

Private and Social Returns to R&D: Drug Development and Demographics[†]

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Over the last few decades, business investment has shifted away from physical capital (machines, structures) and toward intangible capital (software, intellectual property) (Alexander and Eberly 2018, Crouzet and Eberly 2019). Despite this increase in intangible investment, measured productivity growth has been sluggish (Gordon 2017, 2018). Yet, if productivity is measured as a Solow residual—the residual output net of the contribution of capital and labor—this represents a puzzle: if intangible investment has increased so much, why is it not reflected in higher output and higher measured productivity growth?¹

Here, we present one possible resolution: a significant share of this increased intangible investment is geared toward medical R&D targeting older patients. To the extent that these patients are no longer in the labor force, their improved health and well-being would be welfare enhancing but not directly productivity improving.² We explore this point in several steps.

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¹ Intangible capital might be expected to increase measured productivity both because it is undermeasured in the capital stock and because of direct contributions to productivity, say through R&D.

² Our analysis follows the traditional definitions of national output and income. Improvement in health would lead to an increase in more heterodox measures of national income (Nordhaus 2003) but not in productivity growth.

First, we show that pharmaceutical firms account for an increasing share of the total R&D spending in the economy. In the 1970s, US pharmaceutical firms accounted for less than 3 percent of the overall R&D spending in the economy. Today, that share has risen to approximately 10 percent, and their share among manufacturing firms has risen from 8 percent to 35 percent.³

Second, we show that much of this increased spending is geared toward developing drug candidates targeting ailments typically afflicting older patients. Using detailed data on firms' drug development pipelines, we show that a significant share of drug candidates under development treat diseases that disproportionately affect patients that have exited the labor force (over 65 years old). By exploiting between-firm heterogeneity in the profile of firms' drug development strategies, we can obtain an estimate of the fraction of overall R&D spending by pharmaceutical firms that is geared toward developing drugs targeting specific groups. We find that the share of expenditures allocated to treating diseases common in the over-65 group has increased by more than 50 percent since 2000. Though much of our analysis is focusing on the post-2000 period, many of the trends we document are also present in the pre-2000 sample (Acemoglu and Linn 2004).

Our estimates suggest that about a third of total R&D spending by pharmaceutical firms is geared toward those age 65 and over. While prolonging life expectancy and improving quality of life, these investments in R&D have little effect on measured productivity and output growth.

³ During this period, US pharmaceutical firms also account for an increased share of R&D spending among all publicly listed firms (7 percent to 25 percent). Though our sample is restricted to the largest firms in the economy, these firms account for the bulk of R&D spending in the economy—approximately two-thirds.

Male life expectancy at birth in the United States increased from 70 years in 1980 to 76.3 years in 2018. However, the effective retirement age for men has been hovering around 66 since 1980 and has risen only slightly to 67.9 by 2018, while the statutory retirement age increased from 65 to 66. Absent a significant change in retirement patterns, R&D spending targeting seniors is unlikely to directly enhance the labor force and output growth (Fernald et al. 2017, Goodhart and Pradhan 2020).

I. Drug Expenditures by Age

Our argument that increased intangible investment is geared toward medical treatments targeting the elderly hinges on the fact that seniors demand more medical care, as is well documented in the literature (Gruber and Levy 2009; Pashchenko and Porapakkarm 2016; Meara, White, and Cutler 2004; Cravino, Levchenko, and Rojas 2020). Older people tend to consume more pharmaceutical drugs than younger people do because they are more likely to have multiple chronic medical disorders, such as high blood pressure, diabetes, or arthritis. Moreover, the drugs used by older people for chronic disorders are taken for long periods of time. According to Ruscin and Linnebur (2018): “Almost 90 percent of older adults regularly take at least 1 prescription drug, almost 80 percent regularly take at least 2 prescription drugs, and 36 percent regularly take at least 5 different prescription drugs. . . . Nursing home residents are prescribed an average of 7 to 8 different drugs to take on a regular basis.”

We use the Medical Expenditure Panel Survey (MEPS) to illustrate the cost of drug consumption by age. The MEPS program is run by the Agency for Healthcare Research and Quality at the US Department of Health and Human Services, and it tracks data on health services use and cost for a large nationally representative sample of households. We use the MEPS data to match drugs to age cohorts.

We use the years 1996 through 2015 of the MEPS data, covering between 22,000 and 38,000 patients, depending on the year of the survey. Using MEPS’s *Total Payment* and *Clinical Classification Code* variables, we calculate an elderly expense share for each medical condition. By matching drugs to their

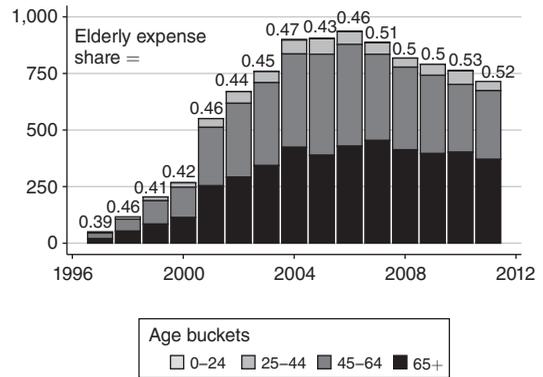


FIGURE 1. LIPITOR EXPENDITURES OVER TIME

Note: The figure shows inflation-adjusted expenditure on Lipitor over time for four different age buckets.

Source: MEPS

medical condition and medical conditions to their age distributions, we can calculate a drug’s elderly expense share. We term “elderly drugs” those drugs with an expense share greater than the elderly population share (ages 65 and above).

Drugs targeting older patients generate significant revenues for pharmaceutical companies. To illustrate, consider Lipitor—a statin used to lower cholesterol in the blood—which was first approved in 1997 and has contributed \$143 billion to Pfizer’s revenue since 1999. Using MEPS, we aggregate expenditures on Lipitor by age groups from 1997, the first year in which Lipitor was introduced, until 2011, the year in which it went off patent. As Figure 1 demonstrates, Lipitor has been prescribed mostly to patients older than 45, with the share of prescriptions to those in the 65+ age group accounting for more than 40 percent of total prescriptions.

Figure 2 plots per capita drug expenditure (in 2015 dollars) for four different age groups: ages (i) 0–24, (ii) 25–44, (iii) 45–64, and (iv) 65 and up. As the figure illustrates, per capita drug expenditure is increasing in age. For example, in 2015 the per capita drug expenditure for the 65+ age cohort was \$2,531, compared to \$1,758 for those in the 45–64 age cohort. Moreover, per capita expenditure increased dramatically from \$1,668 in 2000 to \$2,531 in 2015 for those in the 65+ age cohort.

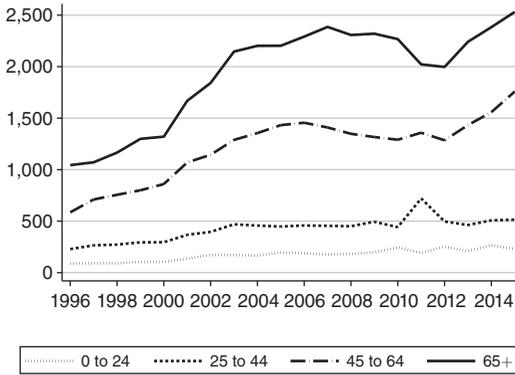


FIGURE 2. PER CAPITA DRUG COST BY AGE BUCKETS (IN 2015 DOLLARS)

Note: The figure shows inflation-adjusted prescription drug expenditure per capita over time for four different age buckets.

Source: MEPS

The increase in drug expenditure per capita was driven mostly by an overall increase in drug cost rather than an increase in the number of drugs.⁴ Drug costs increased significantly during the period. The average cost per drug for people age 65 and over was \$242 in 1996 but increased to \$472 by 2015. This trend is consistent with the fact that the service expenditures (particularly health) of older households has tended to rise over time (Cravino, Levchenko, and Rojas 2020). In the next section, we argue that R&D efforts are focused on such drugs that treat chronic conditions among the elderly.

II. Pharmaceutical Drug Portfolios

A significant share of intangible investment in recent years has been made by pharmaceutical firms. Figure 3 plots the ratio of R&D expenses made by pharmaceutical firms to total R&D expenses by publicly traded firms in the United States.

As Figure 3 shows, pharmaceutical firms' share of R&D among all Compustat firms increased from less than 10 percent in the early 1970s to 24 percent in 2018. Most of the increase in pharmaceutical R&D took place during the

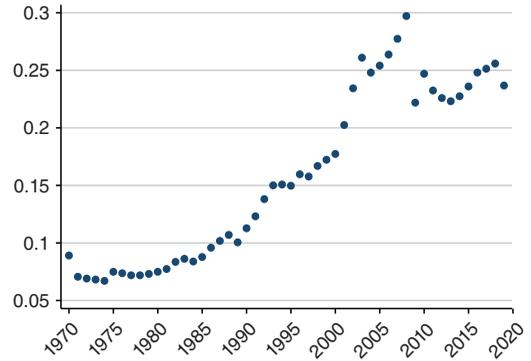


FIGURE 3. PHARMACEUTICAL R&D AS A FRACTION OF TOTAL R&D, 1970–2018

Note: This figure displays the fraction of R&D expenditures of Compustat's pharmaceutical companies to total R&D expenditures of all Compustat firms from 1970 until 2018.

Source: Compustat

1990s and the first decade of the twenty-first century. Though our sample is restricted to the largest firms in the economy, these firms account for approximately two-thirds of total R&D spending in the economy.⁵ Five out of the ten largest R&D spenders in Compustat in 2010 were pharmaceutical firms.

We next document that an increased share of pharmaceutical R&D spending is geared toward developing drugs for older patients. To do so, we use detailed project-level data linked to therapeutic areas. This analysis is enabled by the Cortellis Investigational Drugs data, which include information on the drug development histories of over 50,000 drugs (as of 2015). That information includes development milestones, clinical trial dates, and therapeutic indications. Two data matching steps allow us to link Cortellis drug candidates to Clinical Classification Codes (CCC) in the MEPS data. First, we map Cortellis indication codes to the International Classification of Diseases, Ninth

⁴The number of drugs prescribed per person increased from 2.4 in 2000 to 2.6 in 2015.

⁵In 2019, US publicly listed firms in Compustat collectively accounted for \$444.4 billion of R&D spending, compared to \$669.1 billion total R&D spending in national income and product accounts.

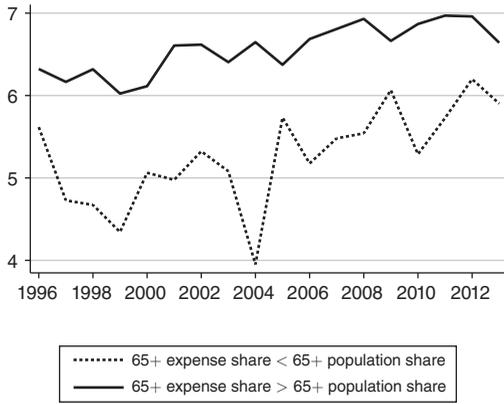


FIGURE 4. DRUG INNOVATION: FLOW OF DRUGS INTO PRECLINICAL DEVELOPMENT

Notes: This graph shows the flow of new preclinical drug projects (in logs) into development. “Elderly expense share” is the percentage of a given CCC expenditure spent by individuals in the 65+ age bucket.

Source: MEPS and Cortellis

Edition, (ICD9) codes.⁶ Next, we use the MEPS mapping between ICD9 codes and CCC.⁷

Armed with this map from drug indication to CCC, we classify drug development activity by age buckets. We categorize each drug indication that enters development by its corresponding CCC’s expense share in each age bucket. Recall that a given drug CCC is classified as “elderly” if its CCC group’s elderly expense share in MEPS is larger than the elderly population share. Figure 4 shows that throughout the 1995–2013 period, “elderly drugs” represent more than half of the overall new drug development entry for preclinical projects. The flow of new elderly drug projects is also less volatile than other drugs—steadily rising throughout the period.

For each of the firms in Cortellis, we calculate the share of their drugs that target patients in the 45–64 and the 65+ age groups, respectively. Next, we match these age cohort shares of drugs

⁶We thank Manuel Hermosilla for this crosswalk.

⁷These data are available through the MEPS Github repository (<https://github.com/HHS-AHRQ/MEPS>).

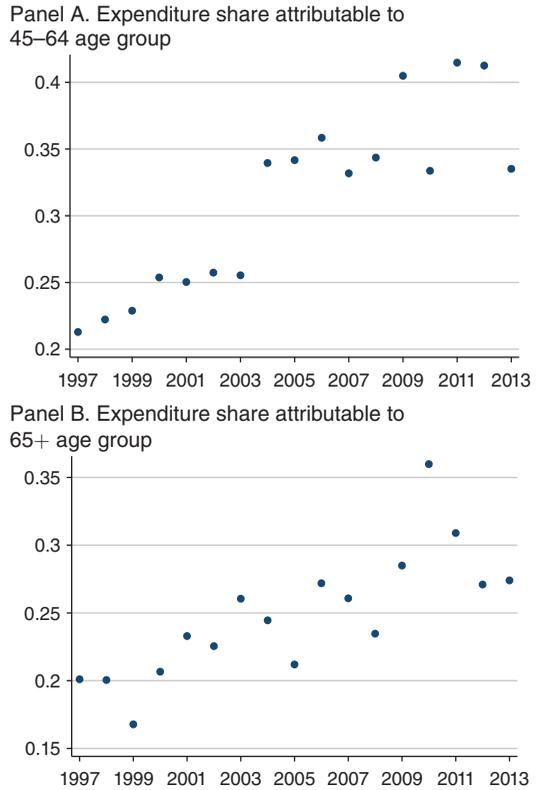


FIGURE 5. R&D EXPENDITURE SHARE BY AGE GROUPS

Note: This figure displays R&D expenditures of Compustat’s pharmaceutical companies that are attributed to drug developments for individuals age 45 to 64 (panel A) and 65 and older (panel B) from 1997 until 2013.

Source: MEPS, Cortellis, and Compustat

in development to Compustat by firm and year. This match gives us a measure of R&D expenditure share by age bucket, firm, and year. We assume that the cost of drug development is similar across age cohorts and hence assign R&D expenses to age cohorts based on their total share in drug development.⁸

⁸To verify that this assumption is reasonable, we examine whether variation in R&D spending per drug in development is systematically related to the share of firms’ drug portfolios targeting different age groups. Point estimates suggest that if anything, firms developing drugs for older patients have higher R&D costs per drug candidate, though the differences are not always statistically significant.

Panels A and B of Figure 5 plot the share of total pharmaceutical R&D attributed to the development of drugs for patients in the 45–64 and 65+ age groups, respectively. Over this time period, Panels A and B show that the R&D share increased by 10 to 15 percentage points in both age groups. Taken together, the development and age-specific expenditure trends suggest that the focus of both R&D investment and sales has shifted toward older patients over time.

III. Discussion and Conclusion

So far, we have shown that a significant share of intangible investment, specifically R&D expenditure, is geared toward treating medical conditions afflicting the elderly. To the extent that these seniors remain out of the labor force, their increased quality of life and life expectancy will not directly increase labor supply and output (via a supply mechanism). Hence, output metrics may not benefit from this type of R&D investment. Indirect mechanisms, however, could compensate. For example, if pharmaceutical R&D leads to longer or more productive working lives, then output and even productivity may benefit from retaining the human capital of older workers (Fernald et al. 2017). Further research is needed to understand whether focusing innovation on older patients increases productive human capital or has other indirect benefits.

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