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THE REVOLUTION OF INFORMATION ECONOMICS: THE PAST AND THE FUTURE

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ABSTRACT

The economics of information has constituted a revolution in economics, providing explanations of phenomena that previously had been unexplained and upsetting longstanding presumptions, including that of market efficiency, with profound implications for economic policy. Information failures are associated with numerous other market failures, including incomplete risk markets, imperfect capital markets, and imperfections in competition, enhancing opportunities for rent seeking and exploitation. This paper puts into perspective nearly a half century of research, including recent advances in understanding the implications of imperfect information for financial market regulation, macro-stability, inequality, and public and corporate governance; and in recognizing the endogeneity of information imperfections. It explores the consequences of recent advances in technology and the policy challenges and opportunities they present for competition policy and policies regarding privacy and transparency.

The paper notes the role that information economics played in stimulating other advances in economics, including contract theory and behavioral economics. It reinvigorated institutional economics, showing how institutions mattered, in some cases explaining institutional features that could not be well-understood in the conventional paradigm, and in others showing how institutional responses to market failures might or might not be welfare enhancing.

The paper argues that the new paradigm provides a markedly different, and better, lens for looking at the economy than the older perfect markets competitive paradigm.

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Introductory remarks and main messages

The economics of information has constituted a revolution in economics, upsetting longstanding presumptions, including the presumption of market efficiency, with profound implications for economic policy. The central models of information economics, developed almost a half century ago but greatly elaborated upon in the intervening years have proven remarkably robust. At the same time, these advances in the economics of information have shown the lack of robustness of the standard competitive paradigm. The models have provided a deeper understanding of other ways in which actual markets differ from the perfect markets paradigm. The imperfections of competition and the absence of risk markets with which they are marked matter a great deal.

Early work in the economics of information suggested too that it would help us understand better the role of institutions and the form that institutions take; work since then has confirmed the promise. So too, the economics of information has provided new intellectual underpinnings to branches of the subject which seemed devoid of a theoretical framework, such as accounting, finance, and corporate governance, and has helped us understand better why work in these sub-fields is so important.

Elaborations of the early models and the adaptation of these models to different market contexts have occupied much of the economics professions attention in the decades since the first models were presented.

Not surprisingly, the policies derived from the new paradigm are often markedly different from those derived on the basis of the standard model. Most importantly, as we emphasize below, there is no presumption that markets are efficient; quite the contrary, the presumption is that markets are not efficient. And in those sectors where information and its imperfections play a particularly important role, there is an even greater presumption of the need for public policy. The financial sector is, above all else, about gathering and processing information, on the basis of which capital resources can be efficiently allocated. Information is *central*. And that is at least part of the reason that financial sector regulation is so important.

Markets where information is imperfect are also typically far from perfectly competitive (as that concept is understood, say, in the models of Arrow and Debreu).[1] In markets with some, but imperfect competition, firms strive to increase their market power and to increase the extraction of rents from existing market power, giving rise to widespread distortions. In such circumstances, institutions and the rules of the game matter. Public policy is critical in setting the rules of the game. Distributive effects of alternative rules may outweigh any efficiency gains. Undoing the adverse distributive effects created by these market imperfections may be very costly, again, largely because of information imperfections.[2]

[1] The market failures referred to in the previous paragraph arise even when firms and households are price takers. We are now describing an important second set of market failures typically arising in markets with imperfect information.

[2] In standard economics, the second welfare theorem explains how any Pareto efficient allocation can be achieved simply through the redistribution of initial endowments. When there is imperfect information, the second welfare theorem is in general not true. For an exposition, see Stiglitz (1994).

Many recent changes in the rules may have had both adverse efficiency and distributive effects. The economics of information has explained why distributive effects themselves may have efficiency consequences, especially in presence of macro-economic externalities.

Looking forward, changes in structure of demand (that is, as a country gets richer, the mix of goods purchased changes) and in technology may lead to an increased role of information and increased consequences of information imperfections, decreased competition, and increasing inequality. Many key battles will be about information and knowledge (implicitly or explicitly)—and the governance of information. Already, there are big debates going on about privacy (the rights of individuals to keep their own information) and transparency (requirements that government and corporations, for instance, reveal critical information about what they are doing). In many sectors, most especially, the financial sector, there are ongoing debates about disclosure—obligations on the part of individuals or firms to reveal certain things about their products. Many of these issues can be framed in terms of property rights—who owns the right to certain pieces of information. But these property rights issues are different from and more complex than those concerning conventional property rights, where it is usually assumed the stronger the better. Here, the ambiguities in the assignment of property rights are apparent, and so called strong (intellectual) property rights may lead to poorer economic performance.

Globalization has heightened all the associated controversies, because now, how the rules are set affects not only distribution among individuals within countries, but also the distribution of income between countries. Many in the former colonial world see the attempt by some in the advanced countries to impose their set of rules as not just an attempt to enrich their corporations, but to entrench old inequities.

How we handle these issues will affect inequality, economic performance, and the nature of our polity and society for decades to come.

This lecture is divided into seven sections. In the first, we lay out some of the key insights of the New Information Economics, contrasting it with the old paradigm which assumed perfect information. The central result of the new paradigm was that markets were not, in general, efficient: there was a need for government intervention. Adam Smith's invisible hand failed simply because it wasn't there. The second section describes several failed but still important attempts to respond—to show that the market was in fact efficient, if not always, at least in relevant cases. The third then describes some of the policy corollaries, and the ongoing policy battles over information. The fourth sets the Information Revolution in the context of the longstanding battle of how to understand the persistent inequality under capitalism—is it exploitation (as Marx suggested) or just rewards, in response to differences in social contribution? We suggest that while Marx had the wrong model of the economy, there is more than a little grain of truth in his exploitation theories. The fifth describes the role of the information revolution in promoting broader changes in the economic paradigm. The sixth looks forward—to the implications of the new paradigm for the economy which is evolving in the twenty-first century. We end with a few concluding remarks.

I. The information revolution

Economists had, of course, long recognized the importance of imperfect information. Indeed, some economic discussions actually triumphed the informational efficiency of the market—arguing that efficiency can be achieved in a decentralized price system, there was no need for a central planner. All the information that a firm or a household needed to know to make its decisions were the prices. Prices coordinated all economic activity. Yet, these statements were made without any formal models of the economy as an information processor. Resource allocations were once-and-for-all decisions. Moreover, the kinds of information imperfections were limited. There was no uncertainty about the quality of a worker or a product.

By and large, formal models made no mention of information—other than to assume that there was perfect information. The hope was that analyses with perfect information would be relevant so long as information was not *too* imperfect.

Some Chicago school economists thought that one could develop an "economics of information"—based on the analysis of the supply and demand for information (much like "economics of agriculture," focusing on the particular characteristics of the demand for and production of information, just like agriculture economics focused on the particular characteristics of the demand for and supply of food). But it should have been clear, even before the formal development of the field described below that that was unlikely. Information (knowledge) is fundamentally different from steel, corn, or the other goods upon which ordinary economics focuses. Information is a public good[3]—indeed, more broadly, knowledge is a global public good (Stiglitz (1999)) and markets on their own typically are not efficient in the provision of such goods.

Arrow-Debreu (AD) provided the key benchmark model describing the behavior of a competitive economy with perfect information through a model of competitive general equilibrium in which all firms were price takers. Most importantly, AD provided conditions under which Smith's "invisible hand" conjecture was correct, not just the first welfare theorem, showing that market economies were Pareto efficient, but also the second fundamental theorem, showing that every Pareto efficient outcome could be obtained through a market mechanism, provided that there was the appropriate initial (lump sum) redistribution of wealth. AD focused on the technical conditions that were required—such as convexity of production sets (making use of key *economic* assumption of diminishing returns)—as well as the *economic* conditions: perfect competition, a full set of risk markets (subsequently called Arrow-Debreu, AD, securities), and the absence of externalities. They had provided sufficient conditions for the efficiency of the market: The question was would results still be true under more general conditions?

[3] In the sense defined by Samuelson, as a good characterized by non-rivalrous consumption (the enjoyment of the pure public good by one individual does not detract from that of others). Pure public goods are also typically characterized by the impossibility (or at least difficulty) of appropriation. As we discuss below, intellectual property rights are an attempt to enable the partial appropriation of the returns to the production of knowledge. Inherently, such attempts have a social cost, because the usage of the information or knowledge is restricted, though there is no marginal cost associated with usage.

Were the sufficient conditions necessary, or almost necessary? After several decades of research, it became clear that AD had essentially discovered the necessary and sufficient conditions.[4]

Most of the limitations on which Arrow and Debreu had focused had in some sense been well recognized well-before the work of Arrow and Debreu. They had put these long standing understandings on sound footings. And there were well developed public policies in response: environmental regulation or corrective taxes, for instance, to deal with environmental externalities, and anti-trust policies to deal with imperfect competition. When there was a natural monopoly, there either had to be strong regulation or government ownership.

Absence of a complete set of risk markets

The one "new" market failure to which AD called attention was the absence of a complete set of risk markets. It was obvious that individuals and firms could not buy insurance against many of the risks which they faced—workers couldn't buy unemployment insurance, firms couldn't buy insurance against the risk that the demand for their products declined. But economists had not realized the importance of this failure. For AD to establish the Pareto efficiency of the economy required there being a full set of what came to be called AD securities—securities paying a dollar in a particular state at a particular date, in effect a *complete* set of insurance markets. It was obvious that not only was there not a *complete* set of AD securities, but there were many important risks for which households and firms simply couldn't obtain insurance at all. One could think of public provision of social protection as having arisen to partially "correct" this market failure.

Presumption that markets are not efficient

AD had, however, shunted aside the key question of information, in all of its dimensions. Earlier, we described how marked advocates viewed the informational efficiency of the economy as one of its triumphs; they especially celebrated how much one could achieve without anyone knowing anything about any other firm or household; all the information that was relevant was conveyed by prices.

But this model made extra-ordinarily strong assumptions that were not even noted: products were homogeneous, and any individual could tell costlessly any deviation of the product from the "specified" characteristics. There was no way of cheating on quality. Everyone knew fully the "true" probability distribution of returns of every asset.

There were no asymmetries of information, where a well-informed individual could take advantage of a less informed one. In the real world, these quality differences are critical. Workers are not homogeneous. A great deal of effort goes into finding workers that are well matched for the job. Insurance firms worry about the risk profile of those they insure. The entire financial industry is focused on identifying "underpriced" assets.

Obviously, these information problems are important to all market participants. The early literature showed that information asymmetries—where one agent had information not available to another—presented a special set of problems; attempt to extract that information or to exploit the informational

[4] There were a few other sets of uninteresting conditions—conditions which remarkably came to play a central role in a particular branch of macro-economics. The economy would be efficient even in the absence of a complete set of risk markets if all individuals were identical—precisely because when they are identical, there would be no insurance. There would be no one else to whom someone could transfer the risk he faces.

advantages gave rise to multiple distortions. A great deal of activity is concerned with addressing these information problems (both the lack of information and asymmetries in information), improving information and reducing asymmetries, if not eliminating them. At the same time, some market participants realize that opportunities for profit can be enhanced by increasing information asymmetries, and devote efforts to ensuring the existence and persistence of these information asymmetries, as costly as they may be to the economy as a whole.[5]

Some two decades after Arrow and Debreu's work, Greenwald and Stiglitz (1986, 1988) showed that information market failures were much more pervasive and consequential: whenever there was imperfect and asymmetric information or *incomplete risk markets*—that is, essentially always—the economy was not (constrained) Pareto efficient; taking into account the limitations of information, there were interventions in the market that could make some individuals better off without making anyone else worse off.[6] (For brevity, in the discussion below, we shall refer to this as the GS theorem.) Correcting these market failures was not so easy; they are not isolated[7]; they are diffuse; they are an integral part of the market economy. In the presence of asymmetries of information and incomplete markets, there are pervasive pecuniary externalities *that matter;* what one firm or individual does has consequences for others, and that is true even when it is only through the price system. Price changes are more than purely redistributive.[8]

Consider a group of seemingly similar people buying health insurance, in a world in which smoking is not observable. Should one person smoke, it will increase the risk of disease, driving up the health insurance premiums of everyone. There is a real cost to this externality which the smoker does not take into account. The market response is to limit the amount of insurance that an individual can obtain so that he has some incentive to behave well; but there is a real cost to this restraint; with risk averse individuals, restricting the purchase of insurance lowers expected utility.

Information market failures obviously affect resources devoted to collecting, processing, and disseminating information. Information is a public good, with no marginal cost associated with the use of an idea by someone else, so normally one would expect an underinvestment in information. Thus, an idea that had some popularity for a while was that markets were informationally efficient, that is transmitting through prices all the information from the informed to the uninformed. But in a sense, that idea (popularized by Fama (1970, 1991), but totally discredited by Shiller (1990) as well as

[5] With perfect competition, there are no pure profits, and firms realize (as we have already noted) that markets where information is imperfect are likely to be less than perfectly competitive. This principle holds in other contexts, as we discuss further below: managers may take actions which result in greater information asymmetries to entrench themselves.

[6] Geanakoplos and Polemarchakis, 1986 provided an alternative proof of the inefficiency of market equilibria when there is an incomplete set of markets.

[7] This stands in marked contrast to pollution externalities, where at least in principle, one could ascertain the emissions of pollutants and impose a charge.

[8] Greenwald and Stiglitz' proof of market inefficiency focused on these pecuniary externalities, showing that in markets with imperfect information or incomplete risk markets their effects are markedly different that in the standard model, where such price effects cancel, with the gains of one individual being offset by the losses of others. Arnott, Greenwald and Stiglitz (1994) explicitly show how changes in prices affect the self-selection constraints with first order effects. Similar results hold for price effects on incentive compatibility or collateral constraints. The analysis of these effects has been at the center of the macro-externalities literature discussed below.

Grossman and Shiller (1981)) was intellectually incoherent, as Grossman and Stiglitz (1976, 1980) pointed out: if the market fully transmitted information, no one would devote any resources to its collection.

Moreover, often, private returns to information can exceed social returns: if I can prove that I am more able than someone else with whom I would otherwise have been grouped (in the absence of information), my wages will go up, but his wages will go down. My gains are at his expense. Much of the returns to information are thus *distributive.*[9]

On the other side, firms will attempt to create barriers to the dissemination of information—politically, they try to create property rights (called intellectual property rights). While these are costly to enforce and seldom enable those investing in information to appropriate all the social returns from their information, to the extent that they are successful, they create a static market inefficiency: because information, once created, is a public good, any barrier to its free dissemination introduces a distortion in the economy. In practice, the static costs are often higher because these restrictions create barriers to entry, supporting a less competitive market environment, and yet the incentives provided for the creation of knowledge may be limited. Indeed, since the most important input into the production of knowledge is knowledge, by restricting the use of knowledge they may actually impede innovation itself. More generally, the dynamic benefits are markedly less than the supporters of strong intellectual property suggest.[10]

Thus, the key insight of information economics—differing from worlds in which there is perfect information—is that *social returns to information typically differ from private returns*, in some cases greater, in other cases less. This has many implications, including that privately profitable transactions may not be socially desirable.

The subsequent literature has exposed a huge number of distortions in specific contexts. There are marginal inefficiencies, where a Pigouvian corrective tax might induce market participants to do more of the things that they are doing too little and less of the things that they are doing too much; and structural inefficiencies, associated with multiple equilibria, with the economy sometimes being in a Pareto dominated equilibrium (Stiglitz (1972, 1975)). Sometimes, limited government actions can ensure that the economy is in the "good" equilibrium.[11]

Information asymmetries can be endogenous

Moreover, households and firms have incentives for creating information imperfections (asymmetries)—they may gain from lack of transparency. So can managers—it can enhance their "market power," by creating an entry barrier to competitive managerial teams. (See Edlin and Stiglitz 1995.)

[9] See Hirshleifer (1971), Stiglitz (1975). While Hirshleifer identified the distributive effects of information, Stiglitz succeeded in analyzing the market equilibria. He showed that there can be multiple equilibria, with a pooling equilibrium (where the two groups are not differentiated) Pareto dominating the "separating" equilibrium whether the different groups are differentiated.

[10] See Stiglitz and Greenwald (2008, 2014), Stiglitz (2014), Baker, Jaradev, and Stiglitz (2017).

[11] For instance, discrimination laws can prevent an equilibrium in which some groups are treated worse than others (Stiglitz, (1973, 1974)).

Complexity is one way that especially financial firms introduce opacity. Many financial transactions seem designed more to increase complexity and the associated market power than to "solve" societal problems. Recent research has shown how complexity increases uncertainty even about systemic stability and the effects of regulatory policy. While society would like a better functioning, more stable financial system, market participants are simply concerned with maximizing profits. The GS theorem emphasizes the disparity between private returns and social returns. But this recent work has noted other aspects of the market failures in the financial sector: By becoming too big to fail, too interlinked to fail, or to correlated to fail, financial institutions can ensure a bail-out, in effect a transfer of resources from the public to themselves. Firms thus have incentives to become too big, too interlinked, too correlated to fail: there is a *systemic* problem.

With a high probability of a bail-out, they can engage in excessive risk taking, in which they realize the upside (the profits) and the public bears the downside (the losses). Moreover, with financial institutions that are too big to fail, too interconnected to fail, or too correlated to fail, success may not be based on relative efficiency but on relative size and linkages. Moreover, the huge excessive complexity which they have brought to the financial system makes the consequences of regulations more uncertain. If, as a result, regulators are discouraged for undertaking necessary regulations—for instance, relying on self-regulation—this provides an opportunity for those in the sector to increase further their profits.

These problems would simply not exist if there were perfect information, in which case private contractual arrangements would internalize the externalities. These market failures clearly provide a rationale for government intervention. Much of the intervention has focused on *behavior,* e.g. restricting excessive risk taking and actions in which there is a risk of conflicts of interest. But our analysis has suggested that government needs to go beyond this, to regulate, e.g. the size of banks (to reduce the risk of too-big to fail), linkages among banks (to reduce the risk of too-interconnected to fail), contractual arrangements (to reduce the risk of excessive complexity[12]). Recent research has also noted that (in part because government cannot monitor the actions of individual banks) what matters is the entire "ecology," e.g. the diversity of financial institutions.[13] This mitigates the dangers of "too correlated to fail," and provides part of the rationale for *structural regulations,* e.g. the Glass-Steagall Act, which inhibited the growth of universal banks.

Production and information are interlinked

But the inefficiencies of the market economy go deeper, because production of knowledge and information is intertwined with other activities Thus, there is a presumption that market is not only inefficient in the production of information/knowledge, but also in the production of goods. For instance, knowledge and information is produced as a by-product of the production of goods; if this information leaks out to others, then the value of this information won't be fully internalized in the determination of the levels of production (Stiglitz and Greenwald (2014)).

Macro-consequences of informational externalities

Keynes provided an explanation of the Great Depression and other deep downturns that had afflicted capitalism from its beginning. But in the 1970s, dissatisfaction grew over the disparity between macro-

[12] See Battiston *et al.* (2013), Battiston *et al*. (2016a) and Roukny *et al.* (2016).
[13] See, for instance, May, 2014; Haldane and May, 2011, and Battiston *et al* 2016b.

economics, as it had developed following Keynes, and standard micro-economics. Information economics provided the necessary underpinnings to reconcile the two. It explained, for instance, why there was credit and equity rationing[14]; why this led to risk averse behavior on the part of firms (Greenwald and Stiglitz (1990)); and why wages might not adjust even when there was significant unemployment (Shapiro and Stiglitz (1984)) and other variants of efficiency wage theory (Stiglitz, 1987c). These "financial frictions," as they came to be called, gave rise to a financial accelerator, whereby small shocks to the net worth of a firm could give rise to large shifts in both the aggregate demand and supply curves.[15] The effects of a shock could persist—the restoration of balance sheets, and thus the recovery of the economy to full employment could take a long time. Moreover, the decentralized adjustment of wages and prices meant that in response to a shock, the economy might not instantaneously move to the new equilibrium set of wages and prices consistent with, say, persistent full employment; indeed the economy could persist with wages and prices each adjusting, but real wages and unemployment remaining relatively unchanged (Solow and Stiglitz (1968)), or even worse, the adjustments might lead to even higher unemployment (Stiglitz (2016))[16].

As we noted, Greenwald and Stiglitz (1986) noted that one could describe the market failures associated with adverse selection and moral hazard as giving rise to pecuniary externalities that matter. These micro-economic pecuniary externalities have their macro-economic manifestation, which have been the center of much recent work in macro-economics. For instance, the market equilibrium may be characterized by excessive foreign denominated indebtedness (Jeanne and Korinek (2010)). More generally, borrowers may not take fully into account the effects of their decisions on prices in the future, say if they were forced to liquidate their assets. Each small borrower takes the price distribution as given; but of course, if they all borrow more, then if there is a crisis, next period prices of certain assets will fall as they all are forced to liquidate more of their assets.

One of the implications of the theory is that it may be (in general will be) optimal to treat things that are *observably* different differently. Thus, contrary to prevailing attitudes, taxes and regulations affecting foreign capital and financial institutions should differ from those affecting domestic capital. The "non-discrimination" provisions of some trade-agreements cannot be justified within the context of a model with imperfect information.

Theory of second best

Long ago, Meade (1955) and Lipsey and Lancaster (1956) warned the profession about the theory of the second best. Just because an economy is inefficient, doesn't mean that moving the economy *closer* to a perfect model will improve welfare. In the presence of multiple distortions, removing one may worsen economic welfare. Newbery and Stiglitz (1984) demonstrated this idea in the context of a long standing

[14] See Greenwald, Stiglitz, and Weiss (1984) and Stiglitz and Greenwald (2003) and the extensive list of references cited there.

[15] See Greenwald and Stiglitz (1993) and Bernanke and Gertler (1990).

[16] This line of work emphasized a quite different aspect of Keynes than that which has been the center of much recent work in macroeconomics, highlighting the consequences of wage and price rigidities. Here, it is price adjustments that give rise to problems (consistent with much of the recent policy concerns over deflation). It can be viewed as reviving Fisher's debt-deflation theories. (1933). Information economics also provided an alternative explanation of the slow pace of wage and price adjustments, associated with differential risk (Greenwald and Stiglitz 1989) and of adjustments in employment (Greenwald and Stiglitz, 1995). The contrast between the alternative approaches to macroeconomics is discussed in Greenwald and Stiglitz (1993b, 1987).

presumption by economists in favor of free trade. So long as there are imperfect risk markets, trade integration may lower welfare *for everyone.* But we will never have full information or a complete set of markets, so we are always in a second best world. Hence, we need to tread carefully as we use the perfect markets paradigm as a guide to policy reform. Often it gives misleading advice.

One example concerns the absence of a complete set of risk markets. The question is, *will creating new financial instruments/markets increase welfare,* as the advocates of structured finance seem to have suggested. The answer is far from clear. What is clear is that these new financial products give rise to at least three distinct problems. One we have already noted: the increased complexity of the financial system that results may increase financial fragility and reduce the ability to effectively regulate the financial system. Financial interlinkages may lead to an increase in *intrinsic uncertainty*—with the possibility of there being multiple equilibria (even with rational expectations.)[17]

The second is that differences in beliefs gives rise to gambling (risk trading) opportunities. With both sides of the gamble believing that they are going to win, what Guzman and Stiglitz (2016a, 2016d) call pseudo wealth. Changes in pseudo wealth can give risk to macro-economic fluctuations. They suggest that some of the observed increased volatility may be due to these new structured products.

The third is that the interlinkage of finance undermines the decentralizability of the economy, one of main virtues of the market economy. To know the financial position of any firm requires knowing financial position of all creditors, which requires knowing the financial position of all creditors of creditors.[18]

Financial architecture matters

In short, different architectures affect the extent of externalities and the nature of information requirements. There is no evidence that market driven architectures are efficient: Because of disparity of private and social incentives one would not expect efficient outcomes. The design of the architecture can affect the magnitude and consequences of the disparity of private and social incentives. Many of the new financial products giving rise to greater complexity may result in more "distorted" architectures, which increase the risk of financial fragility.[19]

Structured finance was thus not (as it claimed) really about matching risk.[20] So too there can be significant moral hazard associated with increased indebtedness; but there is no presumption that the market determined contractual bankruptcy provisions are efficient. Indeed, the presumption is to the contrary, as each firm tries to signal that it is better than others. This is one of reasons for necessity of

[17] Indeed, complex derivatives may even result in the non-existence of equilibria. That is, without coordination, market participants can sign a set of mutually inconsistent contracts.

[18] Requiring trading to go through adequately capitalized clearing houses—adamantly opposed by the financial sector—would go a long way to resolving this problem.

[19] Recent research on credit networks (Battiston *et al* (2016a)) highlights inefficiencies associated with particular architectures, e.g. bankruptcy cascades, increased systemic risk with large/correlated shocks (following on earlier work by Allen and Gale (2000) and Greenwald and Stiglitz (2003)).

[20] The information that was collected was markedly different from that which would be the case if what markets were engaged in was "matching." See, e.g. Stiglitz (1982).

bankruptcy laws. (Advocates of the contractual approach to sovereign debt restructuring seem not to understand this.[21])

Information and Other Market Failures

Imperfect competition

One of the important insights of the economics of information is that in the absence of good information, typically competition will be imperfect; and with imperfect competition, there is the possibility (likelihood) of firms exploiting market power, and indeed, with imperfect and costly information, of undertaking actions that enhance their market power.

Information is a fixed cost, introducing a natural "non-convexity" into production. Convexity played a key role in the proofs of Arrow and Debreu. But these mathematical properties have economic implications. The law of diminishing returns long played a central role in economic analysis; but this "law" will not be satisfied when information is endogenous.[22]

With fixed search costs, no matter how small, it pays any firm to raise its price above that of others by a small amount—until the monopoly price is reached, so the only possible equilibrium is the monopoly price (Diamond (1971), Stiglitz (1985)). But then, it pays firms to engage in non-linear pricing which extracts some of the remaining consumer surplus—to the point that there exists no market equilibrium. (Stiglitz (2013) and the references cited there.)

Indeed, the major distortion of monopoly is in fact associated with its trying to extract information to enable it to extract more surplus from consumers. (Stiglitz (1977)). With perfect information, monopoly extracts all the consumer surplus, and it can do so (in theory) in a non-distortionary way. It is because it cannot easily differentiate those who enjoy different levels of surplus from its products that there are distortions: marketing strategies are designed to maximize its ability to extract this surplus from its customers. (Salop and Stiglitz (1977)).

More generally, small sunk costs—and expenditures on information are always sunk costs-- can give rise to persistent monopoly rents with Bertrand competition (Stiglitz (1987b)).

Not only does imperfect information lead to imperfect competition, but also, firms' attempts to manage information imperfections reduce competition. Efficient management of adverse selection/moral hazard involves intertemporal linkages—contracts extending over multiple periods, where, say payments in one period are dependent on events/performance in earlier periods. (Stiglitz-Weiss (1983)). This limits the scope for usual competitive mechanisms—where contracts are short term, with the threat of leaving acting as an important discipline device-- and enhances scope for monopolistic exploitation. It also gives rise to *institutional* responses (like banks) internalizing some of the information externalities.

Explanation of some of key market failures

The AD analysis also gave rise to another question: How do we explain key market failures, such as the lack of complete set of securities markets or limitations in capital markets? Information economics

[21] See Guzman and Stiglitz (2016b, 2016e) and Brooks *et al* 2015.
[22] See, e.g. Radner and Stiglitz (1984) and Arnott and Stiglitz (1988).

(adverse selection and moral hazard) provides at least part of the answer: almost surely, the firm knows more about his profits prospects than possible insurers, and so he would not be expected to buy insurance against a risk of a low profit level unless it was at favorable terms—terms which made it unprofitable for the insurer.[23]

Information economics also provides one of the explanations for why Coasian bargaining would not resolve problems posed by externalities. Coase suggested that through bargaining, an efficient outcome could be achieved, if only there were clear property rights. However, bargaining with information asymmetries typically is not efficient, as parties engage in costly actions to convey information about the value of the externality imposed upon them.

Responding to market failures: the possibility of dysfunctional social institutions

Information related externalities are not only pervasive, they are diffuse, making it difficult to address them with corrective taxation, though corrective taxation should be part of the policy response (see Arnott and Stiglitz (1986)).

Sometimes, the appropriate response is the public provision of information (or restrictions on withholding information). Thus, in designing systems for leasing oil in different tracts, auctions will suffer greatly if some firm is known to have more information than others. This provides a rationale for exploratory drilling to be done by the government.

Sometimes, the consequences of these market failures are so obvious and severe that society responds through the creation of social institutions. The absence of life insurance led to the creation of burial societies to help families meet the unexpected costs of an untimely death. There was no moral hazard problem here—no one would die just to have his family collect burial insurance; and there was little problem of adverse selection. Perhaps the simplest explanation of the "market failure" is that the transactions costs were high. As a result, it may be more efficient to provide such social protection through the government.

More generally, society responds to market failures by developing institutions and contracts. But there is no presumption that these "institutional" solutions lead to Pareto efficiency. Indeed, Arnott and Stiglitz (1991) show that institutional interventions may actually be dysfunctional. Imperfect "family" insurance (imperfect, because risk is shared only among a few individuals) displaces ("crowds out") more efficient (but limited) market insurance.

Further Key Insights of the Information Paradigm

Robustness of standard model

A key question was how robust was the standard model? The answer was: not very, with even slight imperfections of information leading to marked changes in results (e.g. concerning the nature, optimality, and even existence of equilibrium.) (Rothschild and Stiglitz, 1976). Many of the key characterization results also changed, once information imperfections were recognized. For instance,

[23] In the absence of risk aversion, there obviously would be no "trade" in such securities. This is the implication of the Akerlof (1970) lemons model and the no-trade theorems of Grossman and Stiglitz (1980) and Milgrom and Stokey (1982).

markets might not clear even in equilibrium; and the Law of Single Price was repealed. Markets could be characterized by a price distribution, even when there was not any source of exogenous noise.

Robustness of new paradigm

It was natural, at this point, to ask: how robust were these new models? The key information problems and modes of analysis that were identified early (adverse selection, moral hazard) have remained the central foci of research now for almost a half century. At the same time, the precise characterization of the equilibrium turned out to dependent on details of markets and in particular, on assumptions about information. The early literature differentiated between a price equilibrium (in which sellers of say insurance had no information about the characteristics of the buyers[24]), as characterized by Akerlof (1970); and the quantity constrained equilibrium, in which insurance firms had such information, with in effect each buyer being exclusively from one firm. More recently, Stiglitz, Yun and Kosenko (2017) have shown that if individuals/firms can decide whether to hide or disclose information, then neither Akerlof/price nor Rothschild-Stiglitz/quantity equilibrium can be sustained. There always exist an equilibrium (unlike Rothschild-Stiglitz), and the unique equilibrium is a disclosed pooling contract (the one most favored by low risk individuals) supplemented by an undisclosed price contract at the high risk individual's odds purchased only by high risk individuals.

In the presence of adverse selection *and* moral hazard there may exist a pooling quantity equilibrium (Stiglitz and Yun (2013)), something which could not occur if there was only adverse selection.

One of the significant contributions of Information economics was to show the importance of and to analyze the forms of contracts (Stiglitz, 1974a) and institutions, like banks. Loans are not made through auctions, but through institutions like banks, that gather and process information. Information economics also led to a new focus on enforcement and commitment (time consistency). A key issue in contract enforcement, for instance, is verifiability, and thus relates to information.

All of this stood in marked contrast with the AD framework, where not only was the information structure exogenous, with a complete set of markets, but there were no problems with enforcement and no issues of commitment.

2nd fundamental theorem also reversed

We noted earlier that Greenwald and Stiglitz (1986) showed that whenever there was asymmetric information, markets were not efficient, thus undoing the first fundamental welfare theorem of economics. Rather than the presumption being that markets were efficient, now there is a presumption that they are not.

But what about the second fundamental theorem, which asserted that any feasible Pareto efficient distribution of income could be attained through a market mechanism, with the correct initial redistribution of assets? This theorem was enormously important, because it enable the separation of issues of efficiency from those of distribution. Economists should focus on efficiency, leaving distribution to politics, so it was argued.

[24] Or, correspondingly, the buyers of cars had no information about the sellers.

The new paradigm, however, showed that the distribution of wealth (assets) *matters* and effects cannot be undone through (lump sum) redistributions—partly because the information required to achieve those lump sum distributions is not available, and the only feasible redistributive taxes are distortionary.[25]

Key question: what is critical market failure?

Much of the early literature in imperfect information focused on information asymmetries, with some discussions of imperfect information going so far as to suggest that virtually all of the distortions associated with imperfect information arise from these information asymmetries. But the real issue is not so much asymmetry of information but endogeneity of information. For instance, the life insurance firm may know far more about the statistics of life expectancies than those they are insuring. The individual himself may not know whether he is a high risk or low risk individual. The life insurance company may still engage in costly screening activities (including the use of self-selection mechanisms) to identify individuals who have characteristics that are systematically associated with longer life expectancy (see Stiglitz (2002)).

Not only is information endogenous, but so are asymmetries of information (in contrast, most of the earlier literature simply assumed that the asymmetries were given exogenously). As we have already noted, here are large incentives of firms and individuals to create and to enhance market power and to maximize rent extraction, through the creation of information asymmetries.

Information and delegation

While imperfect information implies that the standard analysis of efficient decentralization, based on the AD model with perfect information, is not correct, it is the costs of collecting and dissemination information which make decentralization necessary and give rise to delegation, with profound implications for economic organization. Delegation means, for instance, that there is a separation of ownership and control, and this separation undermines the standard theory of the firm, and gives rise to problems of corporate governance.

Among the important market failures are those associated with corporate governance. Managers do not necessarily do what is in interests of shareholders. There are even larger differences between social returns and *managerial* returns, implying is that there is no presumption that the market solution is efficient. There are imperfections in all of control mechanisms (e.g. take-overs). That's why the rules of the game—the laws governing corporate governance—matter[26]. There is evidence that these issues are particularly relevant in the financial sector.

Economics of knowledge[27]

Most of the results I have just described had applicability beyond information economics narrowly defined, to the economics of knowledge. Indeed, knowledge can be thought of as a particular form of information. Knowledge is, of course, at the center of the theory of innovation. With a modern economy often characterized as a knowledge or an innovation economy, it is clear that understanding

[25] See Mirrlees (1971), Stiglitz (1987a), Brito *et al* (1990), Shapiro and Stiglitz (1984).
[26] Stiglitz (2015).
[27] The ideas in this section are developed more fully in Stiglitz and Greenwald (2014).

the economics of knowledge is key. Knowledge, like information, is different from an ordinary commodity; the tools and insights of standard economics, developed for thinking about the demand and supply of pins, steel, oil and other conventional products, are of only limited relevance in understanding a knowledge economy.

Knowledge, as I have suggested, is a form of information, with many or most of the key properties, most importantly, knowledge is a quasi-public good—with, as we have noted, no marginal cost associated with the use of an idea by someone else. Hence, there is always in inefficiency associated with restricting usage, such as through intellectual property rights. Like many public goods, there is also difficulty in the appropriation of returns. There are typically large spillovers from an important innovation, such as the laser or the transistor, with the innovators typically capturing a small fraction of the social benefits.

The implication is that the insights that we have gleaned from the study of the economics of information apply to innovation and the production of knowledge. Markets on their own are not likely to be efficient and there is likely to be imperfect competition. Thus runs contrary to a longstanding view that the real strength of a market economy is the drive for innovation, through Schumpeterian competition.

II. Early attempts to broaden perspective—to recover earlier results on market efficiency—failed

Arrow and Debreu had provided sufficient conditions for the efficiency of the economy, but not necessary ones; and there ensued a search for weaker conditions under which the market was still efficient.

The most well-known example was that of Diamond (1967) who established the (constrained) efficiency of economy with a stock market. Even with the highly restricted notion of optimality and the highly restrictive assumptions about risk (each firm fell within a risk class, and couldn't change the probability distribution of returns; it could only change the scale of production) the result turned out not to be general. With just two commodities, or with bankruptcy costs, or with decisions which affected the pattern of risk distribution, result was not true; the market was not (constrained) efficient.

As we have already noted, this quest for weaker conditions under which markets are efficient ended with the Greenwald-Stiglitz (1986) theorem, which showed that markets were generically inefficient; they would be efficient only in special cases. For instance, the absence of risk markets would make no difference in an economy with a single individual, since there is no one with whom the individual could share or trade risk.[28]

But there was a second issue—how markets dealt (imperfectly) with the consequences of imperfect information, including the absence of state-contingent commodities. Contracts (with payments

[28] As we have noted, the failure of markets to be efficient can be simply explained: with imperfect information, the key constraints—the incentive compatibility constraints, the self-selection constraints, the collateral constraints—are all affected by what *other* individuals do; each individual fails to take into account how his actions affect these constraints. And these effects are of first order importance. The externalities matter.

dependent on observable state outcomes) provided a way of simultaneously sharing risk and providing incentives (Stiglitz, 1974; Ross, 1973)

There ensued a huge literature exploring optimal contract design. One interesting result is that the predicted *complexity*[29] was far greater than what was observed. For instance, since among unobservable variables are common shocks, optimal contracts should make compensation dependent on others' outcomes: the predicted *forms* of contracts thus are typically different from those which are observed. (See Nalebuff and Stiglitz, 1983a, 1983b).

New Institutional Economics

While the contracts that were observed differed markedly from those which were observed, the information paradigm more generally helped explain many aspects of observed institutions. For instance, sharecropping has long been criticized as attenuating incentives—with half or more of the (marginal) returns going to the landlord. But Stiglitz (1974) explained sharecropping as balancing out incentives and risk sharing—a "reasonable" contract given the limitations of information and risk markets.

While many aspects of contract design were consistent with what theory predicts, the hope that these institutions would lead to Pareto efficiency failed; as we have already noted, they could even worsen equilibrium.

II. Policy Corollaries

There are many policy corollaries to the ideas that I have just discussed. In particular, Washington Consensus/neoliberal policies were predicated on the Smithian presumption that markets are efficient and the presumption that moving towards a perfect market would be welfare enhancing, ignoring second best economics. As we have already noted, the presumption that moving the economy towards first best economy was welfare enhancing was wrong. But even if there were not the case, there would be winners and losers, and the adverse distributive effects could outweigh any gains and the cost of undoing distributive effects could be large.

Policy battles over information: high frequency trading

Today, there are a new set of battles, many directly related to information. It is in this arena that social and private returns are most likely to be large, and therefore the insights of Section are most likely to be relevant.

Consider, for instance, the development of high frequency trading (HFT). It was often justified by "price discovery"—uncovering prices to enable the efficient allocation of resources.[30] But this was a self-serving justification of financial sector: there has never been any evidence presented of its importance; no evidence that having slightly more accurate prices a nano-second earlier than otherwise has led to higher growth or more efficient resource allocations. The reality is that it may be a new form of front

[29] Except under special and easy to reject specifications of utility functions.

[30] HFT is also justified by "liquidity" —enabling individuals to easily move into or out of assets, enhancing willingness to make real investments: but this argument too seems largely a self-serving argument of the financial sector; the evidence is that liquidity dries up when it's needed.

running—those who get information about bids and offers or trades before others can make a profit. Indeed, by extracting some of the rents that would have gone to those who actually do research, HFT reduce the overall efficiency of the economy *a-la* Grossman-Stiglitz (see Stiglitz (2014)).

Other new policy insights: structured finance

The new theory changes views about a variety of government policies. For instance, we have already noted how creating additional risk instruments may actually increase risk. So too welfare may be increased by requiring disclosures—market equilibrium disclosures do not suffice. And welfare may be increased by requiring trading to occur in markets (through clearing houses), as long as they are adequately capitalized[31], for that improves the decentralizability of the economy.

Securitization

The information paradigm helps us understand what went wrong with the securitization market. Before the crisis, there was enormous enthusiasm over securitization, because it allowed the dispersion of risk throughout the economy. But securitization entailed the delegation of different aspects of information gathering and analysis to different entities. For securitization to work well required complex contracts (with put backs, warranties). It failed, partly because of massive fraud[32], but also, because of massive problems in contract enforcement: mortgage originators and even seemingly reputable investment banks simply refused to honor their contracts, highlighting the issues of contracts and enforcement noted earlier, and the important role of government in information markets in preventing fraud. (Greenwald and Stiglitz (1992))

These failures of securitization (capital markets) should not come as a surprise—what is a surprise is the failure of both markets and government regulators to understand and anticipate the limitations of capital markets and securitization; including the limitations on informational efficiency of markets (Grossman-Stiglitz (1980)) associated with difficulties of appropriating returns.[33]

Banks can be viewed as the alternative institutional "solution" to these informational problems.[34] It is noteworthy that a decade after the collapse of the mortgage securitization market in the US, it has not been restored. Evidently, the banks—in spite of their belief in free markets-- want a structure that entails unacceptable levels of public risk bearing.

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[31] Which can be accomplished by requiring joint and several liability among market participants.

[32] That is, the information provided to those who bought the mortgages and mortgage products was massively incorrect—with relatively clear evidence that the sellers did so at least partially intentionally.

[33] The credit rating agencies not only were massively wrong in their evaluations of the probability of default of different tranches of the structured products for which they were paid handsomely, but there is again evidence of fraudulent behavior. (I had privy to the evidence on fraud and the failure to comply with contract provisions as an expert witness in several cases against the rating agencies, the investment banks, and other financial institutions; but the federal government and state governments have brought cases in which some of the evidence has been publicly disclosed. The Final Report of the National Commission on the Causes of the Financial and Economic Crisis in the United States (2011) identified the behavior of the credit rating agencies and the structured financial products as two of the main causes of the financial crisis of 2008-2009.

[34] Advocates of securitization never explained why one couldn't obtain adequate risk diversification through diversified ownership of banks.

Other aspects of financial sector regulation

Much of the profits arising from financial activity is associated with market exploitation, much of which would not arise in presence of perfect information, including exploiting asymmetries of information (including creating information asymmetries) and market manipulation. Akerlof and Schiller in their book *Phishing for Phools* describe the incentives for exploiting "ignorance," irrationalities, and market power[35]. Predatory lending and abusive credit card practices are only the most obvious examples.

We have noted too banks' incentives for increasing complexity—and the disparity between social and private returns in increasing complexity. Increased complexity even gives rise to new opportunities for hard-to-detect fraud. Banks availed themselves of these opportunities. High legal costs, statutes of limitations, and political capture all make it difficult to prosecute.

The financial sector has developed new ways of reducing increasing its rents, and new justifications for its exploitive activity that have sometimes prevailed in courts. Changes in technology and knowledge (e.g. about individual irrationalities and how to exploit them), and legal frameworks may have also enhanced the ability of the financial sector to exploit others.

IV. Reconciling two long-competing theories for describing market equilibrium and explaining inequalities

For more than two hundred years, there have been two basic strands of economic theory. One emphasizes the role of competition (competitive equilibrium theory); the other, market power (exploitation).

In recent decades, the former theory has dominated in the West. There is, of course, always *some* constraints on exercise of market power, *some* competition. But the standard (price taking) competitive model describes few markets. Many of the tests of competition are only tests of presence of some constraints, not tests of how close the economy approximates a perfect competition model.

The imperfect information/imperfect competition model is fundamentally different from either polar case of perfect or no competition. I believe the real world is best described by this mixed model. In an economy that is perfectly competitive, there are, of course, no rents. In an economy where there is a monopoly in each sector, there are no battles over rents: the monopolist simply gets them. In reality, the key battle is over grabbing or limiting rents, over structuring of markets and the rules of game which affect the magnitude and distribution of rents.

The rules of the game matter—markets don't exist in a vacuum. Different rules affect the well-being of different groups; each tries to restrain the feasible set of contracts and actions of others in ways which benefit themselves, and more generally, change the rules to enrich their interests at the expense of others. The public interest, of course, is to create institutional frameworks for corporate and public governance which benefit ordinary citizens and society as a whole. This is why the presumption that

[35] Here, I am focusing the consequences of imperfections in information. The financial sector also enjoyed enormous rents from exploiting other sources of market power, e.g. in running payments system (credit and debit cards).

markets are basically competitive is a poor starting point for policy analysis, for it shunts aside all of the issues associated with the grabbing of rents. Governance is crucial—who makes the decisions, and the rules under which the decisions are made. In the AD model, there is no real governance issue—each firm simply maximizes its market value and all shareholders agree that that is what it should do. With imperfect information and imperfect risk markets, it matters whose judgments are decisive, how different judgments are "aggregated." Different individuals will have different views about what the firm should do (Grossman and Stiglitz (1977)).

We have long recognized that governance matters in the public sector and that there is no simple way of aggregating preferences. That was the essential insight of Arrow (1951). An example: Monetary policy made by those representing workers, focusing on unemployment, will be markedly different from that made those representing bond holders, focusing on inflation. Information economics has made in clear that this is true in the private sector as well as in the public.

Indeed, the *rules of the game* matter in every aspect of the economy—corporate governance, financial sector, monetary policy, bankruptcy, anti-trust, labor. Workers will do better with rules that facilitate the formation of unions, encourage union membership and strengthen their collective bargaining rights, recognizing the "public good" they provide (all workers benefit when wages are increased). All consumers benefit with a strong anti-trust policy that recognizes that when there is market power, prices increase, and an increase in prices lowers standards of living of ordinary citizens just as a decrease in wages would. Even bankruptcy law can have important effects: laws giving derivatives first priority in bankruptcy, even over workers, encourage derivatives, and impose greater risks on workers. Laws saying that student loans cannot be discharged, even in bankruptcy, encourage predatory student lending, lead to the immiseration of those at the bottom, discourage investments in education, and, overall, increase inequality.

V. Broader theoretical impacts of information economics

The information revolution played a critical role in some broader changes in economics, beyond those just described, including giving rise to new sub-fields like contract theory. As we noted in the introduction, it provided for the first time intellectual foundations for fields like accounting. Within finance, it created tensions between two branches, one focusing on the benefits of risk diversification, the other on the collection, processing, and dissemination of information. As we have noted, these are often in tension: securitization and structured financial products allegedly led to better risk diversification and matching of risk profiles with individuals' preferences and situations, but it also reduced the incentives for the collection and processing of information. The crisis demonstrated that the latter effect dominated the former.

But among the greatest legacies of information economics is its contribution to the growth of behavioral economics. While models with imperfect and asymmetric information were able to explain many previously unexplained phenomena, models with rational behavior with imperfect information still could not explain some of what was going on, e.g. in financial markets. This provided the impetus for the development of behavioral economics.

The original work, e.g. of Kahneman and Tversky (1974, 1979, 1981) incorporated insights from psychology. Individual decision making, especially when decisions were made quickly, involved a myriad

of biases, such as confirmatory bias, where individuals weight evidence that is consistent with their priors more heavily (Kahneman (2011)).

More recent work, focusing on endogenous preferences and beliefs, and emphasizing the role of "mental models," the lens through which we see the world, has incorporated insights from sociology and social psychology. Both have helped provide insights into societal rigidities and social change (Hoff and Stiglitz, 2010, 2016), and provided new instruments for policy, especially in the context of development, as illustrated by the 2015 World Development Report, *Mind, Society, and Behavior*.

VI. A Look Forward

At one time, there was a hope that advances in technology, including the internet, would increase competition, by lowering search costs. This is true in some areas, where there is a homogeneous or well-specified commodities and manufactured goods. But new technology has also increased the ability to exploit—increasing asymmetries of information and market power of those who have differential access to information.

More broadly, some of the changes in our economy—in technology, in demand structure, and in our regulatory framework—have exacerbated the disparity between private and social returns to information (knowledge) and enhanced rent seeking and capacity for rent extraction. These changes in underlying fundamentals will require changes in policy to prevent increasing market power and inequality. There is a risk that the move to the "information economy" may give market power to those who dominate in grabbing information (such as Google and Facebook), distorting both the markets for goods and services (increasing the ability to price discriminate)[36] and innovation, encouraging innovation in areas where there is high potential for grabbing rents based on information, thereby moving scarce research resources away from areas where social benefits would be higher. The extent to which this occurs will be determined by rules of the game, for instance about privacy, transparency, ownership rights of information (data) transmitted over a platform, and constraints on the ability of individuals to give up their rights. This is an area rife with externalities and other market imperfections, so government cannot shy away from taking a role; it cannot just "leave it to the market." Moreover, partly because of the network externalities, it is hard to displace incumbents or change structures: decisions today will have long lasting effects, with the market characterized by having one or at most a few dominant firms whose dominance persists for long periods of time.

New technology

The new technologies of the last two decades have played a particularly important role in forcing these issues upon us. They are responsible for the creation of the information economy. Network effects and increasing role of knowledge may naturally lead to more scale economies. When there are strong network effects, there is a natural monopoly. The classical literature on natural monopolies said that they either had to be closely regulated or nationalized. Until recently, these new natural monopolies have managed to fend off even the recognition of their market power, and therefore of any serious attempt at regulation. As Europe as taken a closer look at their practices and found them anti-competitive, the US has complained about the EU taking an anti-American position. This is wrong. European anti-trust authorities are doing what they should, trying to ensure that there is no abuse of

[36] Recall our earlier discussion that imperfections in information have fundamental effects on production.

market power. It is partially because of the political influence of these American near-monopolies that the US has not taken actions.

The abuse of their market power is especially likely and troublesome. I noted earlier that the real distortion associated with monopoly arose from the attempt to differentiate among customers, to extract more of each individual's consumer surplus for itself. Understanding of behavioral economics and the theory of discrimination (based on the economics of asymmetric information) plus access to enormous amounts of new data enhances their ability to exploit their market power. Even more troublesome is that their access to and ability to exploit data on individuals raises deep questions about rights to privacy and the nature of our society.

Schumpeter argued that we should not be much worried about monopolies. One monopoly will be succeeded by another, and competition to be that monopolist incentivizes innovation. Those ideas have now been discredited.[37] But the special features of these new technologies, with their access to large amounts of data that cannot be replicated, may have enhanced the ability of incumbents to persist, in spite of some instances of disruptive technology.

Changing structure of the economy

There are other changes in the economy which may have changed the role of information—in ways again to make the economy less competitive. It is widely noted that we are moving from a manufacturing economy to a service economy. Manufactured goods are produced and sold globally. Thus, it is relatively easy to obtain and transmit information about these products.

By contrast, many of the services which will constitute an increasing fraction of GDP are produced and provided locally. Consumer care about the quality of the services provided, and therefore information about quality is key and reputation effects are critical. But all of this gives rise to local market power.

Interplay between increased market power and politics

Increased economic inequality arising from the natural market forces we have just described leads to increased political inequality—which in turn leads to restructuring the rules of the game (e.g. rules governing privacy and transparency) to enhance market power and increase inequality. But as the rules of the game are shaped to enhance incomes of those with market power, not only is inequality increased but economic performance is likely weakened.

VII. Concluding Comments

Information economics has had a transformative effect on economics and economic policy, directly giving rise to new sub-branches of economics, such as contract theory, which has developed an enormous literature of its own.

[37] Dasgupta and Stiglitz (1980) showed that incumbents have the power and incentive to persist, and Fudenberg *et al* (1983) showed that they could persist with a low level of expenditures on research, and thus a low level of innovation. For a more general and updated discussion, see Stiglitz and Greenwald (2014, and especially chapters 5 and 6 of the 2015 revision).

It has provided explanations of phenomena that previously had been unexplained. A century ago there was a conflict between institutional economics and "theoretical" economics, derived from the work of Smith, Ricardo, Walras, and Cournot. Information economics has, in a sense, united these two schools, by highlighting the importance of institutions, at the same time that it has demonstrated the limits of markets. In many cases, it has been able to explain not only the existence of certain institutions, but even their structure.

We noted too that there are some phenomena which could not be explained within a framework of rational individuals making decisions with imperfect information. These "failures" were important in encouraging the development of behavioral economics.

Information economics, together with other work derived from advances in game theory, have strongly suggested that the economy best be viewed through models which highlight market imperfections, including imperfect and asymmetric information and the other market failures to which they give rise—incomplete risk markets, market power and the possibilities for enhanced rent seeking and exploitation--rather than through the lens of the competitive equilibrium model.

Most importantly, information economics has questioned—and in many cases reversed—longstanding presumptions of economic policy. The presumption is that market economies are *not* efficient. With pervasive market power, there are interventions can simultaneously increase efficiency and equity.

These ideas are particularly important for an institution like the World Bank, attempting to promote development in some of the poorest countries of the world. In these countries, markets are often weak or non-existent, and the institutions that promote the gathering, production, and dissemination of information are particularly weak. For a long time, the Bank predicated its advice on an economic model which ignored the role of imperfect information. Fortunately, for the past two decades, the Bank has been at the forefront in raising questions about that model and enhancing our understanding of the implications of alternative frameworks—like those discussed here—for development policy.[38]

[38] See, for example, the 1998 World Development Report, *Knowledge for Development,* and the 2015 World Development Report already cited.

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