity are seen as an important requirement for venture capital investment. (Black and Gilson, 1998; Jeng and Wells, 2000).

Equally important as regards changing pension-fund strategy, were factors that led regulators and pension fund trustees to *permit* the search for higher yield. It was argued that higher-yielding asset classes were less risky (compared to government bonds) than previously thought, because of funds' ability to (a) spread risk through diversification and (b) transfer risk through derivatives and hedging instruments. Regulatory changes, such as 'the prudent man' ruling, enabling pension fund managers to raise the proportion of portfolios outside government bonds (and blue-chip equities) were also an important factor in the US and UK. Other changes in the 1980s to the tax system, the creation of limited partnerships and other federal initiatives, resulted in the proliferation of the venture capital industry as it became easier to raise venture capital funds, so that the availability of investment for SMEs increased rapidly (Gompers and Lerner, 1999, 2001; Hsu and Kenney, 2005).

The 2007-8 crash highlighted unexpected liquidity problems with certain instruments (notably securitised debt): it suddenly became impossible either to sell these instruments for anything like their previous market value or to use them as security for loans of meaningful maturity. This experience compelled pension funds to run down holdings of *all* instruments – even debt with AAA ratings - that might develop liquidity problems at times of financial market stress. As a result venture capital/private equity was also negatively affected, because it depends on equity market liquidity for the exits, via IPO, that return investors' capital. As typically IPOs present high risk investment or more speculative opportunities, the lack of market liquidity prevents investors accessing the return on their investment, reducing venture capital fund performance and ultimately the ability of investors to raise funds for future investment. The net result is that funding for innovative companies is reduced.

4 Equity markets and financial transfer from Big Pharma to Biotech

The vertical disintegration of the pharmaceutical industry - into Big Pharma companies focused on later-stage development, distribution and marketing, and Small Biotech firms focused on early-stage research - may have been an efficient response to the decline in the productivity of R&D in the integrated companies which

previously encompassed all its stages. Restructuring can be viewed as efficiency-improving from the transaction-cost and resource-based theories of the firm. But from a financial perspective, the vertical disintegration appears to exacerbate the industry's problem of channelling investmen t into early-stage innovation. Small Biotechs' costs of capital, dominated by equity costs, are significantly higher than those of Big Pharma companies (Nikisch et al 2009, Harrington 2011) When small research-based firms stand alone from, or are spun-out by, Big Pharma companies, and these focus on the marketing and reformulation of known high-selling compounds, the differential of small firms' over large firms' capital costs are likely to increase, leaving equity markets more inclined to channel funds towards the large low-risk companies and away from the small.

Empirical studies have consistently shown that the popular capital-asset pricing model (CAPM) sets a substantially higher equity premium (over the risk-free rate of return) for small biotech firms than for large pharmaceutical companies (eg Myers & Howe (1997), which tracks US stocks for 1986-92, and Harrington (2009), which tracks them for 2001-8). The CAPM 'beta', which measures the sensitivity of the firm's to the market portfolio's rate of return (and indicates the level of risk which cannot be diversified away), was typically substantially below 1 in 2000-8 for Big Pharma companies and substantially above 1 for Small Biotech firms. The industry's restructuring, separating biotech's early-stage from Big Pharma's late-stage research, appears to have expanded this differential. Big Pharma was able to reduce its risks by replacing its (usually narrow-range) in-house R&D commitments with a more diversified portfolio of contracts with (or strategic equity holdings in) a wider range of R&D-focused biotech firms. These partnerships with small independent firms gave Big Pharma a set of 'real options' on future drug developments, enabling an easier exit from projects that failed to deliver the necessary results and an easier re-concentration of the small number of projects that did deliver results. In contrast, the uncertainty surrounding results of early-stage R&D means that firms which heavily engaged in it were assigned a higher beta, resulting in a higher cost of capital. Industry restructuring represented a significant transfer of risk from Big Pharma to Small Biotech, and prospective investors in biotech demanded a correspondingly higher reward.

Krueger et al (2011) point out that firms which internally invest in R&D will understate their cost of capital for, and therefore overinvest in, projects with a future earnings variation that is above the industry average. This bias may be corrected when the industry disaggregates, with early-stage R&D transferred to other firms that must raise capital externally. So any fall in biotech investment after the industry's vertical dis-integration may have been the correction of a bias to over-investment, rather than the onset of under-investment. From a private commercial viewpoint, Big Pharma may have applied an inappropriately low cost of capital to its R&D investment decisions, until it spun-out the R&D to specialist firms. This private over-investment in biotech and other early-stage research may have had social benefits, in the form of new drugs that confer widespread advantage without becoming 'blockbusters'. But it would have been 'corrected', from the shareholder perspective, when the industry restructured and Biotechs' costs of capital rose.

Against this pessimistic view, a number of financial market developments can be identified in this period which may have offset Big Pharmas' cost-of-capital;

advantages, and helped maintain the flow of investment to small firms conducting early-stage R&D. Buoyant equity market conditions, especially between the 'dot com' price correction of 2001 and the 'credit crunch' correction of 2008, reduced the cost of equity for all publicly listed firms, including the growing number of Biotechs that were able to make initial public offerings or spin-out flotations during this period. The decline in Big Pharma's equity costs (and in its costs of debt, as interest rates stayed historically low) gave it more scope to satisfy its own investment needs and also channel funds in to smaller biotechs, via research contracts or equity participations.

In addition, the cost-of-equity premium imposed on Small Biotechs may have been narrowed by two other features of stock-market pricing behaviour over this period: the tendency for the equity prices of small firms, and of firms with high valuation ratios (of market value to book value), to outperform those of larger firms in the same sector. Biotech firms are significantly smaller than Pharma companies, and they have almost invariably enjoyed much higher valuation ratios (or Tobin's q ratios) than the more mature Pharma companies. So if the equity market places sufficient value on Biotechs' ability to outperform larger stocks, it might offset the cost-of-capital penalty that the CAPM imposes.

This conjecture appears to be at least partially confirmed by other pricing models which take account of wider influences on the appropriate cost of capital. For example, applications of the Fama-French model – which supplement CAPM's beta with other 'betas' to capture effects of firm size and valuation ratios – narrow the gap between Big Pharma and Small Biotech costs of equity (eg Golec & Vernon 2007, Harrington 2009). The main factor narrowing the gap is the size-related beta: in effect, a risk penalty is imposed on Big Pharma companies due to their larger size, and this substantially offsets the risk penalty imposed on Small Biotechs due to their uncertain R&D outcomes. Table 2, distilled from Harrington (2009), compares the cost-of-capital differences revealed by recent studies using the CAPM and Fama-French (FF) models. It shows the FF model generating significantly smaller differences in beta, and hence in costs of equity, between Pharma and Biotech, although Pharma continues to enjoy lower capital costs by virtue of lower non-dicversifiable risk. During this time, application of the FF and other alternatives to CAPM was increasing, among equity market analysts as well as academic researchers.

Table 2 here

Despite the narrowing of cost-of-equity differences when more sophisticated pricing models are used, data in Table 2 makes it clear that Small Biotech continued to experience a cost-of-capital penalty compared to Big Pharma after 2000; and it provides some early evidence that the gap may have widened after 2005. The Pharmaceutical sector as a whole has long stood out from other industrial sectors in having historically above-average rates of return on capital, going back at least to the 1960s (Borges & Hickey 1968). These high rates of return have been associated with high risks (arising from unpredictability of the success rates and profitability of new products), and high industry growth rates (driving industry demand for capital ahead of supply). But the vertical disintegration of the industry appears to have separated risk and return, transferring the high-growth, high-risk activities to small research-

based firms, and enabling larger companies to enjoy higher profits associated with lower capital costs.

Giacotto et al (2011) provide evidence that the Pharmaceutical industry's return on capital may have been overstated, because of its costs of capital being understated. They argue that positive correlation of cashflows, associated with patent protection on new drugs, leads to costs of capital that are higher (by almost three percentage points on average) than those conventionally estimated using the CAPM. However, Giacotto et al find the reverse is true for some Big Pharma companies, for which a tendency of cashflows to fall towards the mean results in CAPM overestimating the cost of capital. This second pattern appears to be more typical of companies whose 'blockbuster' drugs are coming to the end of their patent protection. So it is still appropriate to characterise the industry as one in which the largest firms are generally highly profitable, and in need of effective ways to channel funds to smaller firms engaged in early-stage innovation.

The restructuring of the industry into a Big Pharma downstream and a fragmented Small Biotech upstream has usually been regarded as a response to falling R&D productivity in pharmaceuticals. However this restructuring, although evident for more than twenty years, has not produced any significant reversal of the adverse R&D productivity trend, or generated a regular flow of new blockbusters to compensate for this trend (Pisano 2006). One common explanation ascribes this disappointment to the low productivity of early-stage R&D, even after its transfer from Big Pharma to smaller innovation specialists. Several studies argue that that there has been a strong – even excessive – flow of new investment into biotech, and that it has failed to deliver a return on this investment. The lack of innovation is due to blockages on the knowledge supply-side, not the financial supply-side.

For example, small innovative companies may have remained too fragmented, unable or unwilling to share knowledge, so that efforts are duplicated and vital connections not made (Pisano 2006). Or there may just be very few, hard-to-identify biotech breakthroughs still awaiting discovery, after the 'low-hanging fruits' were plucked by earlier efforts (Nightingale and Martin, 2004). Given the substantially higher costs of capital for earlier-stage Biotech research, and the recent record of biotech product sales, Big Pharma has a substantially larger financial incentive to invest in the reformulation of known products with ongoing high sales, than to finance research into new products with uncertain marketability or sales potential (Nikisch et al 2009). The bias towards later-stage innovation, in reformulation and marketing, is explicable by capital costs, expected returns and the great uncertainty around these returns (especially given extension of patent protection to reformulations), Big Pharma's growing reluctance to invest in Biotech, and growing inclination to return capital to shareholders to be invested elsewhere (or consumed), is an efficient response to the disappointing returns on earlier biotech investment.

An alternative explanation identifies the restricted flow of new investment from Big Pharma to Biotech as a possible cause of Biotech's disappointing innovation record, rather than its effect. In this view, Big Pharma has deprived Biotech of funds by returning (to shareholders) capital that would previously have been put to innovative use through strategic R&D partnerships or in-house R&D. When funds have been channelled to Biotech, it has been on terms that are too restrictive to promote radical

innovation – because required rates of return are set too high, time horizons are too short, and/or innovators are offered an inadequate price when their intellectual property is eventually sold.A number of recent studies support this second explanation.

Lazonick and Tulum (2010) contend that an implication of financialisation in the pharmaceutical sector is that the lack of innovation performance can be related to the increasing use of share buybacks at large pharmaceutical companies. Instead of finances being used to develop long term drug pipelines, investment is made to maintain share price, which Lazonick argues is motivated by executives short term objectives of managing personal stock option at the expense of long term innovation programs. In fact in some companies spending on share buy-backs is greater than R&D expenditure. Clearly there are implications for biotech companies too, as effectively pharmaceutical companies are the vital link for biotech companies to the healthcare market.

Serfati (2008) raises another example of stock price manipulation at the expense of innovation observing the rapid growth of intangible capital as part of the market value of public companies as the result of financialisation. Serfati's core argument is that the increasing emphasis on maintaining shareholder value is related to the growing proportion of company value resulting from intangible capital. The increasing pressure to deliver shareholder value and maintain a share price has encouraged the manipulation of intangible capital to maintain company valuations. A significant part of intangible capital results from the value of human capital, relational capital and structural capital. A key part of a technology company's intangible value comes from IPR. According to Serfati the implications for innovation are that investment in R&D is increasingly directed towards options that maintain the value of intangible capital (such as protecting IPRs, protecting relational capital, maintaining advertising, investment in near market opportunities), at the expense of investment in future income opportunities (i.e. long-term innovation). Here there are clear links to the parallel argument made by Lazonick (2008) that shareholder value encourages companies to invest retained earnings in stock buybacks, to protect the stock price (and potentially maintain executive pay), which by default (in simple terms) would also protect intangible value.

Pisano (2006), presenting evidence that public and private US biotech companies were (with one exception, Amgen) unable to make an operating profit in 1980-2004, and showed the same (stagnant) R&D productivity as traditional pharmaceutical companies, links these disappointments to structural problems in the industry. In particular, biotech companies tend to be too spatially dispersed, and to work with too short a time-horizon to aggregate and develop the knowledge needed for big pharmaceutical breakthroughs. Spatial dispersion arises from the number of small start-up businesses, and the weakness both of their 'vertical' links to companies doing earlier- and later-stage work and their 'horizontal' links to other small firms that may be researching very similar areas. It is compounded by the growing pressure on universities and other primary research sites to create their own spin-off companies, or to license their discoveries exclusively to one developer. Spatial dispersion is harmful for development, Pisano argues, because (even with open licensing) there are problems in trading the relevant intellectual property between companies.

Short time-horizons add to these problems, because the time within which companies are expected to commercialise a discovery is generally less than the time needed for a typical breakthrough to be brought to market. Pisano cites Lerner & Malmendier as establishing the typical research contract length at just 4 years. Even if companies survive for longer than this, researchers tend to move between them, and the industry's 'collective memory' is depleted whenever companies close or restructure, or teams disperse. The dispersal or loss of relevant knowledge appears to be more of a danger in a system that allocates research-investment funds through financial markets, and generates a high turnover of new small businesses, than a system that 'internalises' fund allocation through longer term firm-firm or bank-firm partnerships.

Giacotto et al (2011) provide evidence that, for a majority of Big Pharma companies, short-term capital costs are lower than long-term capital costs. This arises in part from the limited life of patent rights. A rising structure of capital costs is likely to reinforce the incentive for to prioritise investment projects with short-term paybacks over those with longer-term and more uncertain returns. It could therefore reinforce the preference of the typical Big Pharma company for short-term gains from financial restructuring over longer-term gains from biotech R&D.

5 Conclusion: financialisation as an enabler of innovation?

Financialisation can be defined as the increased allocation of resources (externally) through financial markets, as opposed to their allocation (internally) through the administrative decisions of large firms. On this definition, financialisation is promoted by the break-up of diversified conglomerates ("horizontal de-diversification"), as widely observed since the late 1980s especially in the US and UK, and by vertical disintegration. The refocusing of companies on a set of closely related 'core businesses' shifts the task of diversification from managers to shareholders, and gives financial investors a freer choice of portfolio design. It also enables financial investors to make more accurate assessments of returns on capital and appropriate capital costs for different firms and sectors, and so in principle to drive a more efficient allocation of new investment.

In this paper we have sought to assess to the extent to which financialisation can help increase the flow of finance from maturing industries with decreasing growth and profitability prospects, to new and innovative industries with high growth potential. The Pharmaceutical industry was chosen as a case in which vertical separation has generated a need for heavy investment flows from large, cash-rich producers and distributors to small, cash-hungry innovation-based companies. These flows must mainly occur via public or private financial markets, so their scale and impact provides a measure of the success of financialisation. According to advocates of shareholder value, financialisation should act as an enabler of innovation, allowing shareholders and investors to search the market for opportunities that offer the greatest future return.

For the biotech industry financialisation could be presented as offering strong potential for helping to drive investment towards the commercialisation of new science based entrepreneurial opportunities. However, whilst we note that investment via venture capital intermediaries has flowed into UK biotech, the scale of the

financing in the UK has been too low to obtain meaningful outcomes. It is important to acknowledge the inherent risks of science based entrepreneurship which may partially explain the poor performance of UK biotechnology firms; but it would appear that the flow of finance into this sector in the UK has not been a particular beneficiary of financialisation. Although the UK private equity industry grew dramatically in the years preceding the financial crisis, the proportion of investment in UK biotech remained small. Furthermore even in advanced venture capital markets, such as the US, as a result of financialisation, the speculative behaviour of investors has in fact put the development of important innovation at greater risk and greater cost after investors have extracted returns. In the biotech industry which is heavily reliant on public investment in basic R&D, it raises important questions about the trade-offs inherent in financialisation, if this has neither resulted in an increased flow of capital to innovative firms, nor contributed to lower treatment costs.

Studies of capital costs and returns on capital across a number of sectors have raised a number of puzzles concerning developments since 2000. In particular, there appears to have been only a modest decline in equity and debt costs (and hence in the weighted average cost of capital), despite a strong rise in equity markets and valuation ratios in 2001-8 and a fall in borrowing costs during the long phases of monetary policy relaxation. And there appears to have been only a modest increase in non-financial-sector investment in 2000-08, despite a sustained rise in corporate profitability – dating back to the mid-1990s – linked to rising labour productivity and constrained real wage growth. This paper suggests some explanation for these puzzles in the case of one specific but significant sector, Pharmaceuticals. Here, sustained profitability was associated with structural change which enabled large producers to maintain high returns on equity that were traditionally linked to high risks, while transferring those risks to the small innovation-based firms that increasingly conduct the sectors early-stage research and development.

This structural change increased the need for financial flows from ‘Big Pharma’ to ‘Small Biotechs’, intermediated by financial markets (for publicly listed shares or private equity). But it did not – even with the advent of new valuation methods - reverse the traditional premium of Small Biotech over Big Pharma capital costs, and may therefore have generated financial market incentives that impeded the flow of investment to the firms on which the industry now depends for its next innovations. Recent literature has criticised the suggestion, associated with transaction-cost and resource-based theories of the firm, that structural change in Pharmaceuticals has been beneficial for the process of innovation. This article assembles evidence which challenges the complementary suggestion that structural change has been beneficial for the financing of innovation. It highlights a possible conflict between the social benefits of channelling finance to smaller innovators and financial market incentives which still assign larger downstream businesses a lower cost of capital and higher rate of return.

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Table 1 UK Biotechnology investment analysis

BVCA member investment analysis

	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995
Biotech investment £m	58	72	84	58	68	59	73	68	29	30	18
Technology related BVCA investment £m	681	678	817	546	1,658	1,615	1,093	707	595	319	253
% of technology investment	*8.5%*	*10.6%*	*10.3%*	*10.6%*	*4.1%*	*3.7%*	*6.7%*	*9.6%*	*4.9%*	*9.4%*	*7.1%*
Biotech investment (early stage) £m	34	45	62	33	39	49	54	31	16	19	n/a
% Early stage of Biotech investment	*58.6%*	*62.5%*	*73.8%*	*56.9%*	*57.4%*	*83.1%*	*74.0%*	*45.6%*	*55.2%*	*63.3%*	*n/a*
Total BVCA investment	2,535	3,239	4,184	4,919	7,847	8,256	6,164	5,466	6,357	9,679	11,676
% of early stage biotech	*1.3%*	*1.4%*	*1.5%*	*0.7%*	*0.5%*	*0.6%*	*0.9%*	*0.6%*	*0.3%*	*0.2%*	*n/a*

Source: Authors' calculation from British venture Capital Association (BVCA) Annual reports

Table 2 Costs of equity, for Pharmaceuticals and Biotech, using different pricing models

CAPM method				
Big Pharma β	Biotech β	Big Pharma cost of equity (nominal, %)	Biotech cost of equity (nominal, %)	Study
0.7 (1981-5)	1.54 (1984-8)	16.7 (1981-5)	21.1 (1984-8)	Myers & Shyam-Sunder (1996)
1.05 (1989-93)	1.43 (1986-92)	14.2 (1989-93)		Myers & Howe (1997)
0.69 (2001-5)	1.32 (2001-5)	9.8 (2001-5)	14.2 (2001-5)	Harrington (2009)
0.61 (2006-8)	0.97 (2006-8)	9.3 (2006-8)	11.8 (2006-8)	Harrington (2009)
FF method				
0.92 (1982-2005)	1.06 (1982-2005)	14.5 (1982-2005)	16.2 (1982-2005)	Golec & Vernon (2007)
		9.8 (2001-5)	10.6 (2001-5)	Harrington (2009)
		9.1 (2006-8)	12.9 (2006-8)	Harrington (2009)

Source: Harrington (2009) Tables 1, 3, 5