Detail Disagreement and Innovation Booms

Preliminary

August 31, 2014

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Abstract

We argue it is natural for investors in financial markets to disagree on precisely which types of innovations are likely to be successful in a specific field. We call this type of heterogenous priors *detail disagreement*. Detail disagreement in financial markets profoundly affects the innovative process. Our model predicts the presence of detail disagreement creates a form of competition neglect. This mechanism entails higher asset prices that subsequently crash, more investment, firm creation, and specifically to our approach, more diversity in innovation. We show investors' portfolios, asset prices, and both the quantity and nature of firm creation during the tech boom of the early 2000s as well as the last few years are consistent with our approach. We discuss the potential welfare implications of such speculative episodes.

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Introduction

In the face of a new discovery, it is natural for investors to disagree not only about its overall effect but also about the details of its implementation. In this paper, we study the implications for asset prices, innovation and competition of this second type of disagreement, that we call *detail disagreement*. In particular, we focus on disagreement among investors about which firms will be successful in a specific sector. Understanding the effect of detail disagreement and the speculation it generates on financial markets provides an explanation for the dramatic boom and bust patterns accompanying technological innovations. For instance, between 1998 and 2001, the emergence of the Internet saw a large increase in the valuation of high-tech firms, large numbers of new firms being created and introduced on public markets and subsequently a large drop in asset prices. A similar pattern has been emerging again since about 2009. We argue detail disagreement plays an important role in shaping these events, distinct from aggregate disagreement.

The main contribution of this paper is to highlight the link between detail disagreement and innovation booms. We present an equilibrium model of firm creation and financial markets in the presence of detail disagreement. This model clarifies the role of detail disagreement in shaping innovation booms. Further, it highlights conditions under which detail disagreement has a greater influence on innovation and asset prices. Our second main contribution is to show detail disagreement not only impacts the quantity of innovation and its price, but also the very nature of innovation. We show detail disagreement gives rise to explorative episodes, where firms are created across more ideas and technologies. We illustrate these predictions in the context of the Internet boom of the early 2000s and the recent expansion of the high-tech sectors. Finally, we consider the potential normative implications of the presence of detail disagreement. Other dimensions can generate innovation booms: aggregate disagreement or uncertainty for instance. However, we highlight unique predictions of our framework, mainly portfolio specialization in markets and the explorative dimension of innovation booms.

How does the presence of detail disagreement create an innovation boom? Let us take the example of social networking platforms like Facebook or Twitter. Even if all investors agree a large social network will emerge and dominate the market in the long run, they are likely to disagree on which particular firm will take over the market. Naturally, investors buy shares in firms they believe are likely to succeed and not those they expect to fail. This is the first step towards creating the boom: *portfolio specialization*. The matching of investors with firms they believe in directly impacts asset prices. Each firm is valued by investors who believe it will succeed, pushing its price above the average belief prevailing in the market. Adding up, this association implies that, even though all investors agree on the total value of the sector, the price of a portfolio of all firms in the sector will be higher than this value. Of course, in the long run, only one firm succeeds and takes over the market. As this

information is revealed all other firms disappear and there is a massive asset price drop.

Now, take the perspective of an entrepreneur who considers entering this sector. The attractive prospect of large amounts of capital from investors encourages more entry, fueling the innovation boom. But the quantity of firms is not the only margin of adjustment. For instance, if the entrepreneur creates a firm very similar to Twitter, investors are not likely to develop a different opinion about the new firm. Moreover, the new firm will have to compete directly against Twitter. On the other hand, by creating a more radically different technology, the entrepreneur can ride the differences of opinions, and create a group of investors that specifically prefers to invest in her project. This effect transforms innovation booms into *exploration booms*. Firms not only make small improvements on existing technologies, but instead seek to create innovations that are greatly different from existing products.

To better understand what exactly about detail disagreement favors the emergence of these episodes, we investigate the role of the competitive structure of the industry. Our example of social network features a winner-takes-all structure: there is a finite amount of profits that will be captured by only one firm. We show such structures are particularly sensitive to detail disagreement. Indeed, once investors match with firms they particularly believe in, they behave as if the competitive pressure from other firms is absent. This effect of *competition neglect* has a large impact on industries where displacement across firms is strongest. We also show it is at the heart of generating the explorative dimension of innovation as investors are less sensitive to the knowledge externality of following mainstream technologies. This role of competition neglect distinguishes our approach from the standard Miller (1977) effect where disagreement increases prices.

Finally we consider the normative implications of the presence of detail disagreement. Detail disagreement generates larger amounts of entry, but speculative investors tend to find it socially optimal. Looking back at the social network industry, it might seem wasteful to have so many resources involved in a large number of firms where only one is needed in the long run. However, if all investors think that when firms are created they will be able to obtain that likely to success at an attractive price, they all favor firm creation. Naturally, we also show that if the planner imposes common beliefs to evaluate the economy, he will prevent the large amounts of firm creations. However, if one is willing to entertain social benefits of higher levels of exploration, for instance to generate disruptive innovations, the speculative episodes linked to detail disagreement might still be desirable.

We start by describing more precisely the logic of how detail disagreement can generate an innovation boom in Section 1. We illustrate each step of the process with evidence from the last 15 years, including the Internet boom, and the more recent expansion in high-tech sectors. Section 2 presents the formal model and studies the interaction of competition with detail disagreement. We then turn to the endogenous diversity generated by detail disagreement in Section 3. Finally, we consider normative issues in Section 4.

Literature review

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1 Narrative and evidence during the Tech Booms

We start by exposing the basic mechanism of the model. We relate this mechanism to events in high-tech sectors of the economy during the tech boom of 1998-2001 as well as ongoing events since 2009. This evidence relates the model to observables and suggests detail disagreement plays an important role during these periods.

1.1 Detail disagreement

The premise of our analysis is that market participants often disagree on which firms or technologies are likely to be successful. We focus on a type of disagreement not caused by heterogenous information sets but by heterogenous priors; our agents agree to disagree. Morris (1995) provides some motivation to the assumption of heterogenous priors. In evaluating the potential success of a firm, priors likely play a larger role when the technologies used or the products sold are novel. In contrast, for more mature industries, large amounts of information are available, and beliefs have had time to converge. This difference provides us direction to study the role of disagreement: its effect is stronger in high-tech sectors. To implement this comparison, we use a classification proposed by the Bureau of Labor Statistics in Hecker (1999) for 3 digits industry code (following the SIC classification, hereafter SIC3) sectors, subsequently adapted to the NAICS industry classification by the National Science Foundation (2006). This classification is based on the proportion of employment in an industry accounted for by scientific, technical, and engineering personnel engaged in research and development.

We focus on a particular type of disagreement we call *detail disagreement*. Detail disagreement is disagreement, within a sector, over which particular firms or technology will be successful. The key element is that this disagreement is expressed in terms of the relative evaluation of many firms. We show disagreement about relative performance has different implications than the absolute disagreement often studied in the literature.[4] To contrast the two types of disagreement, a simple example is useful. In the last few years, social network platforms such as Facebook or Twitter have emerged as a new business. Even if everybody agrees there will be only one important social network in the future, investors can disagree on which particular one will succeed; this is detail disagreement. In contrast, when the Internet first came about in the late nineties, one can think substantial disagreement existed about whether it was going to be an important technology or not, even though investors did not

[4]See for instance Harrison and Kreps (1978) or Scheinkman and Xiong (2003) for seminal treatments of the role of absolute disagreement in financial markets.

have strong views on which particular companies were going to succeed; this is absolute disagreement. Naturally, both types of disagreement likely coexist in these two events or any other events. We focus our attention on detail disagreement in this article.

1.2 Investor behavior

A consequence of investors' disagreement about firms within a sector is they take different positions in the firms they finance. When detail disagreement is strong, investors focus their investments on their "favorite" firms, the ones they estimate most likely to succeed. Therefore, we should expect to see more concentrated portfolios in sectors with strong detail disagreement. Importantly, portfolio concentration distinguishes our approach from other models of the uncertainty inherent to innovation. Models like Scheinkman and Xiong (2003) focusing on investors belief on the sector as a whole or Pastor and Veronesi (2009) focusing on uncertainty of the representative agent's beliefs do not make such a prediction. Going back to our comparison of the high-tech sectors with the remainder of the economy, we can observe such specialization both for private and public firms. For private firms, this concentration manifests itself in obtaining funding by some very concentrated investors, namely venture capital funds. This specialization in obtaining financing has anecdotally increased over the last few years with the development of more structures to finance new business: incubators, pre-incubators, online platforms like Kickstarter... All these structures facilitate the matching of investors to the precise firms that, in their point of view, have the strongest prospects. The use of all these structures is concentrated in high tech firms.

For public firms, we directly observe portfolio holdings for a subset of investors. All investors with more than $1 million invested in the stock market must report their holdings quarterly to the Securities and Exchange Commision using form 13-F. We use these filings to compare the holdings of investors across sectors defined by a SIC3 code between 1999 and 2013. To capture investors focused on a particular sector we focus on investors with more than 25% of their holdings in a sector.[5] Such investors represent between 5% and 10% of the total ownership of a stock, this number being larger for larger stocks. At each date, for each investor-sector pair, we compute various measures of the concentration of the portfolio in a sector: the number of stocks owned in the sector, the fraction of stocks owned in the sector, the Herfindahl index of holdings in the sector, and the concentration ratio of holdings in the sector (the fraction of the portfolio invested in the 5 largest positions). Sectors vary greatly in size — between 1 and 1500 companies — and investors in wealth. Therefore we compare these concentration measures between high-tech and non-high-tech sectors, controlling for sector size and wealth in a non-parametric way, by including numerous fixed effects for range of values interacted

[5] In unreported analysis, we show our findings are robust to a range of specialization between 5% and 50%.

with date fixed effects. Finally we cluster standard errors at the manager level. We report the results in Table 1.

Table 1: **Portfolio concentration difference between investors in high-tech and non-high-tech sectors**

	Portfolio Composition				
Variable	# Stocks		Fraction of Stocks Held	Herfindahl	Concentration Ratio
Tech Dummy	-4.22***	-1.6***	-0.058***	0.089***	0.065***
	(0.54)	(0.42)	(0.0051)	(0.016)	(0.0071)
size-wealth-date f.e.	Y	Y	Y	Y	Y
fraction-date f.e.	Y	Y	Y	Y	Y
managers f.e.	N	Y	N	N	N

Panel regression of number of stocks held in industry Portfolio by fund managers (or Herfindahl index of their portfolio of that industry) on a indicator whether the industry is classified as a "tech" industry using the BLS classification.
A increase in the Herfindahl (and concentration ratio) index corresponds to an increase in concentration.
The "size-wealth-date" fixed effects are interactions of quantiles of managers' size in an industry by wealth quantiles for each date.
The "fraction-date" fixed effects are interactions of quantiles of managers fraction holding in the industry interacted for each date.

Across all measures, we find investors specialized in a high-tech sector hold more concentrated portfolios. For high-tech sectors, investors hold less stocks, and their portfolios have higher Herfindahl index and concentration ratio. The magnitude of the effect is large. The average investor holds about 12 stocks in a sector (the first quartile is 1, the third is 35) and tech investors hold on average 4.2 less stocks than non-high-tech. The Herfindahl index is larger by 9 percentage point and the concentration ratio by 6.5 percentage point. Rather than compare different set of investors across sectors, we can zoom in on investors specialized simultaneously in different sectors, some high-tech, some non-high-tech, by adding investor fixed effects to our specification. We report the result in the second column of Table 1. Even though the effective sample shrinks, we find these investors own significantly more concentrated portfolios in their high tech holdings.

Further we can inspect if this concentration changes over time. In Figure 1.1, we report the estimated difference in number of stocks held between high-tech and non-high-tech by quarter in the top panel and the Herfindahl index and concentration ratio in the bottom panel. Even though the statistical power to distinguish across periods is lower than unconditionally, the pattern is consistent with our theory. During the Internet booms of the early 2000s, we observe higher portfolio concentration. Since about 2009, a new increase in portfolio concentration is visible.

1.3 Asset prices

What does detail disagreement imply for the pricing of firms? The owners of firms are those who value it most. Therefore valuations are skewed towards the beliefs of investors that are the most optimistic

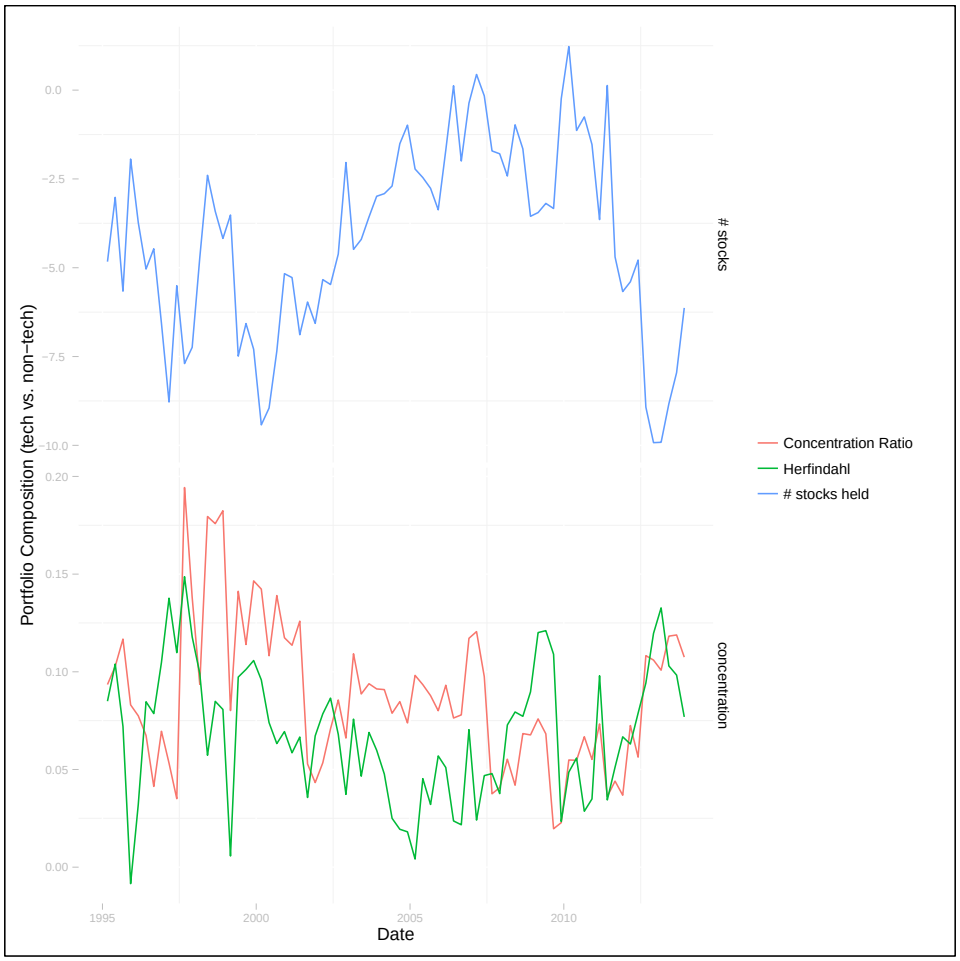

Figure 1.1: Evolution of the difference of portfolio concentration between high-tech and non-high-tech sector over time

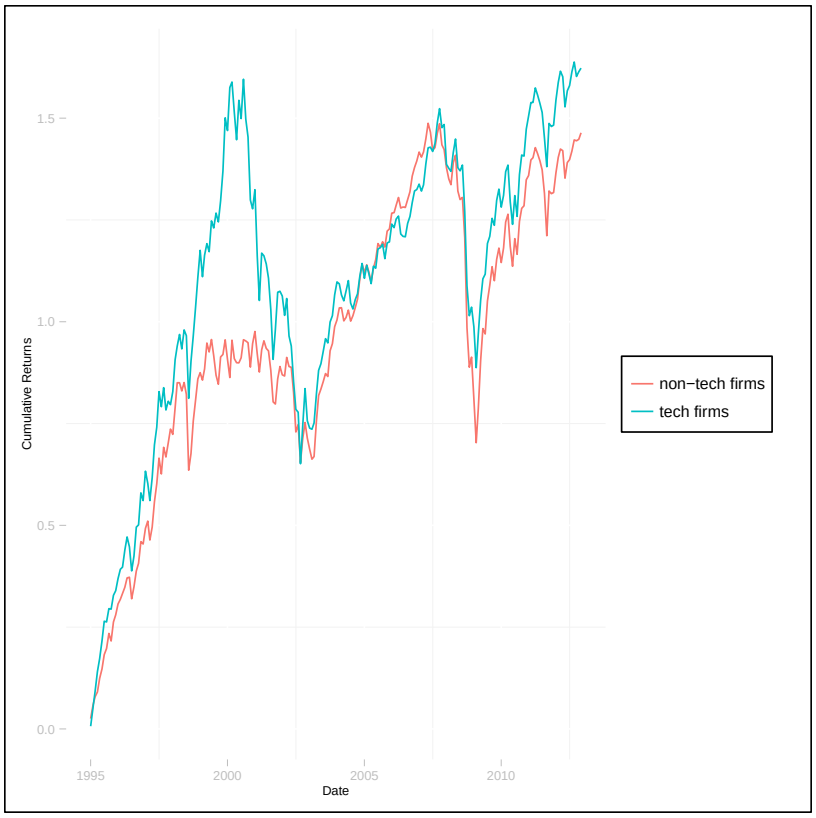

Figure 1.2: Cumulative log returns in the high-tech and non-high-tech sectors

about the firms. If we assume the presence of short sell constraints, pessimistic investors cannot take positions against the success of the firms they expect not to succeed. A key remark specific to detail disagreement is that this effect does not aggregate. In particular if we were to ask investors their individual beliefs on the sector as a whole, they would all agree and give a value lower than what is reflected in the total price of the sector. The heterogeneity inside the sector is what allows the overall sector to have such a high valuation. These high valuations subsequently reverse once the uncertainty about the technology is resolved as it is impossible for all investors to get confirmation of their beliefs.

To observe valuations, we rely on prices on public markets. Using monthly data from CRSP, we compute the cumulative return of a value-weighted portfolio of all high tech firms. We compare it to the same calculation for the remainder of firms in Figure 1.2. The boom and bust during the Internet development of 1999-2002 is striking. In parallel to the recent rise in portfolio concentration in the high-tech sector, we observe a takeoff of prices in the high-tech sectors relative to the remainder of the economy since about 2009.

For private firms, it is much more difficult to measure valuations. However, it is worth noting that short sell constraints are strongest for those firms as there is no market at all for short positions.

Therefore, if one believes our mechanism is present, the boom in prices observed in public markets is just the tip of the iceberg. One would expect much higher valuations for firms in private markets.

1.4 Firm creation

Detail disagreement does not only impact the price of firms but the quantity and nature of firms present in the economy. The capital a new firm is able to raise does not reflect the average belief about its future profit but that of those most optimistic about it. Therefore a new firm is able to raise more capital and this effect fosters more entry. This standard link between valuation and entry is another manifestation that detail disagreement stimulates the demand for capital.

Using data from the Quarterly Census of Employment and Wages from the Bureau of Labor Statistics, we measure the evolution of the log number of establishments in high-tech vs non high-tech sector over the same time period. We represent these quantities, normalized in 1998, in figure 1.3. Panel (a) represents the evolution in log number of establishments in high-tech and non-high-tech sector and panel (b) shows the difference between the two. We observe the two booms in the high tech sector: during the Internet bubble and since about 2009. A similar pattern of entry can be observed when transitioning from private ownership to the deeper public markets. Using data from Thomson SDC, we compute the entry rate in high-tech and non-high-tech among public firms. We report them on Figure 1.4. Again, the first boom and bust at the turn of the century as well as the expansion of the last five years are visible.

Detail disagreement affects more than the quantity of firm creation but also the very nature of firms that are created. Indeed, the presence of detail disagreement shifts the problem faced by creators of firm. With agreement, a business receives financing if its productivity is sufficient relative to other businesses. In the presence of detail disagreement, a business receives financing if some investors believe its productivity is superior to other businesses. This difference provides an extra incentive for firms to differentiate themselves and explore new technologies. Creating new space for disagreement to express itself is a good way to obtain new financing. This mechanism is more subtle and we come back to it at length in Section 3. Anecdotally, the first Internet boom has experienced a large variety of firms, and the last few years have seen a profusion of new firms and technologies created in high-tech sectors. Further symptom of this exploration is the popular notion of "pivoting" whereby tech startups often switch their business focus several times in their first years of existence until they are able to secure financing. Such activity can be seen as an exploration of business possibilities to find one that an investor will value relatively to the existing ones.

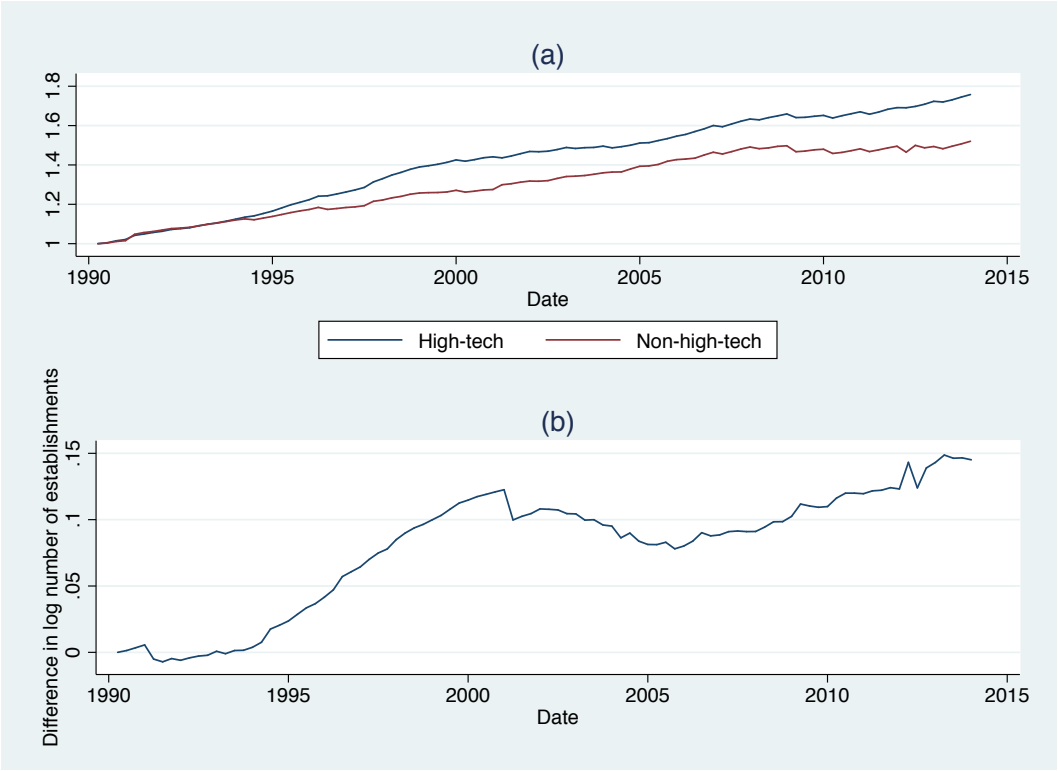

Figure 1.3: (a) *Normalized log number of establishment in the high-tech and non-high-tech sectors* (b) *Difference in log number of establishment*

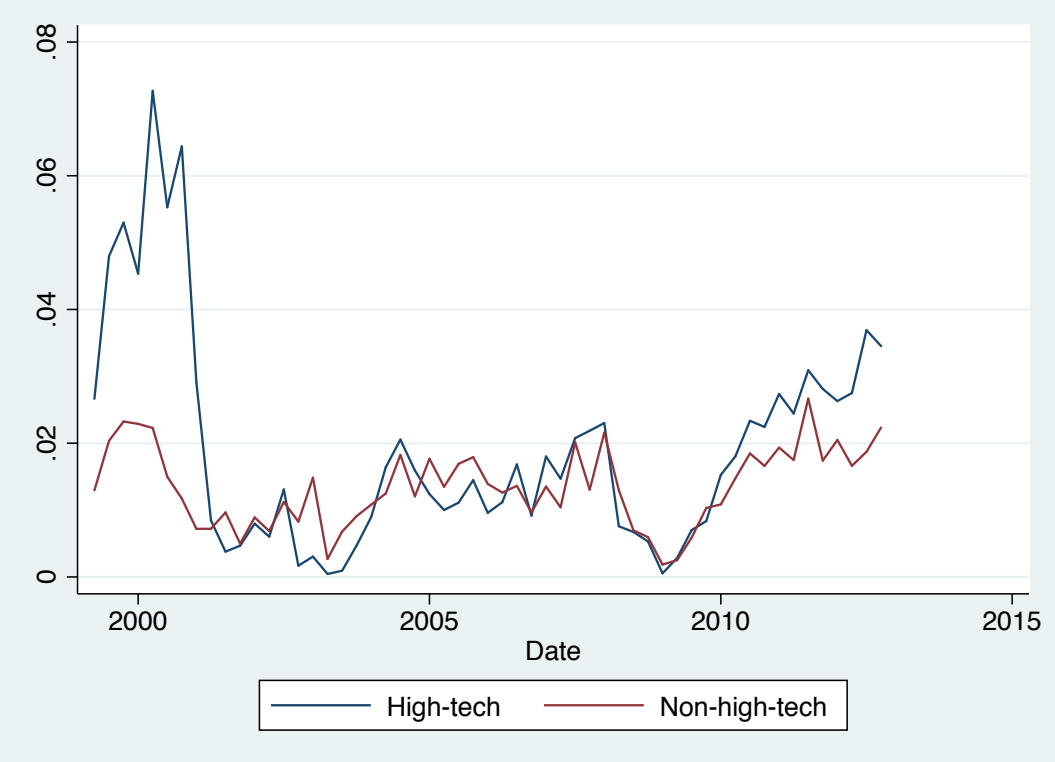

Figure 1.4: Fraction of IPOs in the high-tech and non-high-tech sectors

2 A model of detail disagreement

We have verbally described the mechanism by which detail disagreement favors the emergence of innovation booms. We showed that a conjonction of events consistent with the model happened both during the Internet boom of 1999-2002 and is ongoing since 2009. To precise our approach, we now turn to a formal model of detail disagreement. We start by a simple setup in which all firms compete to capture a market. Then we analyze the role of the competitive environment in shaping the effect of detail disagreement. Beyond the points we have already put forward, the main takeaway is that the presence of detail disagreement among investors profoundly affects the competitive environment, creating a form of competition neglect.

2.1 Model setup

We study an economy populated by a unit mass of investors indexed by $j \in [0,1]$, an infinity of firm creators that in equilibrium create a number n of firms indexed by $i \in \{1,\ldots,n\}$. To simplify the exposition we replace n by a continuous variable in optimization problems in order to obtain simple first order conditions. This is without loss of generality in this setup. There are two types of decision makers in the economy: investors and firm creators. Firms are created and traded on financial markets at date 0 and output is realized at date 1.

Firms

Each firm i in the economy is of type θ_i, unknown at date 0. At date 1, the firm produces a cash-flow $y_i = \theta_i 1\{\theta_i = \max_{i'} \theta_{i'}\}$. This assumption corresponds to a winner-take-all setting. The strongest the winner is, the more profits are collected. This setup corresponds intuitively to our description of the social network industry where a single firm is likely to capture all the market, but which firm is currently unknown.

Firm creators

Firm creators decide whether to create a firm. Their decision is entirely static as they sell the firm on capital markets as soon as they create it. To create a new firm, they hire a unit of labor. We assume both labor and capital markets are competitive and therefore that firm creators are price-takers. Noting p_i the price of firm i and w the wage prevalent on the labor market, each firm creator decides to create a firm if and only if they can generate positive profits:

$$\pi_i = p_i - w \geq 0,$$

with indifference in the case of equality.

Investors

All investors are ex-ante identical and are endowed with possession of all firm creators and one unit of date 0 consumption good. Their utility of consumption is linear across periods. Further, they can provide l_j units of labor at an increasing convex cost of effort $W(l_j)$ in exchange for the wage w. Investors buy shares s_i^j of firm i in order to obtain future consumption. We assume short-selling is not allowed, $s_i \geq 0$. Once firms are created, investors potentially differ in their beliefs as they have different priors on firm types. We write $\mathbb{E}_j$ the expectation operator correponding to the beliefs of agent j. The optimization problem of an agent is therefore:

$$\begin{aligned} & \max_{c_0, s_i, l} \quad c_0 + \mathbb{E}_j \left[\sum_i s_i y_i \right] - W(l) \\ \text{s.t.} \quad & c_0 + \sum s_i p_i \leq \pi + wl \end{aligned}$$

Beliefs

To study the role of detail disagreement, we focus on two extreme cases: one with completely common beliefs, the second with tight heterogenous priors. To discipline the comparison, we focus on a case where the distribution of beliefs across agents under disagreement corresponds exactly to the common belief under agreement. Finally we include a common and idiosyncratic component to firm productivity to differentiate the role of aggregate and detail disagreement.

We assume $\theta_i = \bar{\theta} + \tilde{\theta}_i$. For the case of agreement, the common belief is that $\bar{\theta}$ is drawn from a cumulative distribution function $H(.)$ and that the specific productivity values $\tilde{\theta}_i$ are drawn independently from a cumulative distribution function $F(.)$. The distribution for each firm type θ_i is therefore $H * F$, where the symbol $*$ represents the convolution product. For the case of disagreement, each investor receives a draw of this joint distribution of types and has this draw as a tight prior. The assumption of a completely tight prior is somehow extreme as investors are sure of their knowledge about the firms. We make this assumption as it greatly simplifies derivations, and some milder version of the results we derive hereafter hold without such tight prior. Notice however that uncertainty plays a minor role in this setup as investors are risk neutral.

Equilibrium conditions

Finally, we need to insure all markets are in equilibrium. This corresponds to the fact that the labor market clears, the market for ownership of the firms, and the market for time 0 consumption. This

corresponds to the conditions:

$$\begin{aligned} n &= l, \\ \forall i, \int_j s_i^j &= 1, \\ \int_j c_0^j &= 1. \end{aligned}$$

2.2 Equilibrium

Agreement

Under agreement, all firms are equally likely to be the most productive:

$$\mathbb{E}_j \left[\sum_i s_i y_i \right] = \sum_i s_i \frac{1}{n} \mathbb{E} \left[\theta | \theta = \max_{i'} \theta_{i'} \right].$$

Because agents are risk-neutral, they take an interior position in asset i if and only if the price equals their expected valuation of the asset. Remarking the distribution of the maximum of n draws from the same distribution F is F^n leads to:

$$\forall i,\ p_i = \frac{1}{n} \mathbb{E} \left[X | X \sim H * F^n \right].$$

This first equation pins down the demand for firms. To obtain the supply of firms, we use the first order condition for labor supply and the zero profit condition for firm creators, to obtain:

$$W'(n) = w = p_i.$$

This concludes the determination of the equilibrium.

Proposition 1. *Under agreement, the price and quantity of firms in the unique equilibrium are given by the unique solution to*

$$\begin{aligned} \frac{1}{n} \mathbb{E} \left[X | X \sim H * F^n \right] &= W'(n), \\ p &= W'(n). \end{aligned}$$

Disagreement

Under disagreement, agent j has a tight belief about the productivity of firms. Therefore, the expected date 1 consumption of agent j is:

$$\mathbb{E}_j\left[\sum_i s_i y_i\right] = \sum_i s_i \theta_i^j 1\left\{\theta_i^j = \max_{i'} \theta_{i'}^j\right\}.$$

Clearly, investor j only invests in the stock she expects to succeed, and only does so if her belief about the productivity of this asset is larger than the price. In appendix, we show only symmetric equilibria of this model exist. A fraction $1/n$ of investors have firm i has their highest outcome where there valuation is distributed by $H * F^n$. All those that have a valuation larger than the price invest all their wealth (initial endowment and labor income). Therefore, market clearing for the asset implies

$$1 = (1 - H * F^n(p))\,\frac{1}{n}\frac{1+wl}{p}.$$

The first term is the fraction of investor for which their prefered firm has value over p and the second the faction among those that prefer sepcifially firm i. The second term is the total number of shares each of them buys: the ratio of their total wealth $1 + wl$ to the price of a share p.

Noticing that market clearing for labor implies $l = n$ and that the zero profit condition for firm producers implies $p = w$, we arrange this equation to obtain

$$1 = H * F^n(p)(1 + np).$$

To complete the equilibrium one needs to determine the labor supply as before. The marginal cost of effort the agent is willing to suffer is larger than the price of the asset as investors buying shares perceive they will receive an extra return on their investment. This corresponds to

$$W'(n) = \mathbb{E}\left[\max(p, X)\,|X \sim H * F^n\right].$$

Putting these two conditions together, we obtain the determination of the equilibrium.

Proposition 2. *Under disagreement, the price and quantity of firms in the unique equilibrium are given by the unique solution to*

$$\begin{aligned} W'(n) &= \mathbb{E}\left[\max(p, X)\,|X \sim H * F^n\right], \\ 1 &= H * F^n(p)(1 + np). \end{aligned}$$

Comparing equilibria

We can now compare the outcomes of the situation with and without disagreement. First, note that in this case disagreement gives rise to an extreme form of portfolio concentration. In the presence of detail disagreement investors buy shares in at most one firm. By comparison, with agreement, all investors are indifferent to invest in various firm and in a symmetric allocation would hold diversified portfolios of asset. Importantly this specialization of portfolios is the result of detail disagreement. With a degenerated distribution F, agents would either invest in all stocks or none of the stocks, but never have a strong preference for one stock agains all others.

Second, let us focus the number of firms in each sector. For this consider first equation in the two propositions determining the equilibria. Two main differences appear: the expectation taken for the marginal benefit of an additional firm is over $\max(p, X)$ rather than X with disagreement. This first effect is the standard Miller (1977) effect. In the presence of disagreement and short-sell constraints, as only optimistic investors buy firms, beliefs larger than the price are overrepresented, which pushes the price over the average belief, and subsequently the number of firms. This effect is present with aggregate and detail disagreement. The second main difference is specific to detail disagreement. The $1/n$ factor in the equilibrium with agreement disappears, again creating more entry. We call this effect *competition neglect* as it results from the fact that investors have a preferred firm and ignore the presence of other firms in their evaluation of that firm. With agreement, each new firm lowers the valuation investors put on other firms. This displacement effect is not present with detail disagreement, leading to competition neglect. We come back to this effect in the next section.

Finally we prove in appendix that the asset price is always higher under disagreement that under agreement. Again, this reflects the two selection effects of matching optimistic investors and investors who prefer them to each firm. These three types of predictions reflect the differences we documented in Section 1 when comparing high-tech sectors to the rest of the economy.

2.3 Competition neglect

To better understand the seeming disappearance of competition in the model with detail disagreement, we study an alternative structure for the profits of firms. We keep the same data generating process for the types θ_i, but now do not include the displacement effect. All firms produce output $y_i = \theta_i$. In other words, contrary to the previous model, the presence of other firms does not reduce the potential profit of a firm. The actual productive capacity of this economy is much larger than the previous one and all agents in the economy are aware of it. We consider in turns a comparison of this economy to the displacement economy with agreement and without disagreement.

Agreement

Under agreement, each firm is valued at its expected productivity, being the expected value of its type θ_i. The labor supply and firm creation decisions are as in the previous setting. Therefore, the equilibrium is given by

$$\begin{aligned} \mathbb{E}\left[X|X \sim H * F\right] &= W'(n), \\ p &= W'(n). \end{aligned}$$

Creating firms is indeed much more valuable in the eyes of the market. Investors recognize they will always collect the type of the firm, independently of whether it is the most productive or not. Therefore, more firms are created and the price of a given firm is larger.

Disagreement

Under disagreement, even though all investors recognize that all firms will produce, they still decide to specialize their portfolios. Indeed, in a symmetric equilibrium, all firms have the same price. Investors only buy firms for which they expect an output larger than the price. Overall pessimistic investors for which no such firm exists stay out of the market. And, when multiple firms represent such a good deal, the investor only buys the firm with the largest expected gain. Just as in the previous model, investors only buy their favorite firm, even if it is not the only productive firm in their view. Similar derivations as the model with displacement provide the equilibrium conditions:

$$\begin{aligned} W'(n) &= \mathbb{E}\left[\max(p, X)|X \sim H * F^n\right], \\ 1 &= H * F^n(p)(1 + np). \end{aligned}$$

The equilibrium is exactly identical to the model with displacement. This confirms the explanation that once investors specialize in their favorite firm, they do not consider the effect of other firms on the market. This effect is strong as all investors, whatever their belief is, agree that the total productive capacity of this economy is larger than the economy with displacement. Yet, they include as many firms whether this is the case or not. The reason this knowledge is not reflected in market outcomes, is that investors are "blinded" by the good opportunity they face in their favorite firm and extend all their resources to this firm.

Further, note that competition neglect also impacts the economy without displacement. Indeed, beyond the selection effect of firms being evaluated at the expectation of $\max(p, X)$ rather than X, the specialization of each investor in her favorite firm, transforms the distribution at which the type is evaluated from $H * F$ to $H * F^n$. This transformation, once again, is the result of detail disagreement

rather than the aggregate disagreement as H is not transformed, only F is.

To summarize, we showed detail disagreement leads to a form of competition neglect. As each firm is financed by investors who believe it is more productive than competitors, it receives funding as if it was alone in the market. This effect leads to more firm creation and higher asset prices. Naturally, for competition neglect to have a large impact on outcomes, the market needs to be competitive to start with. We showed the increase in firm creation due to competition neglect is much more pronounced in a winner-take-all market than in one where firms all produce independently from each other.

3 Endogenous innovation diversity

In the model we have presented, detail disagreement creates an innovation boom. Compared to a benchmark with agreement, more firms are created and valuations are high. We now turn to another question: how does detail disagreement affect the type of firms created? In particular, we focus on whether an homogenous group of firms is created or a variety of technologies are explored. We present a variation of our model where firm creators choose whether to explore a populated technology or a new technology. We find in the presence of detail disagreement all technologies are explored, whereas with agreement firms are only created in one technology. These results not only shed further light on the profound economic effects of detail disagreement, but also differentiates our theory of innovation booms from others based on aggregate disagreement or uncertainty. We first introduce our model of technology choice, then discuss how disagreement affects this choice in equilibrium.

3.1 Technology choice

Production technology

In our previous model, each firm created was its own technology. We now relax this assumption and let firm creators choose which technology to use. We assume there are two possible fields, indexed by $i \in \{1, 2\}$.

All firms compete to try to capture one unit of profit. Each field has a type λ_i, potentially unknown to investors. The type characterizes the speed of technological progress within the field. The larger the number of firms n_i inside a field, the faster progress happens in this field. The total speed of progress in a field is $n_i\lambda_i$. The field with the largest value of $n_i\lambda_i$ collects the unit of profit. Within that field, all firms are equally likely to collect the profit.

We provide a simple microfoundation for this technology: all firms are continuously looking for new ideas. The final discovery happens when a certain number of ideas have been found. Each firm has an arrival rate of new ideas of λ_i and a firm can build on the knowledge of other firms in the field.

Therefore the number of ideas within each field evolves at a rate $n_i\lambda_i$. The firm capturing the profit is the one having the last idea and therefore all firms have the same probability of doing so.

Beyond these assumptions, we keep the setup as before, with competitive firm creators and competitive financial and labor markets. To separate the role of diversity from the quantity of investment, we impose an inelastic labor supply at some level N. Relaxing this assumption only gives back the result that disagreement increases entry, but does not affect our results on specialization.

Beliefs

We now assume agents disagree about the type λ_i of the fields. We consider three cases: agreement, dogmatic disagreement, partial disagreement. Under agreement, all agents believe that the types are independently uniformly distributed on the unit interval: $\lambda_i \sim U([0,1])$. With dogmatic disagreement, half of the population believes $\lambda_1 = 1, \lambda_2 = 0$, the other half $\lambda_1 = 0, \lambda_2 = 1$. These two cases allow us to show clear differences in equilibrium outcomes with and without disagreement. Finally to understand the behavior of the model under milder cases of disagreement we study intermediate cases parametrized by a, where half of the population believes $\lambda_1 \sim U([0, 1-a]), \lambda_2 \sim U([a,1])$ and the other half the symmetric. When $a = 0$ this situation corresponds to agreement, and when $a = 1$ to dogmatic disagreement.

3.2 Equilibrium diversity

Agreement

To determine the equilibrium, we first derive the investors' willingness to pay for a firm in each sector. This willingness to pay wtp_i corresponds to the probability of the firm collecting the profit. It is equal the probability that the field collects the profit multiplied by the probability that among firms in the field, an individual firm succeeds. This corresponds to

$$wtp_i \quad = \quad \mathbb{P}\left[n_i\lambda_i > n_{-i}\lambda_{-i}\right]\frac{1}{n_i}.$$

Two cases arise depending on whether sector i has the largest number of firms:

$$wtp_i = \begin{cases} \frac{1}{n_i} - \frac{n_{-i}}{2n_i^2} & \text{if } n_i \geq n_{-i} \\ \frac{1}{2n_{-i}} & \text{if } n_i \leq n_{-i} \end{cases}$$

This implies that in the dominant field, adding more firms to the field or the other field both decrease the individual value of a firm. If the current field is not dominant, only adding firms to the other field lowers the value of firms within the current field.

Given the demand for assets from the point of view of individual investors is perfectly inelastic at these valuations, two cases can arise in an equilibrium. If we have an interior equilibrium, both types of firm exist and are produced in the same quantity, $n_1 = n_2$. Given the valuations we just derived, it is straightforward to notice that this equilibrium is unstable. For instance, adding one more firm to sector 1 and taking one out of sector 2 increases the value of firms in sector 1 and decreases that of firms in sector 2,. This pushes towards adding even more firms in sector 1, and we conclude this equilibrium is unstable.

The other possible equilibria have to feature firm creation in only one sector. Consider a candidate equilibrium with $n_1 = N, n_2 = 0$. A simple set of prices rationalizes this equilibrium: each firm is valued at its expected value. Because firms in sector 1 are more valuable than the marginal firm in sector 2, they trade at a higher price and firm creators specialize in their production. Further, this equilibrium is stable. Adding a firm in sector 2, does not increase much the likelihood of this sector to capture the unit profit, and firms in sector 1 stay strictly more valuable. As these are the only potential equilibria we conclude.

Proposition 3. *With agreement, the only stable equilibria feature full specialization. Two such equilibria exist:* $(n_1, n_2) = (N, 0)$ *and* $(n_1, n_2) = (0, N)$.

This result should not be interpreted as a general conclusion that agreement always generates specialization. The reason this result arises in our setting is that we have included a positive externality within each field, negative across field, where new firms help their current field and hurt the other field. This benefit of specialization is present in many sectors. Our main argument is that this effect is very much mitigated by the presence of disagreement in financial markets.

Dogmatic disagreement

Let us now turn to the case of dogmatic disagreement. We distinguish the two classes of investors by a superscript $j \in \{1, 2\}$ where j corresponds to the field they believe will succeed. For firms in sector j, the investor is sure this field will succeed and therefore believes all firm in this sector are equally likely to win. For firms in the other sector, the investor is sure they will not succeed and values them at 0. This corresponds to:

$$wtp_i^j = \begin{cases} \frac{1}{n_i} & \text{if } i = j \\ 0 & \text{if } i \neq j \end{cases}$$

Note that now, from the point of view of investors j, the number of firms in sector $-j$ is irrelevant to the valuation of firms in sector j. Their demand for firms is as if all firms in sector j compete for the same unit of profits. We recognize the competition neglect effect again, across fields. Within a field as beliefs are the same, there is no such neglect.

No matter what asset prices are, investors only buy firms in the sector they believe in. As before, because firm creators face the same cost for both types of firms, either prices are equalized or only one type of firm is produced. Let us consider these two possibilities in turn.

If both firms are produced and face the same price, then investors of each type buy firms of the corresponding type. The only way to equate prices is to equate the number of firms across sectors, $n_1 = n_2$. This equilibrium is stable. Indeed, if we add one firm to field 1 and take one out of field 2, field 1 becomes more populated and investors of type 1 are less willing to pay for each individual firm. On the other hand investors in field 2 are willing to pay more for their firms. This pushes towards increasing entry in field 2 and reducing that in field 1, insuring the stability of the equilibrium.

Now consider the case where $n_1 = N, n_2 = 0$. The price of firms in field 1 has to equal the willingness to pay of agents of type 1, $p_1 = 1/N$. For firms in field 2, two conditions have to be verified. Firm creators have to prefere creating firms in field 1, so we need the price of firms in field 2 to be less than that of firms in field 1, $p_2 < p_1$. For investors of type 2 to not demand any such firms, we need the price to be more than their willingness to pay. As there are no firms in the field 2, this willingness to pay is equal to 1, so we need $p_2 > 1$. The two conditions cannot be satisfied simultaneously, so this situation cannot be an equilibrium. We summarize these results in the following proposition.

Proposition 4. *With dogmatic disagreement, the only equilibria is stable and involves complete diversity. In this equilibrium,* $(n_1, n_2) = (N/2, N/2)$.

The presence of detail disagreement has two effects on the equilibrium structure. Not only it allows for the equilibrium with diversity to be stable, but also prevents the specialized equilibrium from existing. Both results come out of the effect of competition neglect. What made the equilibrium with diversity unstable was that adding more firm in one field would strengthen it. With detail disagreement, as investors ignore the other field altogether, all that happens in their view is displacement within the field. Second, the specialized equilibrium cannot exist, as even if one field is much more populated than the other one, investor specialized in the latter will not consider it less likely to succeed.

Partial disagreement

The results we just derived are under the assumption of a strong form of disagreement where investors ignore the other sector altogether. To investigate the robustness of this results we consider the case of partial disagreement. Each group of investors still has a preference for one field, but now they also consider possible a success from the other field. The parameter a controls the strength of disagreement. We leave the formal derivation of the equilibria to the appendix, and focus on commenting the outcome.

Proposition 5. *Only two types of equilibria can exist depending of the level of disagreement a: a*

diverse equilibrium $(n_1, n_2) = (N/2, N/2)$*, and specialized equilibria* $(n_1, n_2) = (N, 0)$ *or* $(n_1, n_2) = (0, N)$*.*

- *if* $a > 1/3$ *only the diverse equilibrium exists*
- *if* $1 - 1/\sqrt{2} < a < 1/3$*, both types of equilibria exists*
- *if* $a < 1 - 1/\sqrt{2}$*, only the specialized equilibria exist*

This proposition shows that our results on disagreement favoring diversity hold even without a strong form of disagreement. In particular, as soon as disagreement is large enough the specialized equilibria cannot be sustained. Interestingly, note that in the intermediate region, both types of equilibria coexist. In this model, partial disagreement does not result in partial specialization.

4 Normative considerations

Our analysis has focused on a completely competitive market structure up until now. However, empirically we observe a variety of ways in which innovation is financed. In this section we consider how financing structure and reglementations can help foster innovation or improve the welfare of agents in the economy. We first consider the role of bundling to finance innovation. Then, we consider the impact of taxing or subsidizing firm creation on innovation and welfare.

4.1 Which financial contracts?

In a series of articles, Fagnan et al. (2013), Fagnan et al. (2014) and Lo et al. (2014) argue that the research of cures for Cancer and other diseases is greatly slowed down by their current financing structure. They argue medical research is an extremely risky endeavor and only one firm will rip the benefits of finding the cure. They advocate the use of securitization, creating pools of funding to finance several medical research firms simultaneously to diversify the risks taken by investors. We consider this question in the context of detail disagreement.

Remarkably, the competitive structure of research for the cure for Cancer matches quite closely the setup of our model of Section 2. Firms try different approaches to compete for a single outcome: finding the cure and collecting the profits of selling it. In our setup the presence of idiosyncratic risk involved in individual projects does not play any role because we assume risk-neutrality. Still, we can ask how the outcome of the model changes if we force investors to trade diversified claims on all firms.

In a world with agreement, investors are indifferent about which portfolios of firms they hold and therefore the equilibrium is completely unchanged by forcing bundling. On the other hand, in the presence of detail disagreement, bundling forces investors to change their holdings. We derive the

equilibrium of this case in the appendix. Disagreement, in particular absolute disagreement, still plays a role as agents optimistic about the pool of the firms buy shares of the index and pessimistic agents stay out of the market. However, the effect of competition neglect is completely cancelled. If an agent wants to buy the firm he believes in, she has to buy all other firms at the same time. The valuation she puts on the basket is the same as she puts on the individual firm she prefers. Therefore the competition neglect effect is cancelled. Asset prices and firm creation are much lower.

Actually, following the logic of our model, if one tries to foster firm creation, bundling ownership across firms is the most hurtful for industries similar to medical research. Two reasons contribute to this conclusion. First, high-tech industries taking a jump into the unknown are likely places where opinions will differ the most strongly and speculation is the most likely. Second, medical research is by construction a winner-take-all business. Therefore, the competition neglect arising when allowing investors to speculate will have its largest effect in such a sector. Forcing indexing would prevent these effects from arising. Though, to be fair to the hypothesis of Fagnan et al. (2013), such industries are also those where firm-level risk is maximized; which force dominates is an empirical question.

4.2 Optimal firm creation subsidies or taxes

Even if markets are competitive and in the case of agreement, most of the models we have studied up until now need not deliver efficient equilibrium. Indeed, we focused on technologies where firms exert displacement externalities on each other. A natural policy tool to adress these frictions is a tax on firm creation, rebated lump sum. Equivalently this corresponds to allowing the planner to decide the equilibrium number of firms. Another advantage of this tax is that it can be evaluated without knowing individual agent's beliefs, before firms are created. This simplifies the welfare analysis are all agents are ex-ante identical in the model. However, the presence of disagreement still necessits a choice of welfare criterion. We focus on two criteria: the Pareto criterion and the belief-neutral criterion of Brunnermeier, Simsek, and Xiong (2012). The Pareto criterion can also be interpreted in a positive fashion: it reveals which policy would prevail if agents were asked ex-ante to vote on their preferred policy. We focus on a simplified version of the model of Section 2.1, where the output of the winning firm is 1 rather than its type.

Under agreement, the optimal number of firm is clearly 1 and therefore the optimal policy is a tax on firm creation. Indeed, adding more firms multiplies labor costs but does not provide any additional output for the economy. The market does not reach this outcome as creating more firms yields a private benefit by displacing the profits of existing firms.

In the presence of detail disagreement, even more firms are created. This would suggest more inefficieny. However, one has to evaluate welfare taking into account the disparity of beliefs once firms

are created. Let us start by the Pareto criterion. In this case, one can show that the equilibrium number of firms exactly coincides with the optimal number of firms.[6] This conclusion might appear surprising, but can be understood in the context of competition neglect. Each firm created provides expected ressources to investors who believe it will profit for sure. The presence of other firms does not affect those expected profits as the investors are sure the firm they invest in will collect the profits. Therefore, from the point of view of investors in each firm, not only this firm is more attractive than without disagreement but also the externalities imposed by other firms are absent. Even before they start disagreeing, the perspective of future speculation makes investors desire a high level of entry, as they all think they will pick the winner, and that brings them high utility today.

On the other hand, if we impose common beliefs among investors, whatever this common belief is, there are always too many firms created ex post. Indeed, whether their beliefs are tilted towards a particular firm or are balanced across firms, resources will have been wasted. In the first case resources have been wasted on non-productive firms, in the second on multiplying costs without adding benefits.

What these conclusions show us is that, even before they know how they will speculate, investors in the presence of detail disagreement are favorable to the emergence of the innovation boom of the competitive equilibrium. This is in stark contrast with the case of agreement where even though there is less entry in the competitive equilibrium, entry is excessive. Enforcing agreement in the welfare criterion counteracts this conclusion as it forces recognition of the displacement effect. Without taking a stand on the welfare criterion, we can at least conclude that the innovation booms we considered are not the inefficient fruit of market competition, but a desired social outcome from investors that recognize they will disagree and speculate.

4.3 Role of innovation diversity

We have left the role of innovation diversity aside in our discution of potential policies up until now. The reason is that the social benefit of innovation diversity is difficult to evaluate empirically and can be arbitrarily modified within the model. We briefly discuss arguments in favor and against a benefit of innovation diversity. We have showed that detail disagreement fuels innovation diversity. Therefore, the point of view on the social benefit of innovation diversity shapes the evaluation of innovation booms driven by detail disagreement.

A benefit of innovation diversity is that it favorizes the emergence of potentially game-changing technologies. Acemoglu, Akcigit, and Celik (2014) explore this direction. They focus on the role of openness, materialized by younger managers, for the emergence of disruptive innovation. Disruptive innovation are discoveries that end up being widely cited. Our results can be viewed as detail disagree-

[6] In the case of the model of Section 2.1, we find there is actually too little entry in equilibrium.

ment creating a form of openness at the scale of the market. Indeed differing opinions across investors opens the possibility for original ideas to be funded. Such tail innovations are rare and difficult to measure.

On the other end, one can also argue that diversity is a form of wasteful dispersion. In the presence of strong knowledge externalities across firms, having many firms explore similar ideas can actually yield faster technological growth. And, we showed in Section 3.2 that even when these knowledge externalities exist, disagreement can yield diversity. Determining the precise conditions when diversity is excessive or not in the presence of detail disagreement is an important question, beyond the scope of this paper.

Conclusion

Innovation, a jump in the unknown, favors the emergence of *detail disagreement*: disagreement about the details of which technologies are likely to be successful. In this paper, we showed the presence of detail disagreement can generate innovation booms. Such episodes are characterized by high asset prices that subsequently drop, large number of firms being created, and a particular spurt in the diversity of technologies explored. We showed this pattern of events occured during the Internet boom of 1998-2001 and seems to emerge again, albeit less violently since 2009.

When considering the real side of the economy, detail disagreement has distinct implications from aggregate disagreement. Detail disagreement yields a form of competition neglect. Investors match with the firm they prefer, and ignore the presence of other firms when evaluating profit prospects. We showed this effect has a profound impact on the competitive structure of the economy, particularly in sectors with a winner-take-all aspect. Further, this effect also affects the nature of innovation undertaken, yielding more diversity in technologies. Finally, competition neglect also changes the normative evaluation of economies. In the presence of detail disagreement, economies with real frictions can have efficient equilibria.

Still, many questions remain. We briefly discussed which financing structures are favorable to the expression of detail disagreement. The emergence of new financing structures in the last few years — such as online financing platforms, or more and more early financing of projects — is likely to interact strongly with detail disagreement. Should we encourage the development of such structures? Further, in our models firms are passive. In practice, firms can react, decide and adapt over time the type of products they sell. Rajan (2012) studies the lifecycle of a firm's originality in the perspective of securing financing; clearly, the presence of speculation can also affect firms' decisions over their lifecycle. Finally, a more in-depth empirical study of detail disagreement is in order. We see two main challenges in this direction. First, measuring beliefs of investor is challenging, and relative beliefs

across firms seems even more complex. An indirect approach we have taken in this paper is study the portfolios held by investors as a signal of those beliefs, but a tighter connection would be desirable. Second, an important outcome of our models is the diversity of innovation. Very little measures of such diversity have been undertaken in the literature. Given the potentially large growth consequences of the level of exploration in the economy, it would be useful to get a better grasp at this quantity.

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