

On the Formation of Capital and Wealth: IT, Monopoly Power and Rising Inequality

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Abstract

We show information technology (in short IT) caused rising monopoly power and rising income and wealth inequality since the 1970's. Our reasoning proceeds in four steps.

step 1 examines surplus wealth - the difference between firm's wealth (equity and debt) and capital employed. Surplus wealth rose from -\$0.59 Trillion in 1974 to \$24 Trillion in 2015 which is 82% of total stock market value, reflecting sharply increased monopoly power 1974 - 2015. In step 2 we construct an index to measure proportion of firms transformed by modern IT and then demonstrate a strong association between firms transformed by IT and surplus wealth. Step 3 is theoretical, explaining why economic principles (and empirical evidence) predict IT enables and accelerates erection of barriers to entry and once erected, IT facilitates maintenance of barriers. Step 4 develops a model where firms have monopoly power. Three independent methods estimate the share of monopoly profits in output to be about 21%-23%, rising from 0 in early 1980s and reflecting the rising monopoly power. Using the model we prove that rising monopoly power *lowers permanently* equilibrium wage rate, investment, capital stock, output and consumption. In an economy with embodied technical change it also lowers the growth rate and natural interest rate.

JEL classification: D31, D33, D42, D43, D62, E22, E25, L1.

Keywords: surplus wealth; Information Technology; monopoly pricing power; income inequality; wealth inequality; relative shares; monopoly surplus; monopolistic competition; technical change and TFP.

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Income and wealth inequality has risen sharply since the 1970's (see Piketty and Saez (2003), Saez and Zuchman (2015)), while real wages have grown slower than productivity implies and the rate of capital formation declined. Although widely discussed, a consensus explanation of these facts is yet to emerge. Textbooks offer many possible causes for inequality, but most explain changes in it as outcomes of government actions (e.g. Stiglitz (2012)). Monopoly power is a potential cause, but the typical view is that in advanced economies it arises either from government granting it to wealthy supporters or from government failing to enforce laws against anti-competitive behavior (e.g. Stiglitz (2012), Ch. 2). Apart from land, monopoly rent is capitalized by the market into *Monopoly Wealth* or *Surplus Wealth*, which is the difference between *capital* and *wealth*.

This paper explains the above phenomena with a unified paradigm: they are primarily *caused* by the Information Technology (IT in short) revolution. IT effects on labor markets via automation and globalization are extensively studied (e.g. Acemoglu and Restrepo (2017) and references) but the IT effect explored here is through its causing a rising monopoly power. Our reasoning consists of four steps. In an *asset valuation* step 1 we demonstrate the rise of monopoly power by showing surplus wealth has grown dramatically since the 1970's, reaching 82% of the value of all stocks. It grew, during the last 40 years, much faster than capital, explaining the rise in wealth inequality since the 1970's. Although alternative explanations exist for wealth being larger than capital, a sharp rise in monopoly power is the only plausible explanation for this magnitude of surplus wealth. In step 2 we examine the distribution of surplus wealth across firms and show it is strongly associated with firms transformed by modern IT, establishing the empirical link between monopoly rent and IT.

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Wharton Research Data Services (WRDS) was used in preparing this paper. This service and the data available thereon constitute valuable intellectual property and trade secrets of WRDS and/or its third-party suppliers.

Since monopoly rent results from limited competition, our step 3 is a *theory that* explains why we should expect the above results, by studying IT properties that imply : (A) IT enables creation of barriers to entry and facilitates their maintenance with rising business concentration; hence, it enables rising share of monopoly profits and rising *functional* inequality; (B) IT causes an increased concentration of individual wealth created by firms transformed by IT, hence to rising *personal* wealth and income inequality. In the *output flow* step 4, we estimate parameters of a Dixit-Stiglitz model and show rising monopoly power explains (i) rising share of monopoly profits, reaching 23% of non financial firms' value added (confirmed by three independent estimates), and declining shares of labor and capital, (ii) slow growth of wages and downward pressure on interest rates, (iii) decline in the level of output, capital and consumption, (iii) divergence of trend output/(man hour) from trend wages, (iv) existence of a bias in the standard measure of TFP.

Our goal is to measure the monopoly power effects of IT, therefore *order of magnitudes of results matter!* We prefer to use standard tools and seek no new methodological developments, but this is not always possible. Since we study IT and monopoly power, each part of the paper intersects with large literature related to it. We therefore clarify, *within each part*, where our work differs from or complements contribution of others. The most significant area of disagreement is the treatment of “Intangible Capital” or “Knowledge Capital” which we explain in detail in the next section.

1. Asset Valuation: The Evolution of Surplus Wealth 1950-2015

We start by discussing some conceptual issues, our methodology and related literature. We then turn to study examples and then turn to the trend since 1980's.

1.1a Conceptual issues, methodology and related literature

To compute any measure of wealth one usually thinks of a political entity, like a nation, as a unit of measurement, which is the way the Federal Reserve and the BEA aggregate US wealth in Table B.1 of “*Z.1 Financial Accounts of the United States*” (in short, *Z.1*), which reports net wealth of US residents. *This is not our approach.* Our unit of measurement is the firm and we ask two questions: how much capital does it employ and how much wealth does it create for its owners, *regardless of who they are and where they live?* Since we assess the market value of wealth the firm creates, our firm needs to have securities that trade on public exchanges with market prices. Such

firm employs capital which consists of assets valued in the firm's financial reports. The wealth created by the firm, shared by stockholders and bondholders,² is then deduced from the market value of the firm's securities. Hence, surplus wealth fluctuates over time.

Given the above criteria, we decided to use the WRDS Compustat data files for 1950-2015 that provide standard financial reports on all firms with securities trading on public exchanges. The number of firms reporting and coverage of files change from year to year for various reasons: not all firms respond, some firms provide incomplete information, new firms go public and old firms disappear either due to mergers or failure, etc. These problems are more pronounced in the earlier years of 1950-1970, when the number of reporting firms is relatively smaller. After 1970 our sample sizes exceed 3,000 firms; they contain virtually all of US based corporations and the aggregates are reliable. We study only US based firms for which security prices and equity values are available. Since the Compustat universe focuses on corporate business, it may appear it covers the combined sectors of "Nonfinancial Corporate Business" and "Financial Corporate Business" in the Z.1 report. This is not the case since the Z.1 includes *all* corporations, including private corporate firms with securities that do not trade publicly and, therefore, their values are imputed by Z.1 staff.

The complex accounting of *financial intermediaries* and the multiple participants in risk bearing of such firms raise deep conceptual issues. Viewing a firm as jointly owned by stockholders and bondholders is not applicable to a bank since the FDIC, the Federal Reserve and the General Public share, with stockholders and bondholders, its default risk. Such risk sharing is recognized by the market; it has an effect on the bank's "output" and is incorporated in its equity market value. Therefore, construction of "capital employed" in the bank's production function is a task beyond this paper. We thus avoid the Compustat individual balance sheets of financial intermediaries and exclude from our samples all firms with SIC codes 6000 - 6499 (i.e. far wider than just banks). Instead, we compute surplus wealth of "Financial Corporate Business" by using only the aggregates in Z.1 (Tables S.6.a and B.1). This procedure deprives us of detailed individual firm information we have for nonfinancial firms. Whenever possible, we report results for *combining* non-financial Compustat aggregates with Z.1 financial aggregates. When estimated asset values and capital are

² To that end we adopt the convention, common in the finance literature, that considers the firm a joint enterprise of stockholders and bondholders. The rules of ownership stipulate that bondholders are promised a specific return and stockholders receive all residual profits and take all residual risk. Assets of the firm and profits of stockholders constitute the collateral of the bondholders.

needed, results are deduced only for Compustat samples of non-financial firms. We will show, however, that our key results are virtually the same for the two sectors.

Since we use accounting data, we present first some accounting identities that explain our methodology and discuss adjustments we make in the financial reports to approximate surplus wealth. We then present in Table 1 several examples of these magnitudes for individual firms.

Start with standard accounting terms of total assets, intangible assets, total liabilities and market value, which is the market values of common stock at the date of the annual report plus book value of preferred stock. Net worth = Total Assets - Total Liabilities then leads to the definition of

$$(1) \quad \text{Excess Market Value} = \text{Market Value of Equity} - \text{Net Worth.}$$

Absent any other factor, Excess Market Value = Surplus Wealth. The fact is, however, that surplus wealth is not necessarily equal to (1), since other factors are at work and some items on the balance sheet need to be taken into account. Our natural proxy for Capital is

$$(2) \quad \text{Capital} = \text{Real Tangible Assets} = \text{Total Assets} - \text{Intangible Assets} - \text{Redundant Assets}$$

and we explain later why these two items are excluded. The definition of surplus wealth is then

$$(3) \quad \text{Surplus Wealth} = \text{Excess Market Value} + \text{Intangible Assets} + \text{Redundant Assets.}$$

Total wealth created by the firm is the sum of the wealth of stockholders and bondholders

$$(4a) \quad \text{Total Wealth} = \text{Market Value of Equity} + \text{Liabilities}$$

hence, by (1)

$$(4b) \quad \text{Total Wealth} - \text{Total Assets} = \text{Excess Market Value}$$

and combining (2) and (3) and (4b) we have

$$(5) \quad \text{Surplus Wealth} = \text{Total Wealth} - \text{Capital Employed.}$$

Intangible and redundant assets are surplus wealth *already on the balance sheet* of firms, and we later explain these data items, including the question of “Current Price” adjustment of total cost.

In a fully flexible Walrasian competitive economy *surplus wealth=zero* holds at all dates or, in a random setting, the surplus fluctuates around zero. The fact that the market value of a firm can be different from replacement value is, obviously, well known. It is the basis of Tobin’s q (Brainard and Tobin (1968), Tobin (1969)), meant to measure *adjustment* potential in a competitive economy hence such difference is only temporary and over time the zero surplus equilibrium condition holds. Since we exclude from capital some assets, deep conceptual differences exist between our surplus wealth and Tobin q. Nevertheless, a large body of research uses the Tobin q as a tool to study

problems related to surplus wealth. These studies show q fluctuates and explains concentration of economic activity. Such conclusions are often derived in the context of competitive economy (e.g. Salinger (1984), Wright (2004), Gonzalez and Trivín (2016), Gutiérrez and Phillipon (2016) and Peters and Taylor (2017)). We note particularly Wright's (2004) important observation that Tobin q 's historical average over 1900-2002 is less than 1 but, in its fluctuations, *it rose in 1999 to the highest level in the 20th century of about 1.8*. Other papers show increased concentration without using Tobin's q . (e.g. Bessen (2016), Azar et. al. (2016a), Azar et. al. (2016b), Grullon et. al. (2016)) and some of them explain that increased market power of firms has *caused* the rising concentration.

The above empirical results support the core idea of this paper by providing vital empirical evidence for growing economic concentration and rising market power. Naturally, our perspective is different. When firms have market power, fluctuations of Tobin q does not reflect adjustment of a competitive economy to shocks and the three measures of (i) rising Tobin q , (ii) increased market concentration and (iii) rising pricing power, *are all endogenous outcomes* of the growing impact of IT. Being correlated is a result predicted by arguments developed in the theoretical part 2 below.

1.1b The problem of Intangible Capital

Our exclusion of intangibles from “capital employed” is a deviation from recent literature. To explain it we note that the problems discussed at the outset, with emphasis on asset valuation, have puzzled many scholars, and one literature explained the high asset values (and other problems) by arguing that *intangible assets constitute a new form of capital*. A simple statement of their main argument says that intangible capital or, “knowledge capital”, has high competitive returns hence it explains high asset valuation. High returns cause a shift towards intangible capital and away from labor and physical capital, explaining the decline in labor and tangible capital shares. (e.g. Hall (2001),(2003), Atkeson and Kehoe (2005), Hansen et. al. (2005), Hulten and Hao (2008), Eifeldt and Papanikolaou (2013), Peters and Taylor (2017)). In addition, McGrattan (2016), and McGrattan and Prescott (2004), (2005) are papers that focus only on market values.

To evaluate the above argument we resort to standard competitive theory. Intangible Capital are assets which constitute ownership rights to patents, inventions, trade secrets or other forms of knowledge, hence “Knowledge Capital” and “Intangible Capital” are interchangeable. To check if a valuable patent owned by a firm is a “capital,” perform a hypothetical experiment. Imagine the

patent expires at date t ; hence, the firm has all prior knowledge but *not the ownership* of that knowledge. The revenue of the firm will fall not because the firm's productive capacity declines, but because the firm loses control of the price and competition brings it down. The patent has nothing to do with the productive capacity of the firm and its removal from the firm's balance sheet does not alter its productive capacity. The patent expiration alters the ownership of knowledge, and the value of the patent is actually *the market value of the right of the firm to prevent other firms from using this knowledge*. In a pure competitive economy knowledge is a public good; it is valuable but not owned by anyone, therefore the value of this patent is part of surplus or monopoly wealth. Indeed, the market value of any intangible asset is exactly the market value of the right of the owning firm to prevent others from using the knowledge associated with that intangible asset. It is often legal for a firm to own property rights on knowledge or trade in them, and this only shows monopoly wealth is valuable but not a factor of production. Consequently, a firm may purchase a patent or a trade secret, or it may purchase another firm that already owns some rights over some knowledge. In both cases the firm will record the value of these purchased assets as "intangible assets" on its balance sheet.

In short, standard competitive analysis implies intangible assets would have zero market value under pure competition and their positive value reflects a market power of the owner of such knowledge. It is surplus wealth. Most intangible assets arise when firms acquire other firms with surplus wealth. We later demonstrate this fact with examples in Table 1.

The empirical success of the studies cited above actually support the main idea of this paper. Appendix A shows the value of intangibles is about a quarter of total surplus wealth, and *the two are highly correlated*. Hence, the results of those empirical studies would improve if they use surplus wealth in a non-competitive context instead of intangibles ("knowledge capital") in a competitive context. Similarly, all results of this paper remain valid even if intangible assets are recorded as capital, the difference being quantitative. Appendix A provides the data needed for a reader who wishes to recompute any result under this assumption.

What about a firm's spending on R&D? We discuss the issue in Section 2.3b, in connection with output and income. Briefly stated, these expenditures are important for protecting the firm's market power by taking all actions that strengthen barriers to entry and expand its own markets.

1.1c Other data adjustments and errors

A. *Asset Revaluation.* Compustat asset values are stated in *historical* terms and need to be adjusted to current prices. We do it by using Table B.103 of Z.1 lines 1 and 45, where current and historical total asset values are provided, and the ratio between them for 1950-2015 is used to adjust Compustat asset values from historical to current values. Since most of the change in prices was due to changed value of real estate holdings, this adjustment ensures that surplus wealth does not contain any land value. This is so since market price of equity reflects the value of land owned while *current value* of assets contains those same values, hence by (1) the two cancel each other in the surplus.

B. *Redundant Assets.* If capital is an efficient input, a reduced amount of capital assets reduces the productive capacity of the firm. An asset is, therefore, said to be a *redundant asset* if a reduction in its quantity *does not* reduce the firm's productive capacity. This does not mean holding a redundant asset is irrational. It does mean redundant assets are excluded from capital needed for productive capacity and from the replacement value of the firm's assets; hence they are part of surplus wealth. Since reasons for holding redundant assets are not easily observable, the normal practice is to assume current valued assets are needed by the firm and are, therefore, the replacement value of the firm's capital.

However, some redundant assets can sometimes be identified. By December 2015 the holdings of liquid assets by foreign subsidiaries rose to \$2.4 Trillion (see Whalen and McCoy (2016)), while domestic holdings of liquid assets rose since 2008 by about \$1.9 Trillion. These foreign assets increased due to a legal provision that allows Indefinitely Reinvested Foreign Earnings to be free of US income tax. Hence, \$2.4 Trillion are kept abroad not out of productive needs but as a device to save income tax, hence not necessary for productive capacity. It is a part of the firm's value but not in as capital employed but rather as a surplus wealth. The reasoning that applies to recent abnormal domestic hoarding of liquid asset is more complex and appears as an outgrowth of the 2008-2009 financial crisis and the low interest rate since then. That part of these liquid assets which is not needed for normal operations of a firm or for its desired investment program, is surplus value. Management could distribute it as dividends or purchase their own shares to benefit shareholders, but they prefer to keep it under their control since they view it as costless and, possibly, useful for unknown future opportunities. Such motives are difficult to measure, and only little data is available about it; hence, we ignore it. As for the foreign held assets, we have data only for eight recent years and *whenever we use it we shall explicitly state so*. Most tables and figures that apply to 1950-2015 do not include foreign held assets. To help the reader assess the effect of including intangible and redundant assets in the surplus, we include in the basic data file of Appendix A the sample aggregates of intangibles. We also report in the text, whenever used, the amount of foreign held liquid assets. One can then recompute both total assets and surplus values to test the implication of excluding these items from the surplus.

C. *Data errors.* There are two data errors which we note. In aggregating capital employed and wealth created by firms, we add variables that we would have liked to control. First, when aggregating private debt, inter-firm holdings would be cancelled by indebtedness of firms that issued the debt. However, since most debt of firms is owned either by households or by financial institutions, and these are excluded from our aggregation, the effect of ignoring such inter-firm holdings is small. Since surplus wealth is computed by subtracting aggregate debts from aggregate assets, our inability to account for inter-firm holdings of debt *has no effect on surplus wealth*. The only effect is a small upward bias in the size of aggregate wealth generated by non-financial firms in our Compustat data. Second, we are unable to estimate the inter-firm holdings

of equity within the non-financial Compustat universe, and this component causes an upward bias in the estimated size of capital employed. If firms own securities in firms outside this universe, their values are correctly recorded. Again, this data error *has no effect on the surplus* since any asset added to the balance sheet alters the market value of a firm and is hence cancelled in the estimated surplus. No doubt some measurement errors remain. Since the same procedure is used in all years 1950-2015, and since we mostly focus on ratios like (surplus)/(market value), the behavior of proportions over time is a reasonably accurate measure.

1.1d Surplus wealth in 2015

Table 1 explain our approach³ and offers a first demonstration of the association of IT with surplus wealth. It contains four groups of firms. Those in the first are in decline or slow growing, resulting in negative surplus wealth. One may view negative surplus as reflecting too high a value of capital but the surplus is market dependent. From December 2015 to December 2016 prices of Marathon Oil and US steel shares rose sharply, resulting in positive surpluses in 2016. We thus find that the first group, defined by $S \equiv \frac{\text{Surplus Wealth}}{\text{Total Wealth}} \leq 0$, constitutes 21.2% of our universe of 4,200 firms in 2015. The second group, defined by $0 \leq S \leq 0.30$, consists of relatively low tech firms selling standard goods or services with close substitutes and only small market advantage. It constitutes 13.7% of our universe in 2015. The third group, which constitutes 12.1% of the firms, is defined by $0.30 \leq S \leq 0.70$. Firms in this group have solid technological base and major market advantage.

The fourth group, defined by $S \geq 0.70$ constitutes 53% of the 2015 firms and reflects the advanced US sector transformed by IT where most innovations take place⁴. We stress that IT is not restricted to traditional sectors such as semiconductors and computers, but applies to all firms in *diverse economic sectors* that have advanced technological base transformed by the IT revolution. Technologically advanced firms have surplus wealth that, in most cases, exceeds 80% of total wealth created. The aggregates at the bottom are ratios of the totals over the 4,200 Compustat firms in 2015. Hence, when capital *includes* assets held abroad, we find that surplus wealth is 44% of all wealth

³ In examining Table 1 recall that according to the Data Adjustment procedure in (A) above, the values of tangible and intangible assets in Table 1 equal their book value multiplied by 1.2456 (from Table B.103 of the Z.1) in order to adjust for their historical value. This increases capital employed and reduces the surplus. Since for rapidly growing high tech firms most assets are recently acquired, this procedure causes a downward bias in their estimated surplus wealth. For example, the book value of Facebook Inc. assets are only \$49.407 Billion and most were acquired in recent years, yet Table 1 records them at \$61.541 Billion. Also, as we explain later, Facebook intangibles were acquired in 2014 and valued at \$21.272 Billion, yet they are valued in Table 1 by the adjusted value of \$26.496 Billion.

⁴ In December of 2015 Apple Inc. and Microsoft's equity prices were relatively low. Between 12/31/2015 and 5/1/2017 Apple Inc. price rose by 36.25% and Microsoft's by 46.76%. Both firms moved from group 3 to group 4.

created and 71% of total market value of non financial firms. If we add aggregate data for *financial* firms, the ratio of surplus wealth to total market value rises to 79%. Finally, when we adjust capital and surplus wealth fully for foreign held assets, we find that *total surplus wealth equals 82% of total stock market value and 78% of capital employed!* This shows that surplus wealth is so large that 82% of all value that changed hands on stock exchanges in 2015 was trades of surplus wealth. In 2015 US wealth ownership was in a state where capital invested is approximately financed by bondholders, while stockholders own and trade surplus wealth.

Table 1: Selected Statistics for Some US Firms, Fiscal 2015

(Values in million of 2015 dollars)

Sample Firm by Four Groups	Total Assets at Current Prices	Intangible Assets at Current Prices	Total Debt	Market Value	Capital Employed	Foreign Liquid Assets	Surplus Wealth	<u>Surplus</u> <u>TotalWealth</u>	<u>Surplus</u> <u>Market Value</u>
US Steel	11,447	244	6,754	1,167	11,203	na	- 3,282	-0.41	-2.81
Marathon Oil	40,247	143	13,758	8,523	40,104	na	-17,823	-0.80	-2.09
General Motors	242,294	7,408	154,197	51,015	234,887	na	-29,675	-0.14	-0.58
Chevron Corp.	331,458	5,715	112,217	169,378	280,343	45,400	1,252	0.00	0.01
Berkshire Hathaway	687,891	94,004	293,630	325,196	583,487	10,400	35,339	0.06	0.11
Northfolk Inc.	42,674	0	22,072	25,190	42,674	na	4,588	0.10	0.18
Caterpillar Inc.	97,776	11,753	63,612	39,575	69,022	17,000	34,165	0.33	0.86
General Electric	613,697	102,476	389,582	292,164	407,222	104,000	274,525	0.40	0.94
Southwest Airline	26,546	1,786	13,954	27,886	24,760	na	17,080	0.41	0.61
Microsoft	361,821	27,122	96,140	354,392	226,399	108,300	224,133	0.50	0.63
Honeywell International	61,428	25,500	6,284	55,428	19,328	16,600	42,384	0.69	0.76
Dow Chemicals	84,733	19,644	41,843	61,500	46,316	18,773	57,027	0.55	0.93
Apple Inc.	361,821	11,222	171,124	615,336	259,099	91,500	527,361	0.67	0.86
Alphabet (Google) Inc.	219,503	24,558	27,130	528,168	136,645	58,300	418,653	0.75	0.79
3M Corp	40,754	14,760	20,971	91,789	13,994	12,000	98,767	0.88	1.08
Pepsico Inc.	86,777	32,919	57,637	144,684	13,658	40,200	188,663	0.93	1.30
Amazon.Com	81,517	5,631	52,060	318,344	75,886	na	294,518	0.80	0.93
Amgen, Inc.	89,155	32,919	43,493	122,397	23,636	32,600	142,254	0.86	1.16
Celgene Corp	33,697	19,602	21,134	94,203	14,095	na	101,242	0.88	1.07
Facebook	61,541	26,496	5,189	297,758	35,045	na	267,902	0.88	0.90
Aggregate Compustat (N=4200) Including Financials								0.44 na	0.71 0.79

Source: WRDS Compustat files for 2015 (see Data Appendix C)

The intangibles in Table 1 offer examples for our earlier point, and Facebook is one. Facebook was started in 2003 as a social website at Harvard and incorporated in 2004. As a corporation, it began with initial investment of less than \$50 Million but raised \$16 Billion in its initial public offering in 2012. During 2012-2014 it acquired Instagram, Whatsapp, Pryte and LiveRail- with negligible capital on their balance sheet- for about \$20 Billion, accounting for most of its \$21 Billion⁵ intangibles in 2015. In that year its gross profit margin was 84%; in December 2015 capital employed was \$35 Billion and total created wealth was \$303 Billion. By May 2017 its surplus wealth exceeded \$450

⁵ Intangibles of Facebook Inc. in Table 1 are recorded as $\$(21,272) \times (1.2456) = \$26,496$

Billion, a capitalization that was due to the fact that the firm is growing fast and has no effective competitors. Competitors like LinkedIn can, at best, establish a sub-network with narrow focus. In effect, the firm controls a world public utility with strong externalities. Facebook Inc. is an extreme case, but its monopoly power is typical.

Facebook shows why intangibles *are associated with rapid acquisitions*. In Table 1 Amgen, Celgene, Pepsico, Alphabet, Honeywell, General Electric and Berkshire Hathaway also have large fractions of intangibles due to active acquisition record. Apple, Amazon.com, Chevron and Southwest Airlines do not have such history, hence a smaller fractions of intangibles. We also note that (4a) and (5) imply that if $(\text{surplus})/(\text{market value}) > 1$, debt exceeds capital and there are many such examples (e.g. Pepsico Inc.). These occur when an acquired firm is liquid on its own and is used as a collateral for bondholders to finance the acquisition. In such a case bondholders own more than a firm's capital.

Finally, what causes surplus wealth? Textbooks appeal to advantages a firm has, such as superior labor force, management, location, control of a resource, patents' protection, customer's loyalty or other similar reasons. But these amount to explaining the firm has monopoly or oligopoly pricing power. Other reasons are offered, such as capital adjustment cost (associated with Tobin q), liquidity services of a firm's assets, and taxes. These are valid reasons. However, the magnitude of surplus wealth shows that monopoly power is the only plausible explanation. We use the term "monopoly power" in the broadest sense of a power to impact a firm's profitability by monopoly, oligopoly, monopolistic competition or by monopsony power over the firm's suppliers. The model used in the second part of the paper is, actually, one of monopolistic competition among a finite number of firms. This implies that "monopoly profits" arise in diverse ways that will be noted later.

1.1e Further detailed evidence for an the effect of IT on surplus wealth

What characterizes the firms that produced large surplus wealth in 2015? Some firms have large surplus values due to their ownership of brands with recognized pricing power (e.g. Pepsico). However, Table 1 reflects a different reality: most traditional firms where standard commodities are sold by competitive firms exhibit low surplus ratios. The table points to our main conclusion that firms with high surplus ratios are associated with sectors transformed by advances in IT. We define IT as the technology of processing, transmitting and storing information, but since we study privately owned IT, we go beyond the transistor, DNA or the internet, which are public goods. IT transformed firms in

diverse sectors into becoming advanced technology firms, and it will ultimately transform the entire economy. This diversity implies there is no obvious “*Index of IT Transformation*” which would be associated with surplus wealth to exhibit a *quantitative* relationship between IT and surplus wealth. Such measures were attempted by Bessen (2017) who defined it by the share of hours worked by IT personnel (i.e. computer analysts, scientists, etc.), and by Bresnahan et. al. (2002) who measured it by specific IT equipment used. These are not compelling measures since it is not conceptually clear why any particular head count or number of IT pieces of equipment should predict differences in surplus wealth among Facebook, Biogen, Expedia and Apple. Differences in their surpluses result from those characteristics of their technologies that prevent competitors’ entry and not differences of head or equipment count. A low R² of a regression with dubious interpretation is not the best way to proceed.

Our alternative method starts by listing the following sectors, as our best approximation of those sectors that have gone through significant IT transformation: Computer and semiconductors, online retailing and home delivery; online taxi, travel and leisure reservation services; film production, movie streaming via TV; telecommunication and mobile telephone with associated sectors from payment technologies to electronic home management; artificial intelligence and cloud computing, defense industries; seed alteration and agriculture productivity and finally, social media and the internet. We define them as the “IT transformed sectors” and could consider all 4,200 firms in our Compustat sample for 2015. For each firm *i*, compute the following index:

$$\chi_i = \begin{cases} 1 & \text{if } \{\text{firm } i\} \in \{\text{IT transformed sector}\} \\ 0 & \text{if } \{\text{firm } i\} \notin \{\text{IT transformed sector}\}. \end{cases}$$

If IT does not cause surplus wealth, then χ will not be related to firms with large surplus wealth. Since one must compute χ manually, we computed it only for 500 firms, chosen as follows. Sorting by *size of surplus wealth*, we selected (i) the 200 firms with largest surplus wealth; (ii) the 200 firms with smallest surplus wealth; (iii) 100 firms around the mean value of surplus wealth. Although defining χ_i is almost always obvious, in very few ambiguous cases we set $\chi_i = 0.5$ when a firm has both large online and large regular businesses. For each firm we also computed Tobin $q = \frac{\text{wealth}}{\text{capital}}$ where intangibles were excluded from capital but liquid assets held abroad were not (most are unknown). 50 firms with the largest surplus wealth account for 50.4% of aggregate surplus wealth of non-financial business in 2015, and the top 200 account for 74.4% of the total, hence our coverage is rather

extensive. A large number of small firms have positive or negative surplus and some large firms with large absolute value of negative surplus wealth are in the bottom group. Detailed information available in Appendix C and an exact record of the 500 firms is in Appendix B.

To illustrate, Table 2 records 60 firms: 20 from each of the three groups. Note two facts. First, all top 10 firms belong to the IT transformed sector. Second, the groups have $\bar{\chi}=0.78$, $\bar{\chi}=0.45$ and $\bar{\chi}=0.05$, showing that *surplus wealth rises sharply with value of $\bar{\chi}$* and supporting the conclusion of a strong association of IT transformed firms with surplus wealth.

Table 2: 60 US Firms with Largest, Middle and Smallest Surplus Wealth in 2015

(Values in Million of 2015 dollars, data without foreign liquid holdings)

20 Firms with Largest Surplus Values			20 Firms with Surplus Values Around the Mean			20 Firms with Smallest Surplus Values		
Firm Name	χ Value	Surplus Wealth	Firm Name	χ Value	Surplus Wealth	Firm Name	χ Value	Surplus Wealth
APPLE INC	1	435861	LIBERTY VENTURES	0	3552	YAHOO INC	1	-7283
ALPHABET INC	1	396179	FRONTIER COMMUN.	1	3539	WILLIAMS PARTNERS LP	0	-7496
AMAZON.COM INC	1	294519	BLUE BUFFALO PET PRODU	0	3536	ENERGY CORP	0	-7558
AT&T INC	1	269517	BLACKBAUD INC	1	3517	ICAHN ENTERPRISES LP	0	-7670
FACEBOOK INC	1	267902	FMC TECHNOLOGIES INC	0	3490	AES CORP	0	-7670
VERIZON COMM.	1	260112	TREEHOUSE FOODS INC	0	3480	PLAINS GP HOLDINGS LP	0	-9648
MICROSOFT CORP	1	258150	WILLIAMS COS INC	0	3462	ENERGY TRANSFER EQUITY	0	-10672
JOHNSON & JOHNSON	1	238127	OUTFRONT MEDIA INC	0	3431	NEWMONT MINING	0	-10759
PROCTER & GAMBLE CO	0.5	209646	AMERICAN WATER WORKS	0	3423	LEUCADIA NATIONAL	0	-12449
PFIZER INC	1	203586	PRA HEALTH SCIENCES INC	1	3406	ENERGY TRANSFER PARTN.	0	-13729
COMCAST CORP	1	177803	BRINKER INTL INC	0	3404	HESS CORP	0	-14465
GENERAL ELECTRIC CO	1	170531	BIO-TECHNE CORP	1	3401	FREEPORT-MCMORAN INC	0	-15417
COCA-COLA CO	0	167927	ACADIA PHARMACEUTICAL	1	3380	AGNC INVESTMENT CORP	0	-15787
ORACLE CORP	1	162979	CHARLES RIVER LABS INTL	1	3377	MARATHON OIL CORP	0	-17822
WAL-MART STORES INC	0	160896	CAVIUM INC	1	3370	STARWOOD PROPERTY	0	-19919
ALLERGAN PLC	1	160859	COMMUNICATIONS SAL& LS	0	3356	ANNALY CAPITAL MANAG.	0	-20543
PHILIP MORRIS	0	151843	WEX INC	1	3354	EXELON CORP	0	-21681
PEPSICO INC	0	149538	EPAM SYSTEMS INC	1	3342	FORD MOTOR CO	0	-27908
DISNEY (WALT) CO	1	147021	SONOCO PRODUCTS CO	0	3331	GENERAL MOTORS CO	0	-29675
IBM	1	135571	B&G FOODS INC	0	3327	CHEVRON CORP	0	-44148
Mean χ Value	0.78			0.45			0.05	

As for Tobin q, recall Wright's (2004) result that Tobin q fluctuates, reaching a random value of 1.80 in 1999, which is the highest ever. Tobin q can be very large for firms with small capital employed hence this measure is very volatile across small firms. However, the mean Tobin q for the 100 firms with largest surplus wealth was 3.73 and 1,223 firms out of 4,200 had Tobin q higher than 3.00. Mean Tobin q for the 200 firms with the smallest surplus wealth was 0.75. All this is not a chance event, it reflects high monopoly power in 2015.

Examining, in Appendix B, the 50 firms with the largest surplus wealth shows that the surplus is found mostly in two categories of firms. Either firms with market power due to well established brand names such as Coca-Cola, Pepsico, McDonald's, Philip Morris, Atria and Reynolds American or in firms transformed by IT, and there are 36 of them out of the 50. Most of these 36 firms did not

even exist in 1970. This comment is significant since in the next section we study the changes of surplus wealth from 1970 to 2015 and trace its association with the evolution of IT.

Finally, Table 3 reports values $\bar{\chi}$ for the groups of firms above, listed in rising order of the size of their surplus wealth. The values of $\bar{\chi}$ rise sharply, showing again that high values of surplus wealth are strongly associated with the degree at which firms have been transformed by IT.

Table 3: Values $\bar{\chi}$ for Groups with Falling Surplus Wealth

Group of Firms	Percent of Firms in Group Transformed by IT
10 Firms with the smallest surplus wealth	0
100 Firms with the smallest surplus wealth	1
Second 100 Firms with smallest surplus wealth	5
100 Firms with surplus wealth around the mean	35
Second 100 Firms with the largest surplus wealth	45
100 Firms with the largest surplus wealth	73
10 Firms with the largest surplus wealth	95

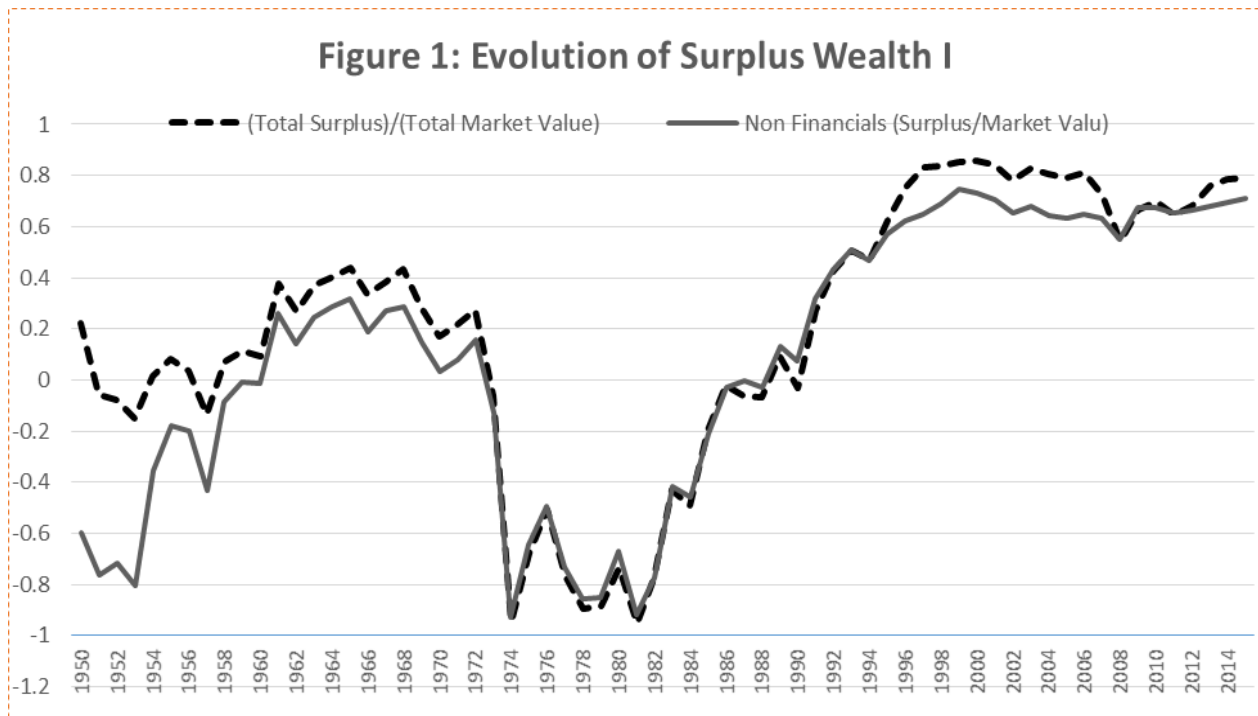
We targeted the relation of IT with *size* of surplus wealth and not surplus normalized by firm size, measured by wealth, capital or market value. Our file contains many small firms and measures like $\frac{\text{surplus}}{\text{wealth}}$, $\frac{\text{surplus}}{\text{capital}}$ or $\frac{\text{surplus}}{\text{market value}}$ leads to *artificially high correlation* between surplus wealth and IT transformation since a large number of small high tech firms dominate $\chi_i = 1$ and many failing oil and natural resource firms dominate $\chi_i = 0$. Also, giving equal weight to Apple and a small firm with negligible surplus is unsatisfactory. Firms with varying sizes are scattered over the file and many large firms are found among the bottom 20 firms in Table 2.

Our cross section study provides empirical evidence for an association of IT with surplus wealth. The second empirical evidence is the evolution of surplus wealth 1950-2015: *it corresponds exactly to the timing of the IT revolution*, and we present it next. We explore the circumstances that lead to the large surplus. Is it a recent phenomenon? Have the surplus ratios changed over time?

1.2 Surplus wealth 1950-2015 traces the evolution of IT

1.2a *The general tendency.* Appendix A reports aggregate Compustat data and in Figure 1 we draw two curves for 1950-2015. One is $\text{surplus} \backslash (\text{market value})$ for Compustat samples combined *with the financial corporate sector* and the second is this same ratio for the Compustat samples alone. In both

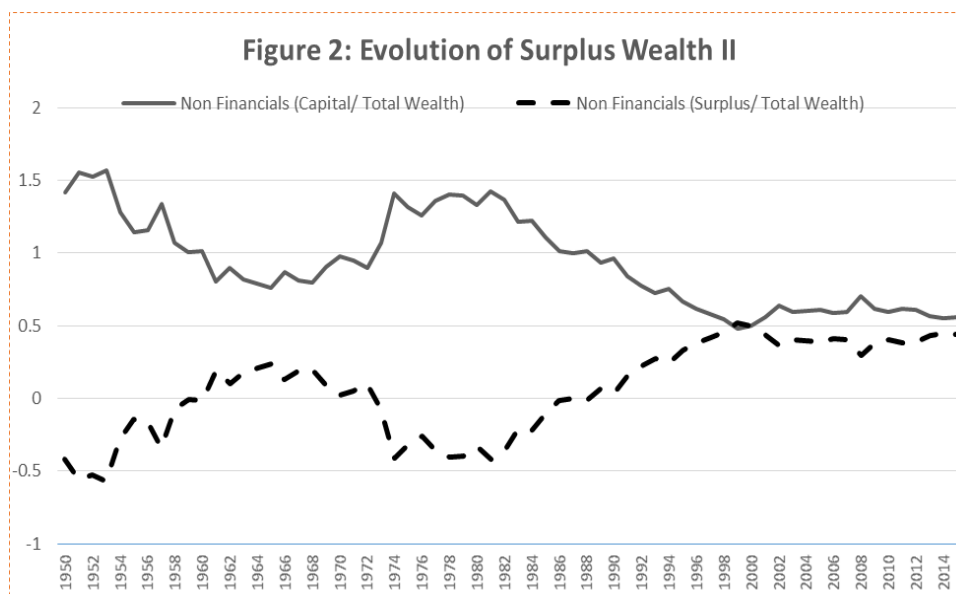
cases the surplus is computed without excluding foreign liquid assets from capital.



Although the Compustat samples are not a panel, we have noted the aggregates are reasonably reliable and comparable over time. Figure 1 shows the large 2015 surplus in Table 1 is the culmination of growth that began in the 1970's. Starting in 1950 there is virtually no aggregate surplus wealth up to about 1958, after which a significant surplus developed as a result of the hardware phase of the IT revolution in the 1960's. This surplus did not last. Most discussions of the early 1970's focus on productivity slowdown and stagflation but the figure shows the effect on corporate profits and private wealth was catastrophic: total surplus fell from \$372 Billion and 43% of total market value in 1968 to -\$590 Billion in 1974. Conditions changed, and a new era began in 1974-1982 that has continued until today, in 2017. This is the span of time that corresponds exactly to the second, software phase, of the IT revolution. Two events are the symbols of the change: Apple 1 was released in 1976 and IBM's PC was released in 1981. The surplus rose from -\$0.590 Trillion in 1974 to a temporary peak in 2000 of \$14.025 Trillion and 86% of total market value. During 2000-2015 the surplus and total wealth continued to rise, but surplus/(market value) remained in the 70%-80% range except for 2008-2012. The peak was in the dotcom boom and the decline in 2008-2012 was due to the Great Recession. To isolate a trend one may interpolate and conclude that the rising surplus/(market value) ratio

continued into 2015 when, adjusting capital and surplus for foreign holdings, it reached 82% of the stock values. It is hard to find any evidence the process of rising surplus wealth has come to and end.

Figure 1 reveals two more facts. First, surplus ratios were negative in the 1970's; hence, the rise after 1974 was, partly, a recovery from the 1968-1974 collapse. Recovery began in 1981-1986, which is exactly the time the software phase of the IT revolution went into high gear: IBM adopted Microsoft's DOS as the PC operating system in 1981, the military ARPANET adopted the internet TCP/IP in January 1983 and Microsoft went public in 1986. Second, comparing the surplus of non-financial firms with the surplus of the combined sectors reveals they are the same, with two minor differences in early 1950s and in 1996-2006. Therefore, we study several questions using only the non-financial firms' data in the Compustat universe, but such conclusions also apply to financial firms.



1.2b Growth rates of capital and wealth. In Figure 2 we plot two aggregate ratios for the non-financial samples (without adjusting for foreign assets): capital/wealth and surplus/wealth. Since wealth includes stockholders and bondholders ownership values, Figure 2 shows that over 1980-2015, capital/wealth declined from 1.33 to 0.56, and surplus/wealth rose from -0.33 to +0.44; hence, capital invested grew much slower than wealth. We compare these two growth rates by using the GNP deflator to restate both non-financial values in millions of 2015 dollars:

	<u>1980 Value</u>	<u>2015 Value</u>	<u>Mean Growth Rate 1974-2015</u>
Total Non-Financial Wealth:	5,523,338	32,364,579	4.91%
Total Non-Financial Capital:	7,365,166	18,017,771	2.48%

The difference of 2.43% reflects (i) a 5.54% growth rate of real market value, and (ii) the change in the leverage rate which we examine later. Such large differences in growth rates between total wealth and capital employed cannot continue indefinitely, but it is not evident where the process is heading.

1.2c *Real size of surplus wealth 1974 - 2015.* How large is the surplus and what is its composition? We present in Table 3 real values for selected years in *billions of 2015 prices* (using GNP deflator). The table shows that *between 1974 and 2015 real surplus wealth increased by \$ 25.9 Trillion* with ownership which, we shall later see, is heavily concentrated. The sheer size of this surplus calls for rethinking of standard views about the relation between innovations and wealth distribution.

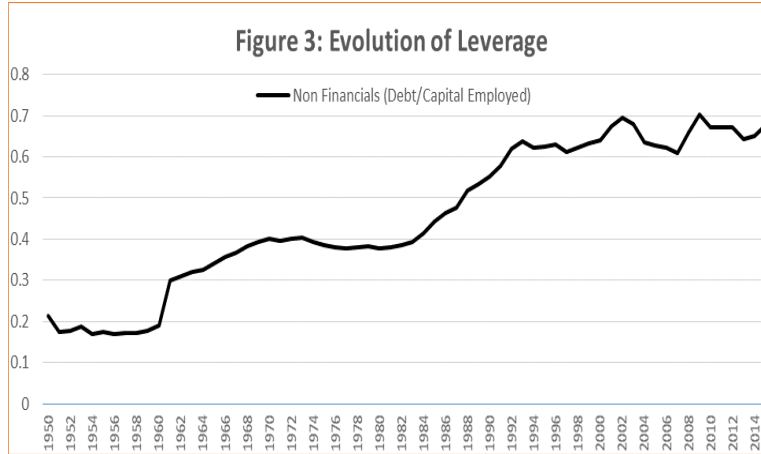
Table 3: Size and Composition of Surplus Wealth

(Billion of 2015 Dollars)

Year	Non-financials Excess Market Value	Non-financials Intangible Assets	Untaxed Foreign Asset Holdings	Non-financials Surplus Wealth*	Financial Sector Surplus Wealth	Total Surplus Wealth
1974	-1,882.85	82.60	na	- 1,800.25	-252.70	-2,052.85
1980	-1,918.22	76.39	na	- 1,841.83	-393.03	-2,234.86
1986	- 357.00	242.47	na	- 114.53	19.18	-95.31
1992	1,775.53	466.15	na	2,241.68	434.63	2,676.31
2000	10,232.61	2,149.65	na	12,382.26	5,588.41	17,970.68
2010	5,744.77	3,625.87	1,363.00	10,733.64	3,392.93	14,126.56
2014	9,660.70	4,752.54	2,299.00	16,712.24	7,270.44	23,982.67
2015	8,805.44	5,541.37	2,434.00	16,780.81	7,067.44	23,848.25

Source: Compustat files and Z.1 (see Appendix C). (*) Non-financials surplus is the sum of the first three components

1.2d *Dynamics of corporate leverage.* Figure 3 plots **debt/capital** ratio of non-financial firms for 1950-2015 (without adjusting capital for foreign holdings). It shows high leverage in 2015 is the culmination of a long sequence that began in the 1950s where US businesses increased leverage from 22% of capital employed to 68%. If we adjust capital for foreign holdings this percentage rises to 78%. Indeed, a large number of advanced technology firms exhibit **debt/capital > 1**; hence, lenders are willing to accept intangible assets as collateral. These changes lead to a state where the financial structure of the non-financial corporate sector may be approximated by a leverage ratio of 1, when bondholders finance the capital stock and receive a stipulated return, while stockholders own and trade surplus wealth, bearing all residual profit risks. Such a division is possible only if the surplus is large enough to provide bondholders with a safe collateral. From this perspective, most value and risk traded on the stock market is of surplus wealth, while ownership of the firm's capital employed is mostly traded on the bond market. Figure 3 shows these conclusions did not hold in 1950, and the growth of a large surplus wealth made this development possible.



Having demonstrated that surplus wealth is very large and is associated with IT, we next provide theoretical arguments why basic economic principles should lead one to expect that IT would cause a rise in monopoly power, an increased surplus wealth, and therefore the rise in both functional and personal inequality.

2. Information Technology Based Changes Caused the Surplus and the Rising Inequality

Monopoly rent results from barriers to entry. Therefore, to explain rising monopoly power we argue that rising barriers to entry are consequences of IT and of the institutions built to finance its development since the 1970s. We stress, however, an important fact. An IT innovator's monopoly power is not derived only from the technology he creates (which can often be copied) but also from the dynamic properties of IT, which enable him to become a market leader and once attained, IT gives innovators significant advantages for maintaining and consolidating his market position. The same properties of IT also explain the growing concentration of wealth in fewer hands.

2.1 Innovations as a cause of monopoly pricing power

Although our core argument is that the large recorded surplus wealth was caused by IT, some traditional brand names and textbook pricing power generate surplus wealth and we have noted such examples earlier. In addition, the term "Monopoly Wealth" may elicit the wrong impression that US firms are engaged in illegal acts since large surplus wealth was attained during the Robber Barons' era with intimidation, corrupt legislators and other illegal means. In comparison, most surplus wealth of late 20th and early 21st centuries is legal, is actively supported by policy and is encouraged in public

discourse. To encourage innovations we protect patents and intellectual property rights legally. Our policy encourages new products and processes, enabling innovating firms to create technology platforms with which to differentiate their products, develop customer loyalty and build economic ecosystems with pricing power. Firms like Amazon, Apple, Facebook, Google, Walmart and others take legal steps to develop propriety networks with externalities which are sufficiently strong to gain their customers' loyalty in an open manner. As the rate of innovations increases, the size of innovating firms rises with growing pricing power and increasing surplus wealth. As IT expands and transforms more sectors, a rising number of firms enjoy legal "moat" protection as compensation for innovations, rendering pricing power more extensive and rising surplus wealth.

The argument above is paradoxical as it shows that increased rate of technical progress increases firms' oligopoly power and moves markets further away from competitive behavior. That is, there is a well recognized conflict between competitive institutions and innovative creativity, since monopoly power fueled by innovations is legally protected. But reality is more complex. First, winners among early innovators gain the reputation and strategic advantages that provide pricing power *even without legal protection*. Moreover, once established, winners consolidate market power with further developments which are kept as trade secrets. Second, trade secrets wear off with time, and all legal protections are temporary; hence, protected pricing power has limited duration. Third, high profitability attracts competing innovations; hence, under a rapid innovations the real competition is among innovators. Given long enough time period, the power that brings down an innovator's monopoly is a competing innovation, which, if successful, replaces one innovator's pricing power with another, who provides better products that consumers prefer. Hence, during long periods of rapid technical advance, consumers face a *sequence* of protected monopoly powers, each replaced by a subsequent market power of a new innovator. Fourth, if the innovation rate slows down, legal protection and economic advantages dissipate, and markets converge back to competitive conditions.

The above implies that pricing power results from two opposing forces: declining technologies cause monopoly power to decline, while rising new technologies cause rising pricing power. This effect can be seen in Figure 1. A powerful *hardware phase of IT* took place in the 1960s, and the rise of the surplus, reaching 43% of total market value in 1968, is no accident. Mainframe computers gained wide use before the 1960s, and the minicomputer was introduced in the 1960s. These developments stalled after 1968, leading to the "productivity slowdown" when a slower innovation

rate caused the surplus to collapse and vanish by the early 1970s. These were replaced by the PC and Internet, leading to the *software phase of the IT*, that took hold in the 1980s.

The above reasoning applies to all innovations. We next explain why IT has several unique characteristics that explain why such innovations have had the complex effects observed in the data.

2.2 *Why has IT caused increased monopoly power and rising income and wealth inequality*

Rising monopoly power *increases factor income inequality* but not necessarily *personal wealth and income inequality*. Since both changes occurred, and since we maintain both are caused by IT, we study both effects: those that enable rising barriers to entry and those that promote rising personal inequality. These are distinct factors that need to be understood separately.

2.2a *IT enables rising barriers to entry and facilitates their consolidation*

(i) *The kernel of monopoly power: private ownership of knowledge*. Innovators are sole owners of important information they can prevent others from using; this is the kernel of their monopoly power. But modern developments of commercially used knowledge, or information, has been entirely enabled and propelled by IT. Both biotechnology based new drugs and new agricultural seeds emerged from a study of the DNA, and Genome Sequencing could not happen without the computer. For this reason Biotechnology is a component of the IT revolution. One might prefer the term “Knowledge Economy” over IT, but in today’s context it is a semantic difference. Biotechnology was made possible by the same technology that made possible smart phones, video games or social media. In this sense IT has *enabled* these innovators to acquire their leadership positions and the corresponding monopoly power they attained. But IT has other unique properties that *facilitate* maintenance of monopoly power.

Each IT development builds upon previous developments, therefore active IT discoveries can erect a pyramid of related innovations which constitute a protective “moat” around any IT innovation. In this manner IT *facilitates* maintenance of a leadership position of an innovator. Indeed, because of this property most IT innovators prefer industrial secrecy and the advantage of being a leader, over a legal patent protection which requires public disclosure of such secrets. Such firms protect market power by on-going upgrades of their technology, making it harder for competitors to catch up. A powerful weapon often used for that is to buy out potential competitors. A purchasing firm may enhance such new technology but sometimes it uses its ownership to suppress it.

IT enables vast amount of information to be communicated and shared, at electronic speed and at dramatically declining cost, by a large number of agents. This is a unique property of IT in human history. For this reason, IT transformed many firms into “platforms” or “ecosystems” where diverse economic agents coordinate activities in accord with vast amount of hitherto private information which is now owned by platform firms and further expands their monopoly power. A platform consists of a central firm with multitude of users, buyers, ap developers, suppliers and business partners related to a single set of activities. Although the computer, mobile phone and Internet are the main platforms’ tools, these examples reveal how ubiquitous they are: social networks; online retailing; electronic payment processing; computerized leisure, vacation and taxi services; computer search engines; real estate sales and cloud computing. It is, thus, no surprise Amazon.com produces little on its own but by using Big Data it knows much about its clients and can sell literally anything produced by others. The vast reach of the platform firm renders monopoly power stronger and more stable.

(ii) *IT enables network externality on platforms.* The economic effects of ecosystems is obvious- they enable wide network externalities among interdependent participants. Such business models are based on the idea a platform is a coordination device used by many people at virtually zero marginal cost to the platform owner; hence, its profits increase with the size of its user base. Externalities are the direct consequences of IT, since all that is shared is information. The size and impact of these externalities suggest that from an economic perspective these firms created *privately owned public utilities*. At the center there is the platform firm which, if a producer of its own products (e.g. Apple, Microsoft), it charges high enough prices to generate the monopoly rent. Apart from pricing its own products, most platform firms charge direct or indirect fees to other platform users (i.e. suppliers, ap developers etc), reflecting monopoly or monopsony rent. However, monopoly power is often more subtle, as some platform firms do not charge any direct fees (e.g. social networks, Google). Hence, on the surface, no monopoly pricing of services provided appear to exist. But then, customers pay in several ways. First, payment in kind by providing the platform firm their private information, which becomes a prized possession of the firm. Monopoly pricing arises when the platform firm charges other firms very high fees for advertising or selling to its members-customers. We say “very high” fees since their financial reports reveal very high profit margins. Therefore, the second payment of customers takes the form of higher prices of products advertised on the platforms by the firms who must cover their advertising cost and therefore have higher selling cost than firms that sell exactly the same product but do not

advertise on the platform. Finally, some platform firms charge *fixed fees* for membership and these constitute a large component of their total profits. We discuss these fees in (iii) below.

(iii) *IT Platforms: increasing returns and rising optimal firm size.* Apart from declining cost over time, IT entails increasing returns to scale over a wide and rising range. Scale economies, coordination externalities and falling computing cost facilitate firm management and increase optimal firms' size. In many cases they lead to a "winner takes all" outcome documented by Autor et. al. (2017) and rising economic concentration (e.g. Bessen (2016), (2017), Azar et. al. (2016a), Azar et. al. (2016b), Grullon et. al. (2016), Gonzalez and Trivín (2016), Gutiérrez and Phillipon (2016) and Peters and Taylor (2017)). This literature provides additional empirical and conceptual support for our perspective.

(iv) *IT enables communication to increase customer loyalty.* A growing number of "customer loyalty programs" allow firms to communicate directly with their customers, to offer added benefits to active customers. Some programs do not charge any fees (e.g. retail stores or hotel chains), but others charge fixed fees which are major sources of income (e.g. Costco, Amazon Prime, credit cards of airline miles programs). Operating such programs is enhanced by the Internet's emergence as a business tool and falling computing cost. Apart from being a source of income, loyalty programs enable firms to discriminate among its customers, as any monopoly would.

2.2b *IT characteristics that cause rising personal wealth and income inequality*

IT also caused an increased wealth concentration in fewer *individual* hands hence a rising personal inequality due to the manner wealth is created by IT innovations. This is our next topic.

(v) *IT causes rising development speed and declining required capital for initial value recognition.* To explain this, consider a major innovation in heavy industries such as railroads, steel, automobiles etc. that were the drivers of growth in the 19th or early in the 20th century. Such innovation was more than just an idea since it typically required substantial investment in the form of a plant and equipment. The innovator had to demonstrate feasibility of product or process, that its production costs are reasonable and that it can sell at a profitable price. Hence, translating an idea into a prototype and then to mass production typically required significant capital investments, and to raise it, the innovator had to give up a substantial ownership share. Also, since *profits arrived after investments* and after marketing development, the innovator realized most value only after the idea proved successful, by which time the wealth created would be widely distributed. With a conservative public attitude, the time taken for

an innovation's adoption could be long. Therefore, one often finds in the literature a discussion of the rate of innovation "adoption," and of why economic development revolves around the adoption rate of an innovation by other firms (e.g. Schumpeter (1934)).

These features changed later in the 20th century but remained in place even in the early stages of the IT revolution in 1950-1970, which was mostly *hardware based*. An innovation in computers or semiconductors required an innovator to do the design and build a plant for most components needed for the final product, and that required heavy capital investments. It should, thus, come as no surprise that during these initial stages IBM was a very large manufacturer of semiconductors!

In contrast, innovations in the recent stage of IT are more *software based* and typically purely informational increments to knowledge. For example: computer program, drug formulation, smart phone app, genetically engineered seed or a video game, are all purely informational changes; they do require some hardware adaptation. However, their key characteristic is that once an innovator has the idea, it typically requires only a modest venture capital, which, in Silicon Valley, is in the range of \$20-\$50 million, to conduct a feasibility study. This initial investment enables the "proof of concept," which reduces the innovation's risk at modest cost. The important result is that *the wealth created ends up being concentrated in a small number of hands*.

The assumption of small initial investment is not always valid. In cases such as new drugs, FDA approval imposes restrictions on a drug's public suitability. A drug company must therefore conduct several complex clinical trials in order to prove feasibility as well as safety. Such studies are very costly, making drug development one of the most expensive areas of feasibility studies. However, surplus wealth developed by drug companies is also among the highest.

An additional key factor that further reduce the capital required for developing a new idea in IT, and contribute to the concentration of wealth created, is *outsourcing*. It was made possible by the growing specialization within IT and by the fact that most systems can be decomposed into standard components, which are developed on their own and assembled at the end. We also note the important impact of government research that contributed significantly to reducing the capital cost of IT innovations (see Wright (2017)).

(vi) *The impact of finance and investment banking*. With proof of concept established, the innovating group needs capital to proceed with its investment plans. To that end it needs a market to realize the value of its innovation by selling securities *at a sharply increased market value*. The innovating

group, in fact, offers its valuable liquid “currency,” without yielding too much equity ownership. For a public sale of its securities, the firm needs investment bankers. First, since most innovations entail technical details whose appreciation requires expert knowledge, the firm needs a public introduction. By taking the firm public, the bankers provide a signal to the market that the valuation of the firm is justified. Second, by selling the securities through their own financial brokers, investment bankers make available to the firm their own network externality, which is very valuable and results in a significant transfer of value *to the banking sector*.

An initial public offering (IPO) completes the creation of liquid surplus wealth, often by a firm with relatively small sales and invested capital. In recent years, an active private market developed in securities of successful firms which allows a new firm to delay the IPO and raise as much capital as it needs from private sources, at a valuation which is commensurate with a potential IPO value. In either case, *the result is a high concentration of equity ownership by the innovator*. Since most IT wealth was gained by stockholders, and since stock ownership is heavily concentrated in a small fraction of the population, it follows IT caused more wealth to flow into a few hands, increasing wealth and income inequality. This conclusion is not entirely sufficient since many IT entrepreneurs were young at the start, without much wealth or stock ownership.

To address this last point recall that since the 1980s IT innovations were mostly *software based*, requiring technical knowledge of computer software. This gave young innovators with computer science training an advantage. Hence, *successful* IT innovations result in young innovators retaining much of their shares and the wealth created by IT being heavily concentrated in few, often young, hands. As noted earlier, this was not true earlier in the 20th century; a major innovation in the growth industries of the time required heavy investments before commercial success was established. This required more investors to join, and the wealth created was therefore spread among more people.

The importance of finance and investment banking for the development of innovations also explains the high surplus wealth we find in the financial sector. However, it appears that some of this surplus wealth is, actually, a capitalization of the public’s risk sharing rent since surplus wealth in that sector is rather persistent; it remained positive *even at the depth of the Great Recession*.

The impact of points (v) and (vi) is the *increased speed of business development* and wealth creation, a conclusion supported by results of others (e.g. Greenwood and Jovanovic (1999)). Another index for this speed is the length of time it takes a new firm, from the date of its incorporation to the

date of its IPO. A recent IPO of *Snap Inc.* was completed on March 2, 2017 when the firm was started on September 16, 2011. It then took Snap Inc. 5.5 years from start to the IPO, whereas Facebook took 8 years and Microsoft 10 years to do it. In sum, compared to innovations in the past, new ideas in IT typically require less time and less invested capital before an innovator realizes the value of an innovation. Consequently, wealth creation has been accelerated to enable an innovator to end up with a larger ownership share, resulting in the ownership of new wealth being more concentrated.

2.3 *Historical perspective, management compensation and R&D, first test: monopoly profit share*

2.3a *Historical perspective of rising monopoly power and rising wealth and income inequality*

Since the 1970s IT innovations created new firms or transformed old ones; hence, declining or slow growing old firms with broadly distributed ownership were overtaken in importance by new, IT based, firms with pricing power, large surplus wealth and highly concentrated wealth ownership. As IT innovations transformed growing number of sectors, average monopoly power rose, causing rising surplus wealth and rising personal inequality. We have also seen in Table 3 that over 1974-2015, some \$25.9 Trillion of surplus wealth was created, mostly in IT based sectors, with highly concentrated ownership. This explains Figures 1-3 which show sharply rising $\frac{\text{wealth}}{\text{capital}}$ ratio and wealth growth rate in 1974-2015 exceeding the growth rate of capital by 2.43%.

We then conclude that the steep rise in income and wealth inequality from 1974 to 2015 was caused by the rise in average monopoly power of the new or transformed firms created by the IT revolution. This was a result of two forces; first, the rising firm size and increased market power of IT transformed sectors, and second, the expansion of the IT transformation into more sectors. This shows the *economy was not in a steady state*, but a transition to a final state will come to an end when IT transforms the entire economy.

Our perspective conflicts with Piketty's (2014) view of wealth accumulating through a lengthy intergenerational process where the rate of return on family assets exceeds the economy's growth rate, causing wealth inequality to rise. The process of accumulation we describe here shows that wealth creation in 1970-2015 had little to do with intergenerational accumulation and mostly reflects rise of individual wealth enabled by IT based innovations together with rapid decline of wealth created in older industries such as railroads, automobiles, steel, etc. Our perspective questions the darker future forecasted by Piketty's (2014), which appears motivated by a model of agrarian society in which

dynastic land (not subdivided by inheritance) is the main form of wealth. Our analysis contradicts Piketty's forecast of rising social stratification as in the 19th century. This is because a rising surplus is not associated with intergenerational wealth transfer within a fixed set of dynasties experiencing growing wealth, but rather, wealth is transformed from one set of surplus owners to the next set who may not be members of the same family. This does not alter other dark and authoritarian implications of growing inequality, but the 19th century Victorian age may not be the appropriate model for it.

2.3b *The role of R&D and management compensation*

We recall that management compensation rose since the 1970's, and relative labor share declined since the 1970's. In part 3 we study the effect of monopoly power on various macroeconomic variables, but start here by explaining our treatment of management compensation and R&D since these are related to the conceptual-theoretical discussion in this part.

Monopoly power, due to innovations, is temporary and is subject to erosion by competing ideas. Therefore, firms with surplus wealth engage in intense technological competition over the edge that gave them monopoly power in the first place. Hence, the vital issues management is concerned with are not only making sure production and marketing schedules are on track, but mostly, that an optimal strategy is employed to preserve a firm's market edge. This is the firm's battle for survival, and the strategy employed seeks organic improvements and/or acquisitions aimed to consolidate the firm's market power. This has implications to our treatment of management compensation and R&D.

The argument above suggests a model of output, as a function of labor and capital, must question the labor designation of management input since it benefits the firm as a guardian of its market position. It is thus more appropriate to consider management *as partners* in the innovating process and their compensation as a profit sharing arrangement with the firm's owners, all of whom benefit from surplus income generated after wage and capital interest cost. This view is supported by the fact that base wage is only a small component of officers' compensation; most of it takes the form of profits from granted equity at prices below market and from granted stock options, all of whose realization depends upon the size of surplus wealth. We, therefore, later treat officers' compensation as profit-sharing, which is part of a firm's surplus income. This point out even further a fact, which is recognized by others (e.g. Elsby et. al. (2013)), that true labor share is actually lower than the BLS published numbers. In the same way, R&D is an important tool management use to maintain the firm's

market position. After all, R&D expenses are the cost of creating knowledge which, we have argued, is not invested capital but as a value added to surplus wealth. We thus treat R&D cost in part 3 as essential to protecting the market position of a firm and for maintaining its surplus value by improving products, developing markets or marketing new products and demonstrating safety of new products. In sum, we treat officers' compensation as part of surplus income and R&D cost as the firm's cost of preserving its surplus wealth and preventing its depreciation.

2.3c *The asset based estimate of the share of surplus income in output: test I*

Although we have studied up to now only *asset* values, they offer a first estimate of the share of monopoly surplus in *output or income*. Output is divided into labor share, capital share and share of monopoly surplus income. Figure 1 shows that as the PC was introduced in the early 1980s, there was no surplus wealth and therefore, the share of monopoly income was zero. Table 1 shows that in 2015 non-financial business exhibited $(\text{surplus})/(\text{total wealth}) = 44\%$. Later in Table 4 we show that adjusted for self-employed and management income, relative labor share was 0.52; hence, the shares of capital income plus share of surplus income in output was 0.48. Assuming, for simplicity, that the rate of return on capital equals the rate on surplus wealth, we have two equations: $\mathbf{R(K+S) = 0.48Y}$ and $\mathbf{S = 0.44(K+S)}$ which imply share of monopoly profits in value added was $(0.48) \times (0.44) = 0.211$ which is a measure of an income flow deduced from asset surplus. We thus conclude that the share of monopoly income rose from 0% in the early 1980s to 21.1% in 2015. Being important, we estimate it again in Sections 3.3a-3.3b by using two different, *independent*, methods that use only flow data (income and expenditures) to discover these alternate sources imply the same 0.21 - 0.23 share of surplus monopoly income in net value added! Hence, the three independent estimates are the same.

We next turn to the effects of rising monopoly power on *income distribution and other flow macroeconomic variables*. These are studied better with a formal model.

3. **Output and Income Flows: A Model of Income and Wealth Distribution**

We formulate a standard Dixit-Stiglitz monopolistic competition growth model in which firms have pricing power. In Sections 3.1-3.3 we specify only part of the model as we focus on distribution questions and income and wealth inequality can be studied without a complete General Equilibrium specification (e.g. Solow (1960)). In Sections 3.4 -3.5 we complete the specifications and deduce wide

macroeconomic implications of rising monopoly power. We work with the *simplest* assumptions but explain why the results remain valid even under more general conditions.

Our Dixit-Stiglitz monopolistic competition growth model is standard, used by others to address diverse problems. Hornstein (1993) and Cooper (1993) used it (with increasing returns) to assess the propagation of productivity shocks. Karabarbounis and Neiman (2014) use it to explain the decline of labor share by capital/labor substitution motivated by the decline in capital cost. The model is close to the one used by Barkai (2016a) who used imputed “required” interest rate to deduce the mark up and aggregate profits. We comment on this method later in Section 3.4.

3.1 A model of growth when firms have pricing power

There is a large number of identical consumer-households with utility over consumption and labor, who optimize dynamically over time with a utility function

$$(6) \quad U_t = \sum_{\tau=t}^{\infty} \beta^{(\tau-t)} u(C_{\tau}, L_{\tau}).$$

Consumption follows a Dixit and Stiglitz (1977) framework with M firms, each producing a different intermediate good. These are used by households and firms to produce final consumption or investment goods, which are CES composites of the intermediate goods in accord with

$$(7) \quad C_t = \left[\sum_{j=1}^M (Y_{it}^C)^{\frac{\theta_t-1}{\theta_t}} \right]^{\frac{\theta_t}{\theta_t-1}} \quad I_t = \left[\sum_{j=1}^M (Y_{jt}^I)^{\frac{\theta_t-1}{\theta_t}} \right]^{\frac{\theta_t}{\theta_t-1}}.$$

(C, I) are consumption and investment, (Y_{it}^C, Y_{it}^I) are amounts of intermediate good i used to produce, consumption C_t and investment I_t . θ_t is elasticity of substitution; it varies with time and we consider only $\infty > \theta_t > 1$, that permits profit maximization. The model does not nest a competitive economy with finite θ_t , and its error rises for large θ_t . The number of firms is fixed since there is no free entry.

Consider a variant of (7), that introduces a compositional effect that distinguished consumption from investment goods. It also permits the prices of consumption and investment goods to exhibit different growth rates, in accord with Gordon’s (1990) demonstration that investment goods prices have declined (see also Greenwood et. al. (1997)). To that end we can replace (7) with

$$(7a) \quad C_t = \left[\sum_{j=1}^M \theta_j^C (Y_{it}^C)^{\frac{\theta_t-1}{\theta_t}} \right]^{\frac{\theta_t}{\theta_t-1}} \quad I_t = \left[\sum_{j=1}^M \psi_t \theta_j^I (Y_{jt}^I)^{\frac{\theta_t-1}{\theta_t}} \right]^{\frac{\theta_t}{\theta_t-1}}.$$

ψ_t measures higher capital efficiency or lower cost of producing capital goods. We do not study this case but examine it only to show that all our distributional conclusions remain valid under (7a).

The Dixit-Stiglitz demand gives rise to monopolistic competitive pricing by producers of intermediate goods; therefore *our assumptions about capital and wealth ownerships are important*. Capital and labor are assumed to be freely mobile, hired in free markets and paid the competitive wage rate and rental rates (W_t, R_t) . Hence, the supply of capital and labor are symmetric, and households own capital they rent to firms. Aggregate capital grows in accord with $K_t = (1-\delta)K_{t-1} + I_t$ (δ is a depreciation rate), and aggregate labor available is exogenous. Regardless of who owns capital, in profit calculations firms consider the alternative cost of renting capital they may own and maximize profits at any date by allocating capital and labor optimally in accord with market prices. Our key assumption is then that stockholders benefit from any pricing power the firm has, and consumers, households or capital owners do not form coalitions to break pricing power of firms. Under such assumptions *capital owners and stock holders perform different functions*. Firms' ownership shares are traded in open markets, and profits are distributed to stock holders as dividends only after capital and labor are paid their incomes in accord with the prices at which they are hired. An alternative model could have a class of entrepreneurs who own all the shares but who do not work, while households own no shares. Entrepreneurs may own capital therefore their consumption and savings are financed by dividends paid by their shares and rental from capital ownership, if they own any.

To derive demand functions for consumption and investments, we first address the issue of measurement units. Starting with Dixit and Stiglitz (1977), it is common to use labor as a numéraire. Since we integrate the model with a neoclassical production structure, we prefer to use consumption as a reference. To that end we first introduce an abstract unit of account, with which to write the budget constraints of the two uses, and later show how to adjust them to consumption as a numéraire.

Since the utility function is increasing in consumption, one can derive the implied demand functions for intermediate goods with prices p_{jt} from the following optimization procedure:

$$(8a) \quad \text{Maximize } C_t = \left[\sum_{j=1}^M (Y_{jt}^C)^{\frac{\theta_t-1}{\theta_t}} \right]^{\frac{\theta_t}{\theta_t-1}} \text{ subject to consumption expense } \hat{P}_t^C C_t = \sum_{j=1}^M P_{jt} Y_{jt}^C$$

$$(8b) \quad \text{Maximize } I_t = \left[\sum_{j=1}^M (Y_{jt}^I)^{\frac{\theta_t-1}{\theta_t}} \right]^{\frac{\theta_t}{\theta_t-1}} \text{ subject to investment expense } \hat{P}_t^I I_t = \sum_{j=1}^M P_{jt} Y_{jt}^I$$

The implied demands are functions of expenditures $(\hat{P}_t^C C_t, \hat{P}_t^I I_t)$, and we define them later in terms of (C_t, I_t) , measured in units of the consumption good. The optimization is standard; the price and implied demand functions are defined by

$$(9a) \quad P_t^C = P_t^I = \left[\sum_{j=1}^M (P_{jt})^{1-\theta_t} \right]^{\frac{1}{1-\theta_t}} = P_t$$

and

$$(9b) \quad Y_{jt}^C = \left(\frac{P_{jt}}{P_t}\right)^{-\theta} \left(\frac{\hat{P}_t^C}{P_t}\right) C_t, \quad Y_{jt}^I = \left(\frac{P_{jt}}{P_t}\right)^{-\theta} \left(\frac{\hat{P}_t^I}{P_t}\right) I_t.$$

It is well known P_t is cost of a unit of consumption or investment at the optimal mix of intermediate goods (see Brakman and Heijdra (2004), Ch. 1). Next, insert (9b) into (8a)-(8b) to find

$$(10) \quad v_t = \left[\sum_{j=1}^M \left[\left(\frac{P_{jt}}{P_t}\right)^{-\theta} \frac{\hat{P}_t^v}{P_t} \right]^{\frac{\theta_t-1}{\theta_t}} \right]^{\frac{\theta_t}{\theta_t-1}} = \left[\sum_{j=1}^M (P_{jt})^{1-\theta_t} \right]^{\frac{\theta_t}{\theta_t-1}} \frac{1}{(P_t)^{-\theta_t} P_t} \hat{P}_t^v v_t, \quad v = C, I.$$

(9a) and (10) imply $\hat{P}_t^C = \hat{P}_t^I \equiv P_t$ hence the final demand functions are

$$(11a) \quad Y_{jt}^C = \left(\frac{P_{jt}}{P_t}\right)^{-\theta} C_t, \quad Y_{jt}^I = \left(\frac{P_{jt}}{P_t^I}\right)^{-\theta} I_t, \quad Y_{jt} = \left(\frac{P_{jt}}{P_t}\right)^{-\theta} (C_t + I_t)$$

and price

$$(11c) \quad P_t = \left[\sum_{j=1}^M (P_{jt})^{1-\theta_t} \right]^{\frac{1}{1-\theta_t}}.$$

Aggregate output is then

$$(11b) \quad \sum_{j=1}^M \frac{P_{jt}}{P_t} Y_{jt} = C_t + I_t = Y_t.$$

We later assume production functions for intermediate goods therefore

$$(12) \quad Y_t = \sum_{j=1}^M \left(\frac{P_{jt}}{P_t}\right) Y_{jt} \equiv \sum_{j=1}^M \left(\frac{P_{jt}}{P_t}\right) A_{jt} (K_{jt})^\alpha (N_{jt})^{(1-\alpha)}.$$

Considering (7a), with an effect of changed efficiency of capital goods, the solutions are

$$(13a) \quad P_t^C = \left[\sum_{j=1}^M \frac{\theta_j^C \left(\frac{P_{jt}}{P_t}\right)^{1-\theta_t}}{\theta_j^C} \right]^{\frac{1}{1-\theta_t}} = P_t, \quad P_t^I = \left[\sum_{j=1}^M \frac{\theta_j^I \psi_t \left(\frac{P_{jt}}{P_t}\right)^{1-\theta_t}}{\theta_j^I \psi_t} \right]^{\frac{1}{1-\theta_t}}$$

$$(13b) \quad Y_{jt}^C = \left(\frac{P_{jt}}{\theta_j^C P_t}\right)^{-\theta_t} C_t, \quad Y_{jt}^I = \left(\frac{P_{jt}}{\theta_j^I P_t^I}\right)^{-\theta_t} \psi_t^{\frac{\theta_t}{\theta_t-1}} I_t, \quad Y_{jt} = \left(\frac{P_{jt}}{\theta_j^C P_t}\right)^{-\theta_t} C_t + \left(\frac{P_{jt}}{\theta_j^I P_t^I}\right)^{-\theta_t} \psi_t^{\frac{\theta_t}{\theta_t-1}} I_t.$$

$$(13c) \quad \sum_{j=1}^M \frac{P_{jt}}{P_t} Y_{jt} = C_t + \psi_t^{\frac{\theta_t}{\theta_t-1}} \left(\frac{P_t^I}{P_t}\right) I_t = Y_t$$

Since equilibrium prices of intermediate goods and consumption are bounded and since $\theta > 1$ and ψ_t rises, (13a) implies that the price of a unit of capital goods *declines*. As noted, these assumptions do not alter our main distributional results, shortly to be developed for the simpler symmetric case. For our immediate purposes, this is all we need in order to proceed. In the rest of the paper we set $P_t = 1$.

Before proceeding we comment on the assumption of fixed number of firms. Innovations entail risks and obsolescence, resulting in a birth and death of firms. A fixed number of firms is interpreted as

a model of “sectors” or “dynasties.” To illustrate, firms developing computer technology started in the 1940's-1950's with mainframe computers (e.g. Univac, IBM). By late 1960's smaller computers took over (e.g. DEC, Data General), and these gave rise to the PC and then to mobile technology. Firms rose and fell, but decline of one resulted from innovations of successors. Knowledge and technology were merged into the surviving firms, and wealth created was invested in the next generation of firms. We are not concerned here with firm survival; although each faces private risk of obsolescence, the dynasty-firm incorporates new innovations that counter obsolescence faced by each individual firm.

3.2 Optimization by intermediate goods' producers

Each firm j has a production function of the form

$$(14a) \quad Y_{jt} = (\Psi_t \Psi_{jt})(K_{jt})^\alpha (N_{jt})^{(1-\alpha)} \quad , \quad A_{jt} = \Psi_t \Psi_{jt}$$

where Ψ_t is a common component, and Ψ_{jt} is a firm specific random technological level. The Ψ_{jt} are drawn from a distribution with mean 1. Date t profit function is

$$\Pi_t^j = P_{jt} Y_{jt} - W_t N_{jt} - R_t K_{jt}.$$

We study monopolistic competitive Nash Equilibrium, hence, producers take aggregate income and price $P_t=1$ as given, select their own prices and allocate labor and capital to maximize profits at each t :

$$(14b) \quad \text{Max}_{P_{jt}, N_{jt}, K_{jt}} [P_{jt} Y_{jt} - W_t N_{jt} - R_t K_{jt}] + \lambda_{jt} [\Psi_t \Psi_{jt} K_{jt}^\alpha N_{jt}^{1-\alpha} - Y_{jt}] \quad , \quad Y_{jt} = P_{jt}^{-\theta} (C_t + I_t)$$

The first order conditions (where (W_t, R_t) are the real rates) are

$$(14c) \quad (\theta-1)P_{jt}^{-\theta} (C_t + I_t) = \lambda_{jt} \theta P_{jt}^{-\theta} (C_t + I_t) P_{jt}^{-1} \Rightarrow \lambda_{jt} = P_{jt} \frac{(\theta-1)}{\theta} \quad \text{all } j$$

$$(14d) \quad W_t = P_{jt} \frac{\theta_t - 1}{\theta_t} (1-\alpha) [\Psi_t \Psi_{jt}] (K_{jt})^\alpha N_{jt}^{-\alpha} = P_{jt} \frac{\theta_t - 1}{\theta_t} \frac{\partial Y_{jt}}{\partial N_{jt}}.$$

$$(14e) \quad R_t = P_{jt} \frac{\theta_t - 1}{\theta_t} \alpha [\Psi_t \Psi_{jt}] (K_{jt})^{\alpha-1} N_{jt}^{1-\alpha} = P_{jt} \frac{\theta_t - 1}{\theta_t} \frac{\partial Y_{jt}}{\partial K_{jt}}.$$

Conditions (14d)-(14e) do not depend upon the symmetry assumption and (7a) impacts only (14c).

Since all income distribution results depend upon (14d)-(14e), they are invariant to the heterogeneity assumptions. Using the above, we turn to resolve the question of *aggregation*:

Proposition 1: In an equilibrium

(i) $P_{jt} \Psi_{jt} = p_t^*$ for all j where

$$(15) \quad p_t^* = \left[\sum_{j=1}^M \Psi_{jt}^{(\theta-1)} \right]^{\frac{1}{\theta-1}} \equiv \vartheta_t^*;$$

(ii) equilibrium quantities act in accord with an aggregate production function and

$$(16) \quad Y_t = A_t (K_t)^\alpha (N_t)^{(1-\alpha)} \quad , \quad A_t = \vartheta_t^* \Psi_t$$

(iii) if $\Psi_{jt} = 1$ for all j, then for all j we have $P_{jt} = p_t^* = \vartheta_t^* = 1$.

Proof: (i) From (14d)-(14e) we deduce

$$(17) \quad \frac{W_t}{R_t} = \frac{(1-\alpha)}{\alpha} \left(\frac{K_{jt}}{N_{jt}} \right) \quad \text{for all j}$$

hence (K_{jt}/N_{jt}) is independent of j. By (14d)

$$(18) \quad \Psi_{jt} P_{jt} = p_t^* = W_t / \left[\left(\frac{\theta-1}{\theta} \right) (1-\alpha) \Psi_t (K_{jt}/N_{jt})^\alpha \right] \text{ is also independent of j.}$$

Insert (18) into (11a) to deduce

$$(19) \quad 1 = p_t^* \left[\sum_{j=1}^M \Psi_{jt}^{(\theta-1)} \right]^{\frac{1}{1-\theta}} \Rightarrow p_t^* = \left[\sum_{j=1}^M \Psi_{jt}^{(\theta-1)} \right]^{\frac{1}{\theta-1}} \equiv \vartheta_t^*.$$

(iii) By (11c) and (19)

$$Y_t = \sum_{j=1}^M \frac{p_t^*}{P_t} \Psi_t (K_{jt})^\alpha (N_{jt})^{(1-\alpha)} \equiv A_t \sum_{j=1}^M (K_{jt})^\alpha (N_{jt})^{(1-\alpha)} \quad , \quad A_t = \vartheta_t^* \Psi_t.$$

Since all K_{jt}/N_{jt} are the same, there is a natural aggregation:

$$Y_t = \sum_{j=1}^M A_t (K_{jt})^\alpha (N_{jt})^{(1-\alpha)} = A_t \left(\frac{K_{jt}}{N_{jt}} \right)^\alpha \sum_{j=1}^M N_{jt} = A_t \left(\frac{K_{jt}}{N_{jt}} \right)^{\alpha-1} \sum_{j=1}^M K_{jt} = A_t K_t^\alpha N_t^{1-\alpha}$$

where

$$K_t = \sum_{j=1}^M K_{jt} \quad , \quad N_t = \sum_{j=1}^M N_{jt}$$

Proposition 2 (without proof): The results hold under (7a), with the following modifications:

(i) $P_{jt} \Psi_{jt} = p_t^*$ for all j where

$$(19a) \quad \frac{P_t^*}{P_t^C} = \left[\sum_{j=1}^M (\vartheta_j^C)^\theta \Psi_{jt}^{(\theta-1)} \right]^{\frac{1}{\theta-1}} \equiv \vartheta_t^*$$

$$(19b) \quad \frac{P_t^*}{P_t^I} = \left[\sum_{j=1}^M (\vartheta_j^I)^\theta \Psi_{jt}^{(\theta-1)} \right]^{\frac{1}{\theta-1}} \equiv (\vartheta_t^I)^* \Psi_t^{-\frac{\theta}{1-\theta}}$$

(ii) equilibrium quantities act in accord with an aggregate production function and

$$(19c) \quad Y_t = A_t (K_t)^\alpha (N_t)^{(1-\alpha)}.$$

With aggregation questions resolved, all further developments are made in aggregate terms. To explain our next step note that (14b)-(14e) and Proposition 1 are sufficient to permit a study of the functional distribution of income. We do that in the next section but keep in mind two important facts.

- First, rising surplus wealth in Section 1 revealed rising monopoly power during 1970-2015 and we now have the tools to quantify it and expand on the asset based estimates in Section 2.3a.
- Second, (14d)-(14e) say, as a first order response, that a rising monopoly power (i.e. declining θ_t) *cause* a fall in the wage and interest rate. We address this question with a full general equilibrium study only in Section 3.4, after resolving the functional distribution question.

3.3 *Time evolution of monopoly power and its effects on the functional distribution of income*

We turn to implications of the symmetric model (7) to income distributions. This expands the results of the *asset based approach* (Section 2.3c) with which we estimated the share of monopoly profits in non financial business to be 0.211 in 2015, versus a 0 in the early years of 1984-1986.

3.3a *Distribution of income I: the labor share approach*

The problem of declining relative share of labor has occupied researchers for some time with multiple hypotheses of explaining it. For a sample of recent work, see Elsby et. al. (2013), Fleck et. al. (2011), Jacobson and Occhino (2012), Karabarbounis and Neiman (2014) and Krusell et. al. (2000). Since we focus on the effect of monopoly power, detailed reviews of their diverse approaches and focus would not help clarify our results. We thus start by noting that by (14d)-(14e)

$$Y_t = \frac{\theta_t}{\theta_t - 1} [R_t \sum_{j=1}^M K_{jt} + W_t \sum_{j=1}^M N_{jt}] = \frac{\theta_t}{\theta_t - 1} [R_t K_t + W_t N_t].$$

Proposition 1 then implies that the distribution of income is

$$(20) \quad \begin{aligned} \text{Labor income} \quad W_t N_t &= (1 - \alpha) \frac{\theta_t - 1}{\theta_t} Y_t \\ \text{Capital Rent Income} \quad R_t K_t &= \alpha \frac{\theta_t - 1}{\theta_t} Y_t \\ \text{Monopoly Surplus income} &= \frac{1}{\theta_t} Y_t. \end{aligned}$$

Labor share is $\frac{\theta_t - 1}{\theta_t} (1 - \alpha)$, and monopoly surplus income share is $\frac{1}{\theta_t}$. These results also hold for (7a) since they depend only on conditions (14d)-(14e) and on (ii) of Proposition 2. We note that competitive conditions hold if $\theta_t \rightarrow \infty$, $\frac{\theta_t - 1}{\theta_t} \rightarrow 1$, and the model's accuracy declines close to competitive condition.

To use (20), note that with knowledge of α , a given labor share imply a value of θ_t . We assume

$\alpha = 0.33$ based on established econometric studies, but the relevant relative labor share requires some explanation. Since we focus on corporate business, self employed wages present a problem due to BLS' imputing their wage as equal to non self employed wage, a practice criticized by Elsby et. al. (2013). Therefore we use the "payroll labor share" with two adjustments. Denote published labor share by sh_w and published payroll share sh_w^{pr} , then the self employed relative share is $sh_w - sh_w^{pr}$ and our first natural change defines adjusted payroll share by

$$(21a) \quad \text{Adjusted Payroll Share Excluding Self Employed} = (sh_w^{pr})/[1 - (sh_w - sh_w^{pr})].$$

A second problem is that payroll share contains management compensation. As noted earlier, the wage component of this compensation is a fraction of their income that includes the value of exercised granted stock and options (see Moylan (2008) and Elsby et. a. (2013)). Indeed, rising management compensation and large profits from the exercised stock options have slowed down the decline of labor share and this also explains the *rise of payroll labor share* during the dotcom years 1998-2002, a conclusion confirmed by Elsby et. al. (2013). As explained in Section 2.3b, officers' compensation should be treated as profit sharing rather than wages and this our second adjustment. To that end we use IRS data on Officers' Compensation ("Returns of Active Corporations" Table 2) to compute the share of Officers' Compensation in total published wages (in Appendix A) which is denoted s_w^{of} , and exclude it from payroll share to deduce the definition of payroll share used in computations of Table 4

$$(21b) \quad \text{Final Adjusted Payroll Share} = (sh_w^{pr} - s_w^{of} sh_w)/[1 - (sh_w - sh_w^{pr})].$$

Inclusion of officers' compensation in surplus income may not be sufficient. In private communication Solow⁶ argues surplus income is often distributed to workers in the form of higher wages, from janitors to managers, paid by firms with large surplus. At this time we do not have adequate data, apart from officers' compensation, to account for such differences.

Table 4 reports our computed payroll labor share 1986-2015 and the implied θ_t in accord with (20), by assuming that $\alpha = 0.33$ and all changes in labor share *are caused by changes in pricing power of firms*. Table 4 shows that as the IT revolution progressed, the pricing power of firms increased from $\theta_t = 5.88$ in 1990 to $\theta_t = 4.36$ in 2015. The removal of officers' compensation from payroll does smooth somewhat the effect of stock market fluctuations but does not remove it, suggesting some firms may use bonuses and stock options to compensate other employees besides officers.

⁶ In a note by Robert Solow, entitled "Monopoly Rent and the Functional Distribution of Income," April 15, 2017

Table 4: Dynamics of Labor Share and Firms' Monopoly Power, Excluding the Self-Employed, 1990-2015

Year	Adjusted Payroll Share	Implied θ_t	Implied Share of Surplus Income	Year	Adjusted Payroll Share	Implied θ_t	Implied Share of Surplus Income
1986	0.54	5.21	0.192	2001	0.55	5.76	0.174
1987	0.55	5.46	0.183	2002	0.55	5.66	0.177
1988	0.55	5.73	0.175	2003	0.55	5.50	0.182
1989	0.55	5.49	0.182	2004	0.54	5.13	0.195
1990	0.56	5.88	0.170	2005	0.53	4.86	0.206
1991	0.55	5.76	0.174	2006	0.53	4.71	0.212
1992	0.55	5.68	0.176	2007	0.53	4.74	0.211
1993	0.55	5.52	0.181	2008	0.53	4.84	0.207
1994	0.53	4.94	0.202	2009	0.53	4.69	0.213
1995	0.53	4.80	0.208	2010	0.52	4.62	0.216
1996	0.53	4.74	0.211	2011	0.52	4.44	0.225
1997	0.53	4.80	0.208	2012	0.51	4.24	0.236
1998	0.54	4.97	0.201	2013	0.51	4.26	0.235
1999	0.54	4.99	0.200	2014	0.51	4.23	0.236
2000	0.55	5.55	0.180	2015	0.52	4.36	0.229

We now have a second quantitative description of one of our important conclusions: pricing power of firms increased from 1986 to 2015, demonstrated by the rising proportion of surplus in Figures 1-3 and by falling labor share in Table 4. This table reports that in 2015 the share of monopoly profits in output of non-financial corporations (about half of GNP) is 23% which is the percentage by which the wage rate and capital rent are below their competitive levels. This is consistent with the independent, asset based, estimate of 21% for 2015, reported in Section 2.3c.

In contrast, Table 4 shows a share of 0.192 in 1986 versus zero surplus *wealth* in 1986, implying a share of zero in that year. Also, Appendix A has $\theta_t=6.35$ in 1980 deduced from labor share, which is in conflict with no surplus *wealth* in 1980 in Figure 1. This means that in 1980-1986 labor share is already lower than expected, if the only factor that lowered the wage was the rising monopoly power. Equivalently, the decline of labor share from 1986 to 2015 is too slow relative to the rise of surplus *wealth* in Figure 1. We return to this question later, but due to this reason the next section reports a third estimate of monopoly surplus income via the “profit share approach.”

3.3b Distribution of income II: the profits share approach

The implication of (20) is that $\frac{1}{\theta_t} Y_t + f k_t \alpha \frac{\theta_t - 1}{\theta_t} Y_t$ is gross profits of the firm after labor and capital expenses, where $f k_t$ is fraction of capital not financed by debt and hence owned by the firm. Define output value by $Y_t = (\text{Value added at current prices} - \text{Taxes on production and imports})$. The firm has an accounting identity which defines the disposition of these gross profits. There are two direct deductions which are the compensation to officers and expenses for R&D which, as explained earlier, are the amounts the firm uses to protect its market power. We, thus, define

$$(22a) \quad (\text{Net Profits})_t = \frac{1}{\theta_t} Y_t + f k_t \alpha \frac{\theta_t - 1}{\theta_t} Y_t - (\text{Officers salaries})_t - (\text{R\&D cost})_t.$$

Net profits are then disposed by

$$(22b) \quad \text{Net Profits} = \text{Dividends} + \text{Corporate taxes and transfers} + \text{Foreign earning retained} + \text{Savings}.$$

Equating (22a) with (22b) is an identity where all quantities are known; hence, it is an equation in θ_t .

To estimate θ_t as precisely as possible, and since surplus wealth data are not used, we limit the study to “Non Financial Corporate Business,” as defined by the Z.1 publication Table S.5.a with three added sources: (1) for R&D spending we use the Z.1 series FA105013043.A; (2) proportion of officers compensation in BLS wages, reported by the IRS, was used above and reported in Appendix A. We deduce the proportion of officers compensation in net value added with published labor share; (3) the $f k_t$ data in Appendix A is computed from our Compustat samples, *adjusting capital for foreign holdings*. All other data is in the Z.1 publication Table S.5.a.⁷ The results are reported in Table 5.

Table 5: Dynamics of the Profits Share and Firms’ Pricing Power 1986-2015

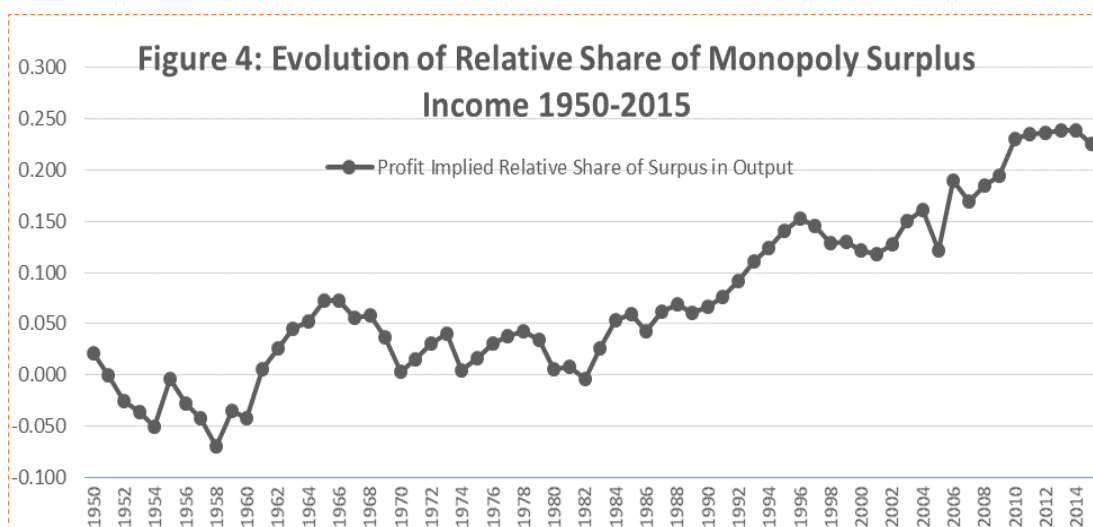
Year	Computed θ_t	Implied Share of Surplus Income	Year	Computed θ_t	Implied Share of Surplus Income
1986	23.675	0.042	2001	8.484	0.118
1987	16.179	0.062	2002	7.806	0.128
1988	14.591	0.069	2003	6.626	0.151
1989	16.610	0.060	2004	6.207	0.161
1990	15.005	0.067	2005	8.262	0.121
1991	13.074	0.076	2006	5.254	0.190
1992	10.859	0.092	2007	5.896	0.170
1993	8.980	0.111	2008	5.412	0.185
1994	8.077	0.124	2009	5.137	0.195
1995	7.127	0.140	2010	4.332	0.231
1996	6.536	0.153	2011	4.243	0.236
1997	6.884	0.145	2012	4.241	0.236
1998	7.795	0.128	2013	4.196	0.238
1999	7.681	0.130	2014	4.188	0.239
2000	8.205	0.122	2015	4.424	0.226

Table 5 reveals a sharp rise in monopoly pricing power from 23.675 in 1986 to 4.424 in 2015 with a corresponding rise of monopoly profit share from 4.2% in 1986 to 22.6% in 2015. We then have *three* estimates of the share of monopoly profit: one deduced from surplus wealth in 2.3c, the second from relative labor share in 3.3a and the third used the profit share approach in this section. Although these used different approaches and different data sources, all three estimates for 2015 are in the narrow range of 21%-23%. This same value is also close to Solow’s (2017) estimate in the cited note. It is also close to estimates of Barkai (2016a) who use a similar model but arrives at them by imputing a “required interest rate” to distinguish between interest income and profits. Since the interest rate is an

⁷ Series used in the computations are then: Gross value added-FA106902501.A; Taxes on production and imports - FA106240101.A; Dividends paid - FA106121001.A; Corporate income Tax paid - FA106220001.A; Other transfers paid - FA 106403001.A; Foreign earnings retained - FA106006065.A; Corporate Savings (excluding foreign earnings retained abroad) - FA106012095.A.

endogenous variable, we prefer our three methods which do not rely upon such imputations.

The profit share approach is our most accurate aggregate method. It is based on an accounting identity; it requires no added assumptions or approximations and, apart from the three series noted above, the data used is consistent and from a single source. With this in mind, we present in Figure 4 the relative share of monopoly profits in value added of non-financial corporations, 1950-2015. It shows this share was zero during 1970-1982 and rose to a high of 23.9% in 2014. It also shows this share was practically zero during 1950-1962 and rose to a peak of 7.3% in 1965 during the early phase of the IT revolution, before falling back to zero in 1970. These results, based on entirely independent sources, are consistent with results in Figure 1 that show a sustained rise of $\frac{\text{surplus wealth}}{\text{market value}}$ after 1886, reaching 79% in 2015, but also a positive surplus wealth in 1962-1970 when this ratio reached a high of 32% in 1965 for non-financial corporations. Although results based on asset prices exhibit high volatility, the consistency between Figure 1 and Figure 4 is very encouraging.



We now return to the dynamics of labor share in the earlier years. Although Table 4 shows labor share is below its competitive level in 2015, it also shows it is low even in 1986, when surplus wealth is actually close to zero. Table 5 confirms this last fact and shows that surplus income share is indeed only 4.2% in 1986. Therefore, the results in Table 5, deduced from profit share, are consistent with all surplus wealth results in Figures 1-3. The low labor share in the 1980's is *then out of line with the rest of our results*. However, it is compatible with the fact that wage growth and labor share *started to fall early in the 1970's*, caused by factors not present in our study. Political factors such as laws to weaken unions, automation, outsourcing, and globalization were operative before the rise of monopoly

power in the 1980's. Hence, by the time monopoly power came into play, wages and labor share were already low. What we do find remarkable is the fact that by 2015 the high monopoly power seems to have become the dominant factor.

3.4 Macroeconomic effects of rising monopoly power

3.4a Effects on the interest rate, wage rate and economic aggregates

We now complete the model developed earlier and, to study *analytically* the effects of rising monopoly power, we simplify the model and assume (i) $\Psi_{jt} = 1$ all j , (ii) $\frac{A_{t+1}}{A_t} = a = \text{constant}$, (ii) labor supply is $N_t = 1$ and is supplied inelastically. The first removes the randomness assumed earlier and is actually a steady state condition. The second is standard in the literature and, we explain later, the third has no effect on our conclusions; any labor supply that permits a steady state leads to the same results.

The agent dynamic optimization takes the form of

$$(23a) \quad \text{Max} \sum_{\tau=0}^{\infty} \beta^{\tau} \frac{1}{1-\gamma} C_{\tau}^{1-\gamma}$$

subject to the budget

$$(23b) \quad C_t + K_{t+1} = W_t + K_t(R_t + (1-\delta)) + \Pi_t$$

The optimum satisfies

$$(23c) \quad 1 = \beta \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} [R_{t+1} + (1-\delta)]^{\delta}$$

To study the effect of a declining θ_t on equilibrium wage rates and interest rates we write the aggregate production function in the standard form of

$$Y_t = A_t(K_t)^{\alpha}(N_t)^{(1-\alpha)} = N_t A_t^{1/(1-\alpha)} [K_t / (N_t A_t^{1/(1-\alpha)})]^{\alpha} = N_t A_t^{1/(1-\alpha)} (k_t)^{\alpha}, \quad k_t = \left(\frac{K_t}{N_t A_t^{1/(1-\alpha)}} \right)$$

and equilibrium conditions can now be scaled. Define first

$$c_t = \left(\frac{C_t}{N_t A_t^{1/(1-\alpha)}} \right), \quad w_t = \left(\frac{C_t}{N_t A_t^{1/(1-\alpha)}} \right), \quad \pi_t = \left(\frac{\Pi_t}{N_t A_t^{1/(1-\alpha)}} \right), \quad N_t = 1$$

then the conditions are

$$(24a) \quad c_t + a^{1/(1-\alpha)} k_{t+1} = k_t^{\alpha} + k_t(1-\delta)$$

$$(24b) \quad 1 = \beta (a^{1/(1-\alpha)} \frac{c_{t+1}}{c_t})^{-\gamma} [R_{t+1} + (1-\delta)]$$

$$(24c) \quad w_t = \frac{(\theta_t - 1)}{\theta_t} (1-\alpha) (k_t)^{\alpha}$$

$$(24d) \quad R_t = \frac{(\theta_t - 1)}{\theta_t} \alpha (k_t)^{\alpha-1}$$

⁸ If additive utility function was introduced and flexible labor supply allowed, we would add the static condition $(u_N/u_C) = W_t$ but we shall see later that it has no impact on the results.

Since labor supply is constant, the asymptotic growth factor is $a^{1/(1-\alpha)}$, analogous to the continuous time growth rate of $\lambda_a/(1-\alpha)$, which is independent of θ_t . It follows that for any fixed $\theta_t = \theta$ the steady state of the economy, which is a function of θ , is defined by

$$(25a) \quad (k^*)^\alpha = c^* + [a^{1/(1-\alpha)}k^* - k^*(1-\delta)]$$

$$(25b) \quad 1 = \beta(a^{1/(1-\alpha)})^{-\gamma}[R^* + (1-\delta)]$$

$$(25c) \quad w^* = \frac{(\theta-1)}{\theta}(1-\alpha)(k^*)^\alpha.$$

$$(25d) \quad R^* = \frac{(\theta-1)}{\theta}\alpha(k^*)^{\alpha-1}.$$

Proposition 3: As θ_t declines over time, at any date, the wage rate and the interest rate initially decline at that date. However, the capital stock adjusts and, in the long run, the interest rate tends to return to the same steady state, which is independent of θ_t .

Proof: It follows from (2b) that the steady state interest rate $r^* = R^* - \delta$ is independent of θ_t . Since

$$\frac{d[(\theta_t - 1)/\theta_t]}{dt} = \frac{1}{\theta_t^2} > 0,$$

and since at date t the capital stock is given, the value of k_t is also given. By (24a) the capital stock at $t+1$ is also determined at date t and therefore, by (24c)-(24d), any decrease of θ_t causes the wage rate and the interest rate to decline *initially*. This decline follows an adjustment of the capital stock so as to adjust k_t over time and allow the interest rate to return to its steady state. ■

Proposition 3 shows that a continuous rise of monopoly power exerts continuous pressure to lower interest rates *at each date* but the process is neutralized by subsequent adjustments of the capital stock which alters k_t . The next proposition shows this is a *downward* adjustment of the capital stock with *lower* investment and permanently lower wage rate path for each θ .

Proposition 4: As θ_t declines over time, equilibrium paths of output, consumption, the wage rate, capital stock and the rate of investment, *all decline permanently*.

Proof: The proof follows from a demonstration that a decline from θ_{t-1} to θ_t causes a decline in the steady state value of $k^*(\theta)$ relative to $\theta_{t-1} = \theta$. To prove this consider (25b)-(25d). Since by (25b) the rental R^* does not change with θ , it requires that $\frac{(\theta-1)}{\theta}(k^*)^{\alpha-1} = \text{constant}$. This means that differentiation of this expression implies

$$(\alpha-1)(k^*)^{(\alpha-2)}\frac{(\theta-1)}{\theta}\frac{dk^*}{d\theta} + (k^*)^{\alpha-1}\frac{1}{\theta^2} = 0$$

therefore

$$\frac{dk^*}{d\theta} = \frac{1}{\theta(\theta-1)}(1-\alpha)k^*\left(\frac{1}{\theta^2}\right) > 0.$$

But then output = $(k^*)^\alpha$; investment = $k^*[a^{1/(1-\alpha)} - (1-\delta)]$; consumption = $(k^*)^\alpha - k^*[a^{1/(1-\alpha)} - (1-\delta)]$ decline. To see why the wage rate declines rewrite (25c) as $w^* = \left[\frac{(\theta-1)}{\theta}(1-\alpha)(k^*)^{\alpha-1}\right]k^*$. By Proposition 3 the expression $\left[\frac{(\theta-1)}{\theta}(1-\alpha)(k^*)^{\alpha-1}\right]$ is a positive constant, independent of θ , therefore

$$\frac{dw^*}{d\theta} = \left[\frac{(\theta-1)}{\theta}(1-\alpha)(k^*)^{\alpha-1}\right]\frac{dk^*}{d\theta} > 0. \quad \blacksquare$$

The conclusion of Proposition 4 is that a rise in monopoly power causes a *decline* in the level of investment and a *fall* in the level of the capital stock and, with unchanged steady state value of capital rental rate, they cause a decline in the macroeconomic variables and in the relative share of capital . The decline in labor share is then due only to the lower wages. The argument remains the same if optimum labor supply is introduced to satisfy $u_N/u_C = W$, an equation which determines N. In such a case a lower wage would also lead to a decline in labor market participation.

Some Important Qualifications

We offer two qualification. First, Barkai (2016b) studies a similar problem with an OLG model where agents have a log utility. These lead the young to save a fixed fraction of income, and since a rise in monopoly power increases their income relative to the old, it also increases their savings. The result is an *increase* in the equilibrium capital/labor ratio and a *lower* natural interest rate. We then note (24b) and (25b) show an OLG economy and log utility lead to results which are difficult to replicate in a more realistic economic set-up where the natural rate is determined by the growth rate.

A second qualification relates to vintage capital. Extensive research has demonstrated the rate of investment alters the growth rate significantly when technical progress is embodied (e.g. Greenwood et. al. (1997), Boucekkine et. al. (2011)). Since rising monopoly power lowers the investment rate and the level of capital in our model, if we introduce vintage capital to embody technology, the equilibrium growth rate will decline and will lower the natural interest rate as well. Since these are second order to the primary effect of θ_t on the variables in Proposition 4, the conclusions of the proposition continue

to hold in such an expanded model. The formal argument of this case is lengthy, therefore it cannot be included here. We sum it up with the following statement, without proof:

Corollary to Proposition 4: If technical progress is embodied in new capital vintages, rising monopoly power lowers the equilibrium growth rate of the economy and hence it lowers the natural interest rate. However, the results of Proposition 4 continue to hold.

3.4b Effects on the gap between wages and output per hour

Turning to the relation between the real wage W_t/P_t and output per hour Y_t/N_t , we note first that under pure competition labor share is $(1-\alpha)$, equilibrium real wage is $[(1-\alpha)Y_t]/N_t$ and output per man-hour is Y_t/N_t ; hence, their ratio is a constant $(1-\alpha)$. Hence, if we set up two index numbers series, one for the real wage and a second for output per man-hour, with a common base at some date, *the two series would be equal* without any gap between the two variables.

With pricing power of firms the two variables under consideration take different forms

$$\frac{Y_t}{N_t} = A_t \left(\frac{K_t}{N_t}\right)^\alpha, \quad W_t = \frac{(\theta_t - 1)}{\theta_t} (1-\alpha) A_t \left(\frac{K_t}{N_t}\right)^\alpha$$

hence, we can see that

$$\frac{W_t}{Y_t} = \frac{(\theta_t - 1)}{\theta_t} (1-\alpha).$$

Since $(\theta_t - 1)/\theta_t$ declines, the *wage declines relative to average labor productivity*, as observed in the data. If we select an earlier date t_0 when the surplus is zero and labor share is $(1-\alpha)$, then setting the two numbers $W_{t_0} = Y_{t_0}/N_{t_0} = 100$ eliminates $(1-\alpha)$. All subsequent differences between the two series would then be due to the appearance of market pricing power measured by $(\theta_t - 1)/\theta_t$ which has declined, thus explaining why the mean wage has fallen below output per man-hour.

3.4c Effects on the error in measured total factor productivity (TFP)

The TFP problem arises because the standard way of computing it assumes no surplus and one would therefore conclude there is an error in the standard computation. To compute this error we note that since $Y_t = A_t K_t^\alpha N_t^{1-\alpha}$ the *true* total factor productivity is

$$\frac{\dot{A}_t}{A_t} = \frac{\dot{Y}_t}{Y_t} - \alpha \frac{\dot{K}_t}{K_t} - (1-\alpha) \frac{\dot{N}_t}{N_t}.$$

Standard method defines TFP by

$$TFP_t = \frac{\dot{Y}_t}{Y_t} - \left[1 - \frac{W_t N_t}{Y_t}\right] \frac{\dot{K}_t}{K_t} - \left[\frac{W_t N_t}{Y_t}\right] \frac{\dot{N}_t}{N_t}$$

hence, the computed TFP is actually

$$\text{TFP}_t = \frac{\dot{Y}_t}{Y_t} - \left[1 - \frac{\theta_t - 1}{\theta_t}(1 - \alpha)\right] \frac{\dot{K}_t}{K_t} - \left[\frac{\theta_t - 1}{\theta_t}(1 - \alpha)\right] \frac{\dot{N}_t}{N_t}.$$

Hence, the error is

$$\text{Error} = \frac{\dot{A}_t}{A_t} - \text{TFP}_t = -\left[\alpha \frac{\dot{K}_t}{K_t} + (1 - \alpha) \frac{\dot{N}_t}{N_t}\right] + \left[1 - \frac{\theta_t - 1}{\theta_t}(1 - \alpha)\right] \frac{\dot{K}_t}{K_t} - \left[\frac{\theta_t - 1}{\theta_t}(1 - \alpha)\right] \frac{\dot{N}_t}{N_t}.$$

Since $\alpha \frac{\dot{K}_t}{K_t} + (1 - \alpha) \frac{\dot{N}_t}{N_t} = \frac{\dot{Y}_t}{Y_t} - \frac{\dot{A}_t}{A_t}$ the correct productivity measure relative to computed TFP is then

$$(26) \quad \frac{\dot{A}_t}{A_t} = \left(\frac{\theta_t}{\theta_t - 1}\right) \text{TFP} - \left(\frac{1}{\theta_t}\right) \left[\frac{\dot{Y}_t}{Y_t} - \frac{\dot{K}_t}{K_t}\right].$$

We illustrate the impact of this factor in Table 7 for 1990-2015 using the results in Table 5.

Equation (26) shows there are two factors at work. First, a fixed bias of computed TFP relative the correct TFP by a proportional factor of $\left(\frac{\theta_t}{\theta_t - 1}\right)$, which is the entire bias when output and capital grow at the same rate. Second, differences between the growth of output and capital cause further bias: in recessions or periods of slow output growth relative to the growth of capital, standard TFP can be significantly biased downward. However, in recoveries, when output grows faster than capital, standard productivity measure is biased downward.

Table 7: Assessing the Implied Error in Computed TFP 1990-2015
(percent)

Year	Standard TFP	Corrected TFP	TFP Error	Year	Standard TFP	Corrected TFP	TFP Error
1990	0.82	0.90	0.078	2003	2.30	2.67	0.362
1991	0.25	0.41	0.162	2004	2.57	2.80	0.233
1992	3.54	3.65	0.105	2005	1.67	1.77	0.103
1993	0.43	0.40	-0.031	2006	0.79	0.85	0.104
1994	1.43	1.40	-0.030	2007	0.89	1.10	0.208
1995	0.85	0.82	-0.010	2008	-0.39	-0.41	-0.022
1996	2.81	2.86	0.077	2009	3.49	3.72	0.272
1997	1.31	2.30	-0.010	2010	2.92	3.44	0.378
1998	2.68	2.81	-0.132	2011	0.58	0.47	-0.109
1999	2.87	3.06	0.187	2012	1.35	1.39	-0.036
2000	2.41	2.74	0.326	2013	0.45	0.43	-0.012
2001	0.75	1.14	0.384	2014	1.09	1.08	-0.011
2002	2.27	2.72	0.457	2015	1.18	1.21	0.022

In 18 of the 26 years 1990-2015, the error is positive. Standard TFP measures underestimated the true rate of productivity growth over 1990-2015 by a mean of 0.1631 percentage point but, since θ_t declined and became more important, the magnitude of, this error *increased* with time; hence, over 2000-2015 the mean error was 0.2251. The error was large during the sharp decline in 2009 when the output decline was not matched by a decline in capital, causing corrected TFP to measure 0.49%, while standard TFP was -0.39%. The error exceeded 0.20% in 9 out of the 16 years 2000-2015 when market monopoly power became more significant. We also note that our corrected measure places a heavier weight on the contribution of capital. Interestingly, the two measures are very close during 2011-2015 when the discussion of “secular stagnation” intensified.

4. A Final Note

The IT revolution improved living standards and its great technical achievements enjoy a high level of consumer and political support. However, these sources of social benefits are also the cause of social losses and rising inequality that threaten the foundation of democratic society. This study focuses on the effect of technological change on efficiency and distribution, and although we show IT enabled higher barriers to entry and increasing monopoly power of firms, we have avoided a policy evaluation. Yet, in spite of the public support of the achievements of IT, it is urgent we begin a public debate of a policy in response to its negative effects. Two examples will explain the urgency. First, consider the case of social networks. These are, in fact, privately owned public utilities. Subversive and terror groups have used social networks to coordinate activities that harm our society and for spreading rumors and enabling the proliferation of "fake news" that undermine the functioning of democratic institutions. These are national security problems and challenges to the functioning of an informative press in a Democracy. Private firms who own these networks will ultimately be regulated, but more public discussion of the issue is needed. Second, it is not obvious a firm should be allowed to exploit or sell private information its customers provide in normal business relation (e.g. billing information). Since such information is a significant component of monopoly profits, and a legal change of current practice would have a big impact, public discussion is needed for establishing a new legal structure to respond to the changes brought about by IT. We hope to address the problem of regulation, and the harder question of the optimal taxation of monopoly profits, in a later paper.

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Appendix A: File of the Aggregates

The next two pages report the results of aggregating each of the 66 files of Compustat firms' financial reports which have been edited in accord with the following criteria:

1. firms with headquarters in the US.
2. non-financial firms: exclude firms with Industrial Classification Code from 6000 to 6499.
3. firms with positive assets
4. firms for which market value can be constructed.

Appendix B: File of the 500 firms

The next two pages report the results of assigning the values of to 500 firms as follows:

- (i) 200 firms with largest surplus wealth;
- (ii) 200 firms with smallest surplus wealth;
- (iii) 100 firms around the mean value of surplus wealth.

Company Name	Chi Value for IT Transformed Sectors	Surplus Wealth at Current Prices	Tobin Q
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Surplus Analysis: Top 200

APPLE INC	1	435861.42	2.24
ALPHABET INC	1	396179.26	3.49
AMAZON.COM INC	1	294518.50	4.88
AT&T INC	1	269517.42	2.22
FACEBOOK INC	1	267901.74	8.64
VERIZON COMMUNICATIONS INC	1	260112.49	2.68
MICROSOFT CORP	1	258150.38	2.34
JOHNSON & JOHNSON	1	238127.22	3.22
PROCTER & GAMBLE CO	0.5	209646.08	4.04
PFIZER INC	1	203586.49	3.07
COMCAST CORP	1	177802.97	3.49
GENERAL ELECTRIC CO	1	170531.18	1.33
COCA-COLA CO	0	167927.02	3.04
ORACLE CORP	1	162979.37	2.86
WAL-MART STORES INC	1	160896.10	1.70
ALLERGAN PLC	0	160859.45	7.05
PHILIP MORRIS INTERNATIONAL	0	151842.57	6.10
PEPSICO INC	0	149537.51	3.83
DISNEY (WALT) CO	1	147021.01	3.22
INTL BUSINESS MACHINES CORP	1	135570.82	2.45
KRAFT HEINZ CO	0	131211.94	6.92
MERCK & CO	1	127364.13	2.66
GILEAD SCIENCES INC	1	126271.03	3.51
ALTRIA GROUP INC	0	124759.51	7.58
ABBVIE INC	0	119347.57	5.75
HOME DEPOT INC	0	119029.50	3.48
CVS HEALTH CORP	0.5	112151.88	3.16
AMGEN INC	1	109653.47	2.95
BRISTOL-MYERS SQUIBB CO	1	102927.68	4.52
CELGENE CORP	1	101242.03	8.18
INTEL CORP	1	95392.57	1.87
MCDONALD'S CORP	0	93858.01	3.13
REYNOLDS AMERICAN INC	0	91172.95	10.43
CISCO SYSTEMS INC	1	90375.90	1.84
3M CO	1	86767.29	4.34
UNITED TECHNOLOGIES CORP	1	83528.86	2.50
WALGREENS BOOTS ALLIANCE INC	0.5	81916.22	2.64
UNITED PARCEL SERVICE INC	1	79393.00	2.91
EXPRESS SCRIPTS HOLDING CO	1	78219.64	5.65
STARBUCKS CORP	0	78147.05	7.06
LILLY (ELI) & CO	1	76894.22	3.33
BOEING CO	1	76498.06	1.71
MONDELEZ INTERNATIONAL INC	0	76430.94	3.62
HONEYWELL INTERNATIONAL INC	1	74470.24	3.07
DANAHER CORP	1	73448.46	5.96
LOCKHEED MARTIN CORP	1	73308.52	2.90
NIKE INC	0	68632.42	3.64
TIME WARNER CABLE INC	1	68333.52	3.79
THERMO FISHER SCIENTIFIC INC	1	64638.37	6.58
EXXON MOBIL CORP	0	64442.44	1.15
BIOGEN INC	1	61209.26	4.85
COLGATE-PALMOLIVE CO	0	60877.40	6.74
TWENTY-FIRST CENTURY FOX INC	1	58442.09	2.50
PRICELINE GROUP INC	1	57082.64	4.86
TIME WARNER INC	1	56510.40	2.61
ABBOTT LABORATORIES	1	53614.24	2.65
QUALCOMM INC	1	49480.70	1.96
TEXAS INSTRUMENTS INC	1	48957.90	4.84
DU PONT (E I) DE NEMOURS	1	48411.42	2.19
SIMON PROPERTY GROUP INC	0	47781.23	2.26
LOWE'S COMPANIES INC	0	47264.89	2.19
MCKESSON CORP	0.5	46832.93	1.94
AMERICAN TOWER CORP	1	45126.03	3.79
NETFLIX INC	1	44218.53	4.48
KIMBERLY-CLARK CORP	0	44106.51	3.66
ALEXION PHARMACEUTICALS INC	1	43709.85	11.39
ADOBE SYSTEMS INC	1	42968.26	6.90
COSTCO WHOLESALE CORP	0	42279.31	2.02
SPRINT CORP	1	42034.62	2.10
EMC CORP/MA	1	40856.82	2.24
MONSANTO CO	1	40019.79	2.94
GENERAL DYNAMICS CORP	1	39599.22	2.61
RAYTHEON CO	1	38945.12	3.31
GENERAL MILLS INC	0	38931.17	4.72
TIIX COMPANIES INC	0	38539.91	3.86
THOMSON-REUTERS CORP	1	38425.80	6.81
NORTHROP GRUMMAN CORP	1	38320.00	3.58
DOW CHEMICAL	1	38254.35	1.59
HP INC	1	37766.99	1.42
DISH NETWORK CORP	1	37581.43	5.26
SALESFORCE.COM INC	1	35807.08	5.69
ECOLAB INC	1	35497.38	4.54
DELTA AIR LINES INC	0.5	33831.12	1.71
HCA HOLDINGS INC	1	33354.93	2.03
T-MOBILE US INC	1	32798.75	1.73
BECTON DICKINSON & CO	1	32789.27	3.21
UNION PACIFIC CORP	0	32296.54	1.47
ILLINOIS TOOL WORKS	0	32092.36	3.65
ENTERPRISE PRODS PRTRNS -LP	0	31142.35	1.64
FIDELITY NATIONAL INFO SVCS	1	30571.11	6.13
FEDEX CORP	1	29908.11	1.73
BOSTON SCIENTIFIC CORP	1	29836.74	5.38
STRYKER CORP	1	29551.76	3.30
PRECISION CASTPARTS CORP	1	29230.39	3.55
PAYPAL HOLDINGS INC	1	28970.90	1.95
KELLOGG CO	0	28422.31	3.84
COGNIZANT TECH SOLUTIONS	1	28137.08	3.31
FIRST DATA CORP	1	28093.81	2.66
CROWN CASTLE INTL CORP	1	27929.31	2.76
LYONDELLBASELL INDUSTRIES NV	1	27550.74	2.02

Company Name	Chi Value for IT Transformed Sectors	Surplus Wealth at Current Prices	Tobin Q
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ZIMMER BIOMET HOLDINGS INC	0	27488.91	3.58
AUTOMATIC DATA PROCESSING	1	27339.60	1.71
EBAY INC	1	27248.59	2.65
PRECISION CASTPARTS CORP	1	26335.22	3.34
ACTIVISION BLIZZARD INC	1	26156.52	3.77
CBS CORP	1	25552.10	2.74
EMERSON ELECTRIC CO	1	25549.03	2.47
BERKSHIRE HATHAWAY	0.5	24939.69	1.04
KROGER CO	0	24493.58	1.72
HILTON WORLDWIDE HOLDINGS	1	24485.82	2.49
CONSTELLATION BRANDS	0	24432.72	4.41
PPG INDUSTRIES INC	1	24392.84	2.74
PRAXAIR INC	0.5	24193.33	2.32
TARGET CORP	0.5	23336.50	1.46
EXPEDIA INC	1	22717.37	4.87
VIACOM INC	1	22652.73	2.75
BAXALTA INC	1	22206.26	2.75
ROPER TECHNOLOGIES INC	1	21753.22	10.62
WASTE MANAGEMENT INC	0	21531.75	2.24
LAS VEGAS SANDS CORP	0	21353.91	1.82
CHARTER COMMUNICATIONS INC	1	21296.12	1.55
CARDINAL HEALTH INC	1	21274.35	1.71
OMNICOM GROUP	1	20884.82	2.28
CENTURYLINK INC	0	20596.33	1.77
ST JUDE MEDICAL INC	1	20069.78	4.11
AMERISOURCEBERGEN CORP	0.5	19835.14	1.74
EOG RESOURCES INC	0	19356.36	1.58
CONAGRA FOODS INC	0	19236.45	2.88
JOHNSON CONTROLS INTL PLC	0	19124.71	1.72
STANLEY BLACK & DECKER INC	0	18834.82	3.73
DOLLAR GENERAL CORP	0	18783.67	3.65
SMUCKER (JM) CO	0	18771.20	4.84
LIBERTY MEDIA SIRIUSXM GROUP	1	18698.70	4.21
LIBERTY INTERACTV CP QVC GRP	1	18044.83	4.47
AIR PRODUCTS & CHEMICALS INC	0	17853.89	1.91
IHEARTMEDIA INC	1	17839.79	3.68
VMWARE INC -CL A	1	17820.29	2.28
DAVITA INC	1	17805.40	2.90
CATERPILLAR INC	0	17164.22	1.20
DOMINION RESOURCES INC	0	17083.90	1.25
SOUTHWEST AIRLINES	0.5	17079.71	1.69
DISCOVERY COMMUNICATIONS INC	1	17058.14	4.48
AMERICAN AIRLINES GROUP INC	0.5	16824.12	1.32
OCCIDENTAL PETROLEUM CORP	0	16614.21	1.31
REPUBLIC SERVICES INC	0	16562.33	2.45
MACY'S INC	0	16387.14	1.76
LABORATORY CP OF AMER HLDGS	1	15969.56	3.75
MOLSON COORS BREWING CO	0	15631.13	3.26
ALLIANCE DATA SYSTEMS CORP	1	15402.74	1.71
JARDEN CORP	0	15399.28	3.08
TYSON FOODS INC -CL A	0	15289.79	2.10
EQUINIX INC	1	15094.09	2.34
SYMANTEC CORP	1	14861.90	2.77
LEVEL 3 COMMUNICATIONS INC	1	14372.42	1.76
SYSCO CORP	1	14369.16	1.73
CA INC	1	14022.80	3.53
APPLIED MATERIALS INC	1	13142.67	1.94
HARRIS CORP	0	13003.45	3.09
PARKER-HANNIFIN CORP	1	12919.08	2.24
EQUITY RESIDENTIAL	0	12847.06	1.45
UNITED CONTINENTAL HLDGS INC	0.5	12676.28	1.32
PHILLIPS 66	0	12644.34	1.23
SOUTHERN COPPER CORP	0	12067.61	1.78
BAXTER INTERNATIONAL INC	1	11903.82	1.56
CBRE GROUP INC	0	11743.22	2.45
KINDER MORGAN INC	0	11257.03	1.16
AVALONBAY COMMUNITIES INC	0	11217.33	1.53
EASTMAN CHEMICAL CO	0	11058.78	2.05
CARNIVAL CORP/PLC (USA)	0	10892.86	1.25
PVH CORP	0	10818.63	3.23
GENERAL GROWTH PPTYS INC	0	10262.32	1.35
L-3 COMMUNICATIONS HLDGS INC	1	10012.21	2.43
ARAMARK	0	9770.39	2.72
NORWEGIAN CRUISE LINE HLDGS	0	9439.28	1.76
XEROX CORP	1	9363.11	1.55
ROYAL CARIBBEAN CRUISES LTD	0	9218.82	1.36
WESTERN DIGITAL CORP	1	8948.02	1.59
INTL PAPER CO	0	8762.60	1.26
INTERPUBLIC GROUP OF COS	1	8721.37	1.79
PPL CORP	0	8695.06	1.20
CROWN HOLDINGS INC	0	8632.99	2.08
APACHE CORP	0	8063.94	1.35
WHIRLPOOL CORP	1	8046.12	1.48
ADT CORP	1	7724.97	2.53
CARMAX INC	0	7631.58	1.46
WEYERHAEUSER CO	0	7432.54	1.48
BOSTON PROPERTIES INC	0	7386.67	1.32
UNITED RENTALS INC	0	7380.60	1.75
PLATFORM SPECIALTY PRODUCTS	0	7305.98	3.06
COMPUTER SCIENCES CORP	1	7213.24	1.79
HALLIBURTON CO	0	7197.26	1.17
PIONEER NATURAL RESOURCES CO	0	6971.25	1.38
DIGITAL REALTY TRUST INC	0	6902.82	1.56
STAPLES INC	0	6840.66	1.75
CAMERON INTERNATIONAL CORP	1	6790.35	1.60
WESTROCK CO	0	6712.04	1.33
VORNADO REALTY TRUST	0	6512.89	1.25
TEXTRON INC	1	6439.19	1.43
ESSEX PROPERTY TRUST	0	6398.77	1.43
BAKER HUGHES INC	0	6158.48	1.28

Company Name	Chi Value of IT Transfer Sectors	Surplus Wealth at Current Prices	Tobin Q
WILEY (JOHN) & SONS -CLA	0	3894.21	3.78
BURLINGTON STORES INC	0	3862.73	2.50
NEWMARKET CORP	0	3858.18	3.42
SCOTTS MIRACLE-GRO CO	0	3845.62	3.16
CARTER'S INC	0	3845.08	3.03
ASPEN TECHNOLOGY INC	1	3843.34	11.40
ARRIS INTERNATIONAL PLC	0	3829.62	2.14
FMC CORP	0	3822.76	1.66
GRACO INC	0	3820.38	5.00
CORELOGIC INC	1	3811.22	3.09
DICKS SPORTING GOODS INC	0	3811.15	1.98
PILGRIM'S PRIDE CORP	0	3806.35	1.98
WENDY'S CO	0	3799.49	2.53
SQUARE INC	1	3760.65	4.72
CINEMARK HOLDINGS INC	0	3728.06	2.18
SERVICE CORP INTERNATIONAL	0	3724.85	1.31
TORO CO	0	3723.03	4.02
ULTRAGENYX PHARMACEUTICAL	1	3693.26	6.30
EMPIRE STATE REALTY OP LP	0	3692.26	2.22
LIONS GATE ENTERTAINMENT CP	1	3689.87	2.00
LEIDOS HOLDINGS INC	1	3687.91	2.38
ITC HOLDINGS CORP	0	3662.52	1.45
REGAL ENTERTAINMENT GROUP	0	3655.35	2.30
PATTERSON COMPANIES INC	0	3654.03	2.39
VERIFONE SYSTEMS INC	1	3644.46	3.82
TAUBMAN CENTERS INC	0	3635.82	1.82
EQT MIDSTREAM PARTNERS LP	0	3635.08	2.11
DONALDSON CO INC	0	3625.27	2.88
SPECTRA ENERGY CORP	0	3620.07	1.10
HCP INC	0	3613.65	1.14
CLEAR CHANNEL OUTDOOR HLDGS	1	3610.55	1.68
WAYFAIR INC	0	3606.37	5.19
MAXIMUS INC	0	3604.00	4.76
GODADDY INC	1	3598.30	3.63
WEIGHT WATCHERS INTL INC	0	3597.44	7.43
MANPOWERGROUP	0	3596.83	1.49
SPROUTS FARMERS MARKET	0	3589.60	4.35
VERINT SYSTEMS INC	1	3565.63	4.46
REXNORD CORP	0	3555.35	2.76
BEMIS CO INC	0	3554.81	2.19
LIBERTY VENTURES	0	3552.31	1.49
FRONTIER COMMUNICATIONS CORP	1	3539.35	1.15
BLUE BUFFALO PET PRODUCTS	0	3536.06	6.54
BLACKBAUD INC	1	3517.38	6.97
FMC TECHNOLOGIES INC	0	3490.33	1.50
TREEHOUSE FOODS INC	0	3479.86	2.99
WILLIAMS COS INC	0	3462.16	1.07
OUTFRONT MEDIA INC	0	3431.07	2.56
AMERICAN WATER WORKS CO INC	0	3422.89	1.19
PRA HEALTH SCIENCES INC	1	3406.30	5.02

Surplus Anlys: 100 Firms Around Mean

Company Name	Chi Value of IT Transfer Sectors	Surplus Wealth at Current Prices	Tobin Q
BRINKER INTL INC	0	3404.22	3.12
BIO-TECHNE CORP	1	3401.70	8.19
ACADIA PHARMACEUTICALS INC	1	3379.87	13.23
CHARLES RIVER LABS INTL INC	1	3376.84	3.01
CAVIUM INC	1	3369.53	9.27
COMMUNICATIONS SALES & LSNG	0	3356.47	2.06
WEX INC	1	3354.47	2.18
EPAM SYSTEMS INC	1	3342.47	5.36
SONOCO PRODUCTS CO	0	3331.18	2.02
R&G FOODS INC	0	3326.98	5.07
GUIDEWIRE SOFTWARE INC	1	3323.50	4.39
VAIL RESORTS INC	0	3316.08	2.44
EQT GP HOLDINGS LP	0	3311.56	2.01
DONNELLEY (R R) & SONS CO	0	3306.54	1.52
COPART INC	0	3283.55	2.75
MSC INDUSTRIAL DIRECT -CLA	0	3250.72	2.92
VEEVA SYSTEMS INC	1	3242.55	5.88
SUPERVALU INC	0	3240.52	1.73
APTARGROUP INC	0	3221.00	2.23
GENTEX CORP	1	3204.97	2.70
POOL CORP	0	3191.84	4.41
MICROSEMI CORP	1	3177.03	3.68
CHOICE HOTELS INTL INC	0	3173.44	5.07
WATSCO INC	0	3172.93	3.04
MARATHON PETROLEUM CORP	0	3164.65	1.07
ACI WORLDWIDE INC	1	3158.09	5.36
MORNINGSTAR INC	1	3142.78	5.27
ULTRA PETROLEUM CORP	0	3136.48	3.59
MEREDITH CORP	0	3134.08	3.89
APARTMENT INVST & MGMT CO	0	3133.05	1.41
GNC HOLDINGS INC	0	3125.56	3.36
CAMDEN PROPERTY TRUST	0	3113.82	1.41
IPG PHOTONICS CORP	1	3112.97	2.73
BRUKER CORP	1	3110.85	2.64
TESORO LOGISTICS LP	0	3101.97	1.66
WEST PHARMACEUTICAL SVSC INC	1	3090.81	2.60
INTREXON CORP	1	3085.26	5.35
W P CAREY INC	0	3058.29	1.37
TRIUMPH GROUP INC	1	3056.66	1.80
NATIONAL OILWELL VARCO INC	0	3049.31	1.15
VECTOR GROUP LTD	0	3049.28	3.34
PAREXEL INTERNATIONAL CORP	0	3048.02	2.79
DELUXE CORP	0	3047.05	5.20
BWX TECHNOLOGIES INC	1	3008.65	3.09
JUNO THERAPEUTICS INC	1	2994.07	2.89
EAGLE MATERIALS INC	0	2988.54	2.44
HEICO CORP	1	2986.35	4.44
FAIR ISAAC CORP	1	2978.67	7.50
INC RESEARCH HOLDINGS INC	1	2976.95	5.72
COLUMBIA PIPELINE GROUP INC	0	2974.70	1.30

Company Name	Chi Value for IT Transformed Sectors	Surplus Wealth at Current Prices	Tobin Q
SUNCOKE ENERGY INC	0	-629.15	0.75
CIVEO CORP	0	-630.27	0.51
FORTRESS TRANS INFRASTR INVS	0	-643.07	0.65
KELLY SERVICES INC -CLA	0	-643.09	0.72
PARKER DRILLING CO	0	-657.43	0.61
EQUITY COMMONWEALTH	0	-657.61	0.90
TROPICANA ENTERTAINMENT INC	0	-658.98	0.57
FIVE OAKS INVESTMENT CORP	0	-668.60	0.78
DIAMONDROCK HOSPITALITY CO	0	-673.11	0.84
FOREST CITY REALTY TRUST INC	0	-689.93	0.94
HRG GROUP INC	0	-692.99	0.98
XENIA HOTELS & RESORTS INC	0	-694.32	0.81
8POINT3 ENERGY PARTNERS LP	0	-697.38	0.45
SANMINA CORP	0	-709.20	0.84
PHI INC	0	-720.29	0.60
BILL BARRETT CORP	0	-731.37	0.61
CABELAS INC	0	-736.85	0.93
CAI INTERNATIONAL INC	0	-741.07	0.70
TUTOR PERINI CORP	0	-742.63	0.82
SOUTHCROSS ENERGY PRTRNS LP	0	-743.80	0.55
AMKOR TECHNOLOGY INC	1	-750.01	0.85
BROOKFLD DTLA OFFICE TR INV	0	-750.73	0.78
HERCULES OFFSHORE INC	0	-759.99	0.44
MEDICAL PROPERTIES TRUST	0	-760.29	0.89
SELECT INCOME REIT	0	-773.68	0.85
EXTERRAN CORP	0	-776.03	0.66
UNITED STATES OIL FUND LP	0	-787.32	0.80
BEAZER HOMES USA INC	0	-789.70	0.74
NEWS CORP	1	-800.06	0.93
ENERGEN CORP	0	-801.27	0.86
PORTLAND GENERAL ELECTRIC CO	0	-802.08	0.91
ARCHROCK INC	0	-802.84	0.75
CBL & ASSOCIATES PPTYS INC	0	-807.02	0.90
MONOGRAM RESIDENTIAL TRUST	0	-815.36	0.80
APPROACH RESOURCES INC	0	-821.49	0.44
SL GREEN REALTY CORP	0	-836.06	0.97
INVENTRUST PROPERTIES CORP	0	-844.56	0.84
SENIOR HOUSING PPTYS TRUST	0	-847.36	0.90
TECH DATA CORP	1	-865.80	0.88
OMAGINE INC	0	-867.86	0.03
PLAINS ALL AMER PIPELINE -LP	0	-877.24	0.96
APOLLO COMMERCIAL RE FIN INC	0	-885.56	0.74
GULFMARK OFFSHORE INC	0	-914.40	0.46
AG MORTGAGE INVESTMENT TRUST	0	-919.11	0.77
WESTERN ASSET MTG CAPITAL CP	0	-921.84	0.78
HALCON RESOURCES CORP	0	-931.47	0.78
EP ENERGY CORP	0	-961.84	0.87
INGRAM MICRO INC	1	-966.48	0.93
DYNEX CAPITAL INC	0	-972.28	0.79
APOLLO INVESTMENT CORP	0	-995.18	0.78
SCANA CORP	0	-1010.04	0.95
PATTERN ENERGY GROUP INC	0	-1033.78	0.78
FS INVESTMENT CORP	0	-1044.89	0.80
FIFTH STREET FINANCE CORP	0	-1061.12	0.67
CENTURY ALUMINUM CO	0	-1063.57	0.51
ALTSOURCE RESIDENTIAL CORP	0	-1066.27	0.65
RESOURCE CAPITAL CORP	0	-1069.30	0.69
RYDER SYSTEM INC	0	-1087.46	0.92
GATY CORP	0	-1088.32	0.87
DCP MIDSTREAM PARTNERS LP	0	-1090.25	0.83
OVERSEAS SHIPHOLDING GROUP	0	-1090.78	0.73
HUNTSMAN CORP	0	-1093.58	0.91
THOMPSON CREEK METALS CO INC	0	-1114.18	0.62
GENER8 MARITIME INC	0	-1120.61	0.62
ONEOK INC	0	-1120.84	0.94
TAL INTERNATIONAL GROUP INC	0	-1132.44	0.79
MEMORIAL PRODUCTION PRTRS LP	0	-1140.33	0.68
IRIDIUM COMMUNICATIONS INC	0	-1157.64	0.71
HECLA MINING CO	0	-1169.96	0.58
SEACOR HOLDINGS INC	0	-1173.54	0.70
CLOUD PEAK ENERGY INC	0	-1200.42	0.46
ARLINGTON ASSET INVESTMENT	0	-1212.75	0.77
APOLLO RESIDENTIAL MTG INC	0	-1213.79	0.73
PENNYMAC MORTGAGE INVEST TR	0	-1228.87	0.82
PINNACLE WEST CAPITAL CORP	0	-1254.41	0.93
HELIX ENERGY SOLUTIONS GROUP	0	-1255.10	0.57
REPUBLIC AIRWAYS HLDGS INC	0	-1276.16	0.72
RICE ENERGY INC	0	-1286.76	0.73
CAESARS ENTERTAINMENT CORP	0	-1295.14	0.90
JONES ENERGY INC	0	-1296.99	0.46
UNIT CORP	0	-1310.08	0.62
EV ENERGY PARTNERS LP	0	-1333.67	0.44
PATTERSON-UTI ENERGY INC	0	-1339.87	0.76
ARCHER-DANIELS-MIDLAND CO	0	-1359.19	0.97
ALLEGHENY TECHNOLOGIES INC	0	-1372.34	0.78
ATLAS AIR WORLDWIDE HLDG INC	0	-1385.62	0.73
REDWOOD TRUST INC	0	-1405.73	0.81
GENCO SHIPPING & TRADING	0	-1420.78	0.34
ENLINK MIDSTREAM LLC	0	-1436.58	0.82
NRG YIELD INC	0	-1437.25	0.82
TALLGRASS ENERGY GROUP LP	0	-1452.36	0.55
ISTAR INC	0	-1452.60	0.79
HAWAIIAN ELECTRIC INDS	0	-1485.67	0.89
SOUTHWESTERN ENERGY CO	0	-1500.26	0.85
TRINITY INDUSTRIES	0	-1513.65	0.85
ASHFORD HOSPITALITY TRUST	0	-1533.03	0.75
RAIT FINANCIAL TRUST	0	-1537.89	0.72
ALTSOURCE ASSET MGMT CORP	0	-1549.96	0.51
MICRON TECHNOLOGY INC	1	-1559.26	0.95
HELMERICH & PAYNE	0	-1560.87	0.82

SurplusAnalysis: Bottom 200

Company Name	Chi Value for IT Transformed Sectors	Surplus Wealth at Current Prices	Tobin Q
MCDERMOTT INTL INC	0	-1577.88	0.63
TRONOX LTD	0	-1599.46	0.73
MTGE INVESTMENT CORP	0	-1613.46	0.76
KB HOME	0	-1622.44	0.74
PENNEY (J C) CO	0	-1632.29	0.87
SKYWEST INC	0	-1702.83	0.71
AIRCASLE LTD	0	-1717.04	0.79
LINN ENERGY LLC	0	-1723.47	0.86
AMEREN CORP	0	-1752.44	0.94
ANWORTH MTG ASSET CORP	0	-1821.13	0.78
HORNBECK OFFSHORE SVCS INC	0	-1821.44	0.51
KENNEDY-WILSON HOLDINGS INC	0	-1825.09	0.80
GREAT PLAINS ENERGY INC	0	-1866.62	0.86
SUNOCO LOGISTICS PARTNERS LP	0	-1878.79	0.89
DOMINION MIDSTREAM PARTNERS	0	-1884.51	0.60
SM ENERGY CO	0	-1894.70	0.73
BREITBURN ENERGY PARTNERS LP	0	-1912.41	0.68
ARCONIC INC	0	-1943.11	0.95
XCEL ENERGY INC	0	-1966.85	0.96
DENBURY RESOURCES INC	0	-1992.96	0.73
AMERICAN HOMES 4 RENT	0	-1993.64	0.76
NOBLE ENERGY INC	0	-2093.59	0.93
MOSAIC CO	0	-2128.49	0.89
LADDER CAPITAL CORP	0	-2253.52	0.69
BLACKSTONE MORTGAGE TR INC	0	-2301.15	0.80
NEW YORK MORTGAGE TRUST INC	0	-2363.18	0.79
TAYLOR MORRISON HOME CORP	0	-2396.05	0.53
PUBLIC SERVICE ENTRP GRP INC	0	-2589.25	0.94
AIR LEASE CORP	0	-2619.85	0.83
CALPINE CORP	0	-2631.49	0.89
OASIS PETROLEUM INC	0	-2681.84	0.62
DYNEGY INC	0	-2716.52	0.80
PROSPECT CAPITAL CORP	0	-2726.15	0.68
HUDSON PACIFIC PPTYS INC	0	-2745.33	0.65
TIDEWATER INC	0	-2748.69	0.54
BOARDWALK PIPELINE PRTRNS-LP	0	-2820.65	0.72
DIAMOND OFFSHRE DRILLING INC	0	-2978.41	0.67
PARAMOUNT GROUP INC	0	-2994.40	0.71
AMERICAN CAPITAL LTD	0	-3010.07	0.61
ARES CAPITAL CORP	0	-3034.79	0.74
ATWOOD OCEANICS	0	-3170.74	0.47
PROLOGIS INC	0	-3196.92	0.92
UNITED STATES STEEL CORP	0	-3273.88	0.71
NORTHSTAR REALTY FINANCE CP	0	-3282.25	0.82
FIRSTENERGY CORP	0	-3393.01	0.94
PEABODY ENERGY CORP	0	-3483.25	0.75
EQT CORP	0	-3507.95	0.80
ARMOUR RESIDENTIAL REIT INC	0	-3633.33	0.78
QEP RESOURCES INC	0	-3648.08	0.65
WPX ENERGY INC	0	-3665.96	0.65
TWO HARBORS INVESTMENT CORP	0	-3674.79	0.79
VEREIT INC	0	-3695.30	0.81
MFA FINANCIAL INC	0	-3746.27	0.77
CAPSTEAD MORTGAGE CORP	0	-3811.67	0.79
CYS INVESTMENTS INC	0	-3866.43	0.78
NEW RESIDENTIAL INV CP	0	-3915.39	0.79
CHIMERA INVESTMENT CORP	0	-4154.44	0.78
HATTERAS FINANCIAL CORP	0	-4227.85	0.79
MURPHY OIL CORP	0	-4267.42	0.70
TARGA RESOURCES PARTNERS LP	0	-4306.23	0.68
AMERICAN ELECTRIC POWER CO	0	-4372.97	0.94
EDISON INTERNATIONAL	0	-4438.87	0.93
MIDCOAST ENERGY PARTNERS LP	0	-4548.11	0.27
COLONY CAPITAL INC	0	-4564.05	0.60
INVESCO MORTGAGE CAPITAL INC	0	-4693.34	0.78
ROWAN COMPANIES PLC	0	-4706.88	0.55
ANTERO RESOURCES CORP	0	-4723.82	0.73
CONSOLIDATED EDISON INC	0	-4902.71	0.91
TARGA RESOURCES CORP	0	-5215.33	0.62
ENBRIDGE ENERGY PRTRNS -LP	0	-5264.10	0.77
INTEGRYS HOLDING INC	0	-5364.57	0.61
COLUMBIA PIPELINE PRTRNS LP	0	-5606.91	0.37
WHITING PETROLEUM CORP	0	-5628.59	0.60
NRG ENERGY INC	0	-5719.11	0.84
CONSOL ENERGY INC	0	-5730.63	0.58
PG&E CORP	0	-5961.25	0.92
ENABLE MIDSTREAM PARTNERS LP	0	-5990.22	0.56
AVANGRID INC	0	-6183.47	0.82
TALEN ENERGY CORP	0	-6266.32	0.60
CONOCOPHILLIPS	0	-6315.42	0.95
YAHOO INC	1	-7283.26	0.87
WILLIAMS PARTNERS LP	0	-7495.94	0.84
ENTERGY CORP	0	-7557.78	0.86
ICAHN ENTERPRISES LP	0	-7669.86	0.82
AES CORP	0	-7670.28	0.83
PLAINS GP HOLDINGS LP	0	-9648.42	0.64
ENERGY TRANSFER EQUITY LP	0	-10672.07	0.85
NEWMONT MINING CORP	0	-10758.96	0.65
LEUCADIA NATIONAL CORP	0	-12448.69	0.77
ENERGY TRANSFER PARTNERS -LP	0	-13729.13	0.80
HESS CORP	0	-14464.68	0.66
FREEPORT-MCMORAN INC	0	-15417.04	0.73
AGNC INVESTMENT CORP	0	-15787.11	0.78
MARATHON OIL CORP	0	-17821.91	0.56
STARWOOD PROPERTY TRUST INC	0	-19919.41	0.81
ANNALY CAPITAL MANAGEMENT	0	-20543.27	0.78
EDELSON CORP	0	-21680.75	0.81
FORD MOTOR CO	0	-27907.69	0.90
GENERAL MOTORS CO	0	-29674.53	0.87
CHEVRON CORP	0	-44148.14	0.86

Appendix C: Set of 66 Yearly Electronic Files

Individual files, 1950-2015, will be available as Appendix C at <http://web.stanford.edu/~mordecai/> and the number of firms in each is recorded in the first column of this Appendix A. These rise from less than 1,000 firms in the 1950's, exceeding 3,000 in 1970, and rising further afterwards.