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13 The Effects of Price Regulation on Productivity in Pharmaceuticals

Patricia M. Danzon and Allison Percy

The purpose of this paper is to measure productivity growth over time and to compare productivity levels cross-nationally for the pharmaceutical industry in four major European markets and the United States. The pharmaceutical industry raises interesting issues for productivity measurement. The product mix includes thousands of different compounds, and the range available differs significantly across countries and over time. Research and development (R&D) is a very important input and determinant of productivity; however, the stock of R&D capital cannot be measured accurately because of inadequate data, long and variable lags between investments and product launch, and international spillovers. The high rate of technological change leads to potential bias in measuring price change. For example, Berndt, Griliches, and Rosett (1993) and Berndt and Greenberg (1996) show that the U.S. PPI for drugs has been seriously upwardly biased owing to delay in incorporating new drugs; Griliches and Cockburn (1996) illustrate the bias from treating generics as new drugs rather than as new forms of old drugs.

Measurement of price change and real productivity growth is complicated in many European countries by the fact that drug prices are regulated, either directly (France and Italy) or indirectly (the United Kingdom). Consequently, trends in drug prices over time deviate significantly from economywide price inflation, and these trends differ across countries (Danzon and Kim 1996).

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Regulation, nontariff barriers to trade, and other factors induce significant prices differences for the same drugs across countries, after conversion at either exchange rates or GDP purchasing power parities (PPPs). This paper demonstrates the sensitivity of estimates of country-specific productivity growth to the price indexes used to deflate nominal expenditure data. Similarly, the adjustment for cross-national price differences affects the estimates of cross-national productivity differences.

A second purpose of this paper is to show the effects of price regulation on input use and productivity and the implications of such regulation-induced distortions on the estimation of productivity growth. The price regulatory schemes in several European countries are designed to promote domestic employment and investment in addition to their primary purpose of controlling drug expenditures.[1] For example, France and Italy grant higher prices for products that are produced locally. The United Kingdom regulates the rate of return on capital invested in the United Kingdom, and the allowed rate of return for a firm depends on its contribution to the U.K. economy. Regulation that grants higher prices for use of certain inputs tends to distort resource allocation (Averch and Johnson 1962), leading to excessive costs and suboptimal productivity. We show that, with input-distorting regulation, factor shares are biased proxies for output elasticities in measuring growth in multifactor productivity.

Our empirical analysis uses data for the pharmaceutical industry from the OECD Structural Analysis (STAN) database, for France, Germany, the United Kingdom, Italy, and the United States for the period 1970–90.[2] In order to distinguish the effects of regulation from other factors that may contribute to cross-national productivity differences, we compare pharmaceuticals to other industries (chemicals and total manufacturing) that are not subject to the same regulatory constraints. We report country-specific estimates of productivity growth using three country-specific price indexes: the GDP deflator, the official pharmaceutical PPI, and a Divisia price index constructed from IMS data (Danzon and Kim 1996).[3] For cross-national comparison of productivity levels, we report results both with GDP PPPs and with a drugs-specific Fisher price index (Danzon and Kim 1998) that is based on prices for all matching drugs in the countries under comparison.

The findings demonstrate that estimates of country-specific productivity growth and cross-national comparisons are very sensitive to the price indexes used and that none is perfect. At minimum, these findings confirm the importance of using industry-specific price indexes for productivity measurement in an industry that is subject to heavy price regulation, such as pharmaceuticals.

1. The transparency rules of the European Union in principle constrain regulatory bias toward local firms, but, in practice, price setting for medical services has remained an area of national discretion.

2. *Germany* in this paper refers to the former Federal Republic of Germany.

3. IMS International is a market research firm that collects data on pharmaceutical sales.

With these caveats, the empirical results are generally consistent with the hypothesized effect, that biased price regulation has increased input use and reduced productivity in France. For the United Kingdom, pharmaceutical productivity is high, relative to other U.K. manufacturing and relative to other European pharmaceutical industries, despite the United Kingdom's biased regulatory system.

Note that the productivity measures analyzed here are GDP-based measures of value added for all firms operating in each country, including local subsidiaries of multinational firms, since this corresponds to the scope of regulation. These GDP-based measures do not reflect productivity in the discovery of innovative new drugs. Innovation in R&D is a critical component of the overall productivity of a particular country's pharmaceutical industry but is beyond the scope of this paper.[4] However, our results suggest that both the level and the returns to unobserved R&D capital are lower in France than in the United States and the United Kingdom. This is generally consistent with other evidence, that France has lagged the United States and the United Kingdom in pharmaceutical innovation (Barral 1995).

In this paper, section 13.1 briefly describes the regulatory regimes and their expected effects. Section 13.2 discusses measurement issues in cross-national comparisons of productivity for pharmaceuticals. Section 13.3 describes the data and methods used in this study. Section 13.4 compares within-country growth rates and cross-national levels of productivity for pharmaceuticals, compared to other manufacturing. Section 13.5 reports estimates of total factor productivity growth. Section 13.6 concludes.

13.1 Forms of Price Regulation and Previous Literature

We selected France, Italy, and the United Kingdom as examples of countries with biased regulation. Germany and the United States provide a benchmark of productivity in countries where price constraints are neutral with respect to location of production. The four European countries have similar populations and similar opportunities for export within the European Union (EU). Although the U.S. market is much larger than the domestic market of any single European country, the total EU market represents larger total sales volume than the U.S. market. Thus, opportunities to exploit economies of scale should be similar, absent regulatory inducements for domestic production and/or barriers to exports.

4. Comanor (1965) and Cocks (1973, 1981) analyze productivity in R&D, focusing on effects of safety and efficacy regulation (see also Peltzman 1973; and Thomas 1990, 1992, 1996). Hancher (1990) describes the regulatory systems in France and the United Kingdom.

13.1.1 Forms of Price Regulation

Biased Price Regulation: France and Italy

France and Italy regulate the manufacturer's price as a condition of reimbursement by the social insurance program. The criteria used for setting prices have included costs, therapeutic merit, and international comparisons. Contribution to the local economy is widely acknowledged to be a bargaining strategy for a higher price, notwithstanding the Treaty of Rome and other nondiscrimination provisions of the European Union (see, e.g., Burstall 1991; Burstall and Reuben 1988).

Price regulation that favors domestic production is more likely to be a binding constraint on multinational firms than on domestic firms that would voluntarily locate a larger fraction of their operations in the home country. Domestic firms are therefore predicted to command a larger market share in countries with biased price regulation, other things equal.

Rate-of-Return Regulation: The United Kingdom

The U.K. pharmaceutical price regulation system (PPRS) regulates the rate of return on capital by comparing net revenues generated from sales to the National Health Service (NHS) to capital that contributes to sales to the NHS. Within this constraint, manufacturers can set prices freely for individual new products. Prices of generics are regulated. Simple rate-of-return regulation is predicted to induce substitution of capital for labor (Averch and Johnson 1962). However, this tendency is mitigated because the permitted return that each firm negotiates with the PPRS depends, within the range of 17–21 percent, on such factors as number of jobs created, innovation, and other contributions to the U.K. economy.

In general, the U.K. system favors domestic firms that would in any case locate corporate headquarters, R&D, and other overhead capital in the United Kingdom. The PPRS may also create incentives for multinationals to shift facilities to the United Kingdom from other countries if the permitted return is increasing in exports or if joint costs can be allocated to the U.K. rate base.

Reference Price Reimbursement: Germany

Prior to 1989, Germany permitted free pricing of drugs. Political concern over the level and growth of drug expenditures led manufacturers to adopt a voluntary price freeze from 1984 to 1989. In 1989, the government introduced a reference price system of reimbursement, focused initially on off-patent drugs.[5] Although this system constrains prices for relatively high-priced (usually originator) drugs, it is formally neutral with respect to input mix and loca-

5. Products are grouped on the basis of similarity of therapeutic effect, and all products in a group are reimbursed at a common reference price. The patient must pay any excess of the manufacturer's price over the reference price. In practice, most manufacturers have dropped their prices to the reference price level (Remit 1991; Danzon and Liu 1996).

tion of production, except that it indirectly favors low-priced drugs, which are typically generics produced by local firms. Since this system was phased in gradually starting in September 1989, our data are too early to show full effects. Our data also do not show the effects of the much more stringent controls adopted in 1993.[6]

"Free" Pricing: The United States

Pharmaceutical firms may set prices freely in the United States, subject to market constraints. Since the late 1980s, managed care has expanded rapidly to pharmacy benefits, through health maintenance organizations (HMOs) and pharmacy benefit management companies (PBMs) that manage drug benefits for indemnity plans. Pharmacy benefit management has accelerated the growth in generic market share and led brand manufacturers to discount their drugs to managed care purchasers. Since 1990, Medicaid and other public programs demand similar discounts. These initiatives are neutral with respect to manufacturer or country of origin, except to the extent that they favor generics, which are usually locally produced.

One potential distortion in the United States is the possessions tax credit, which reduces corporate tax rates based on employment and income generated in Puerto Rico.[7] To show the effects of this tax incentive, we report results with and without Puerto Rico for the years with available data.

13.1.2 Previous Literature

Most previous cross-national comparisons of productivity are at the one- or two-digit SIC level (e.g., van Ark and Pilat 1993). The Bureau of Labor Statistics (BLS) publishes international comparisons of growth rates for two-digit industries but does not compare productivity levels. Since pharmaceuticals are a small fraction of chemicals and allied products (SIC 28), these analyses shed little light on pharmaceuticals. Cocks (1974, 1981) provides detailed estimates of total factor productivity growth for a single firm in the United States.

The only existing international comparison of productivity in pharmaceuticals is Burstall and Reuben's (1988) study of potential savings from plant consolidation in the European Community. Using industry interviews and OECD data for 1985, Burstall and Reuben conclude that scale economies in primary production (active ingredients) had already been realized since most multinational firms operate primary plants in only one or two locations. However, secondary production (processing and packaging) was extremely decentral-

6. The 1993 controls included a price cut and a global limit on drug expenditures, with physicians at risk for exceeding the drug budget. This led to significant volume reduction and substitution toward cheaper drugs (Danzon and Liu 1996).

7. Section 936 of the Internal Revenue Code, enacted in 1976, provides a tax credit equal to the federal tax liability on certain income earned in Puerto Rico. This was modified in 1982. The tax credit affects incentives to locate primary production of active ingredients in Puerto Rico since the value of R&D is realized as the value added to the raw ingredients. The mix of labor and capital within the production process should be unaffected.

ized, with many plants operating below capacity. Industry interviews attributed this in part to government pressure. Burstall and Reuben estimated that half to two-thirds of these plants could be closed.[8] Their cross-national productivity comparisons are based on GDP PPPs. Thus, the question remains how much of any apparent cross-national differences in productivity in fact simply reflect price differences. Their study also did not attempt to model or estimate the effects of regulation on country-specific productivity growth.

13.2 Theory and Measurement Issues with Biased Regulation

13.2.1 Incentive Effects of Biased Regulation

Biased regulation that grants higher output prices as a reward for local production creates incentives for the pharmaceutical firm to deviate from cost-minimizing input levels. Consider a firm that produces output Q with two variable inputs, labor L and capital K, and a technology-related fixed input M, subject to the production function $Q(L, K; M)$ and constant factor prices, w_L and w_K. With biased regulation, output price $P(L, K; M)$ is increasing in domestic employment of L and K with $P_{X_i} > 0$, $P_{X_i X_i} \leq 0$, $X_i = L, K$. For simplicity, assume that Q is independent of P.[9] The firm selects L and K to maximize profits R:

$$R = P(L, K; M)Q(L, K; M) - w_L - w_K. \tag{1}$$

Taking first-order conditions for an interior maximum, and rearranging,

$$PdQ/dX_i = w_i - dP/dX_i Q, \quad X_i = L, K. \tag{2}$$

Equation (2) differs from the standard first-order condition owing to the last term, which reflects the distorting effect of biased regulation. Thus, employment is expanded beyond the cost-minimizing level; this increase is greater the more responsive is the regulated price to increases in local employment or investment.

In a global context with trade, the net effect of regulatory bias depends on the costs to multinational corporations of shifting operations between countries. If multinationals can costlessly shift production from countries with neutral or no regulation to countries with biased regulation that favors domestic production, the location of production is affected, but productivity and costs

8. Burstall and Reuben estimated the potential savings at only 3.5–4.5 percent of the total labor force. They concluded that value added per employee was relatively high in pharmaceuticals compared to manufacturing as a whole in France, contrary to the conclusions reached here.

9. This may be a reasonable assumption for the countries with price regulation for the period under study. Patient cost sharing was minimal in France and Italy owing to exemptions and supplementary insurance. In the United Kingdom, roughly 80 percent of scripts are exempt from cost sharing; for the remaining patients, cost sharing is a fixed amount per script, independent of the price of the drug.

would be unaffected. Capital investment, employment, and exports would increase in countries with biased price regulation, with an offsetting decrease in neutral countries.[10]

However, if shifting production between countries is costly, for example, owing to nontariff barriers to trade[11] or regulatory demands in multiple countries, then the profit-maximizing strategy subject to regulation may be to operate an excessive number of plants at suboptimal scale or suboptimal capacity utilization. The effect on capital/labor ratios depends on the costs and political returns to increasing capital and labor, respectively. Even if capital/labor ratios are unaffected, both labor productivity and multifactor productivity are predicted to be lower if biased regulation induces the firm to forgo economies of scale or scope.

13.2.2 Productivity Measurement

Consider the simple production relation

$$Q_t = A_t f[X_t], \tag{3}$$

where Q is real output, X is a vector of real input flows, including labor, capital, energy, etc., t indicates time period, and A is an index of multifactor productivity that reflects technology, unmeasured management skill, organization, and other factors. Productivity growth can be estimated from the dynamic version of equation (3). Under assumptions of perfect competition in output and input markets, Hicks neutral technical change, and constant returns to scale, the growth in multifactor productivity (MFP) is equal to the difference between the growth in output and the growth in the weighted sum of inputs:

$$\dot{A} = \dot{Q} - \Sigma g_i \dot{X}_i, \tag{4}$$

where $g_i = d \ln Q / d \ln X_i$ is the output elasticity of input i, and $\cdot$ denotes the percentage time derivative of a variable. To obtain empirical estimates of output elasticities g_i, a common assumption is that firms are in competitive, long-run equilibrium. The first-order conditions for profit maximization imply

$$dQ/dX_i = w_i/P, \tag{5}$$

where w_i is the price of the ith input, and P is the final output price. Substituting in (4), MFP is estimated as the residual:

10. In practice, until recently most trade has been in active ingredients, whereas each country's processing and packaging was done locally. This suggests greater economies of scale in primary production of active ingredients, which partly reflects the costs of compliance with environmental and safety requirements.

11. During the period analyzed here, each country retained a separate system of market approval for prescription drugs. Although the European Union has explicitly authorized so-called parallel importing of approved drugs and this does increasingly constrain price differences within the European Union, nontariff barriers to imports have been significant until recently.

$$(4') \qquad \dot{A} = \dot{Q} - \Sigma s_i \dot{X}_i,$$

where the observable factor revenue share $s_i = w_i X_i / PQ$ is used as a proxy for the unobserved output elasticity g_i for factor i. In long-run equilibrium with perfect competition and constant returns to scale, $\Sigma s_i = 1$. This implies that unobservable service flows from quasi-fixed inputs are proportional to—and hence can be measured by—observable stocks, and one unobservable factor share can be estimated as a residual.

The measure of MFP obtained using factor share approximations for output elasticities is inaccurate if firms are not in long-run, cost-minimizing equilibrium (Berndt and Fuss 1986)[12] or if firms have market power such that prices exceed marginal cost (Hall 1988, 1990). For pharmaceutical firms, the latter condition almost certainly applies: pricing at short-run marginal cost would not pay a normal return on sunk investments in R&D and so cannot be a sustainable equilibrium.

Biased regulation is an additional reason why observed factor shares provide a potentially biased measure of output elasticities in the pharmaceutical industry. To illustrate, write equation (2) in elasticity form:

$$(2') \qquad E_{Q,X_i} = wX_i/PQ - E_{P,X_i}$$

or

$$(2'') \qquad s_i = E_{Q_i X_i} + E_{P,X_i}.$$

From equation (2″), the measured factor share is equal to the output elasticity *plus* the elasticity of the regulated price with respect to input levels. Thus, the assumption commonly used in productivity measurement, that factor shares serve as a proxy for output elasticities, does not hold under biased regulation.

In addition, the existence of unobserved sunk investments in R&D capital, M, leads to bias in the standard procedure of estimating the share of physical capital as the residual, after subtracting the share of measured inputs. Assume that investments in M are committed before the regulatory regime is known and that variable inputs are adjusted to the regulatory regime, as in equation (2). Define the ex ante expected shadow user cost of M as

$$(6) \qquad Z_M^* = P^* Q_M(L^*, K^*),$$

where * denotes expected, optimized values in the absence of regulation. The ex post realized shadow user cost of M depends on politically constrained prices and variable factor inputs:

$$(7) \qquad Z_M = P(L, K; M) Q_M(L, K; M).$$

12. Under nonconstant returns to scale, long-run equilibrium is defined as output at the point of tangency between the SRAC and the LRAC curves.

By definition, the ex post factor shares, including the ex post return to the quasi-fixed factor, sum to one:

(8) $$s_L + s_K + s_M = 1$$

or

(8′) $$1 - s_L = s_K + s_M .$$

Thus, if the unobserved share of physical capital is estimated as the complement of the labor share $1 - s_L$, the resulting estimate $\hat{s}_K$ is upwardly biased for the true value s_K; the upward bias is greater the greater the unobserved investment in M and the greater its ex post return, Z_M. However, this upward bias in $\hat{s}_K$ is partially offset if the elasticity of regulated price with respect to labor is positive:

(9) $$\hat{s}_K = s_K + s_M = 1 - \hat{s}_L = 1 - E_{QL} - E_{PL} .$$

From equations (8) and (2″):

(10) $$s_M = 1 - (s_L + s_K),$$

(10′) $$s_M = 1 - \Sigma[E_{Q_i X_i} + E_{P_i X_i}].$$

Thus, the more elastic is the regulated price with respect to variable inputs, $E_{P_i X_i}$, the lower will be the observed ex post return to the quasi-fixed factor. Of course, investments in fixed factors will not be made in the long run if realized returns are systematically below expected returns. But products that are developed by innovative pharmaceutical R&D are diffused worldwide; hence, the incentives for R&D depend on global revenues. The returns to unobserved intangible capital can thus differ significantly across countries. In particular, a country that is small relative to the global market can pay a less than competitive or even zero return Z_M on the global R&D of multinational companies without affecting the supply of drugs, as long as it pays prices sufficient to cover its country-specific marginal costs.

13.3 Data and Methodology

13.3.1 Data

The data on outputs and input levels used here are from the OECD Structural Analysis (STAN) database (1994), described in appendix A, which also lists other sources. The STAN data are generally national accounts compatible. Where national accounts data were not available, STAN substitutes survey-based data. Since definitions for these survey data are not necessarily national accounts compatible, consistency across countries is not assured; however,

within-country trends should be consistent.[13] We report within-country trends over time and cross-national comparisons of input levels and productivity. The cross-national comparisons should provide the best tests of the hypothesized effects of regulation. In addition, under the plausible assumption that regulation has become more stringent over the period studied, particularly in France and the United Kingdom, the differences in trends across countries may also provide evidence on the effects of regulation, assuming other factors unchanged.

The measure of productivity in this database is value added, defined as gross output minus the cost of materials, energy, supplies, and some contract work. Labor is reported as number of employees, unadjusted for hours worked, skill, age distribution, etc. The measure of capital is gross fixed capital formation. We apply a perpetual inventory calculation to estimate the stock of capital and assume that the flow of capital services is proportional to the stock.[14] Other inputs, such as contracted business services, advertising, licensing and royalty fees, etc., are reflected in value added. These data thus do not permit a gross production approach to productivity measurement. The potential bias from not netting out these intermediate inputs should not be great if they are competitively supplied. Data sources and definitions are described in more detail in appendixes A and B.

13.3.2 Data Limitations

Ideally, productivity measurement and comparison across countries would be based on a homogeneous set of products, with product-specific price indexes and quality-adjusted measures of all inputs. In that case, cross-national productivity differences for pharmaceuticals, relative to other manufacturing, would provide a pure measure of the effects of pharmaceutical regulation, after controlling for other country-specific factors that affect all industries in a country, such as management skills.

The available data on outputs, prices, and inputs deviate from these ideal conditions in ways that may influence the productivity estimates. This section outlines the main data limitations that should be borne in mind in interpreting the empirical findings.

13. For the United States, STAN reports the aggregate of SICs 2833–2836. Of these, pharmaceutical preparations account for 82 percent of total value of shipments. The remainder includes medicinals and botanicals, diagnostic substances, and biological products (1987 Census of Manufacturing, ind. ser. table 1a-1).

14. The capital stock in year t is estimated as $K_t = (1 - d)K_{t-1} + I_t$ and $K_1 = (1/d)I_{1-3}$, where I_{1-3} is the mean of gross investment in the first three years with reported data. The results reported here assume a uniform ten-year life of capital. We also made estimates based on the country-specific depreciation rates for equipment and structures reported in Berndt and Hesse (1986), assuming a weight of 0.66 for equipment and 0.37 for structures. For SIC 2383, depreciation charges were 7.8 percent of gross book value of depreciable assets in 1987 (Census of Manufacturing, table 3b), which implies a 12.8-year life of capital in steady state. Cocks (1974) assumes a fifteen-year life for equipment.

Heterogeneous Product Mix

Pharmaceutical markets in all countries comprise thousands of compounds, ranging from some truly global products, which are marketed in all major markets of the world, to purely local products that are marketed in only one country. Each product is available in a range of dosage forms, strengths, and pack sizes that change over time and differ across countries. The extent of global diffusion of a drug is a commonly used measure of its therapeutic value (e.g., Barral 1995) because manufacturers have incentives to launch a drug in any country where it could pass regulatory requirements for safety and efficacy and generate revenues sufficient to cover the country-specific marginal costs.

In 1992, products that were marketed in seven major markets of the world accounted for over two-thirds of sales in the United States, the United Kingdom, and Canada but less than 50 percent of sales in France, Germany, Italy, and Japan.[15] The diffusion of global products, either through outlicensing to local firms or direct marketing through multinational subsidiaries, implies common technologies across markets at least for those products. However, because the key technologies of pharmaceuticals are product specific and are protected by patents, technology does not diffuse throughout the industry until patent expiration. Thus, cross-country differences in product mix in pharmaceuticals are likely to imply cross-national differences in available technology. These differences are likely to be greater the greater the share of local products.

Local products include herbal, homeopathic, and other medicines that typically have less research content than global products. These local products complicate productivity measurement in part because differences in research content and production technologies may imply differences in true productivity and in price-marginal cost margins. In addition, regulation-induced inefficiencies may be different for local products that are produced by domestic firms than for global products produced by multinationals. Estimates of the effects of regulation may therefore be influenced by the market share of local products. Third, since local products are necessarily omitted from cross-national price indexes, these indexes yield a biased measure of overall relative price levels if regulation is more stringently applied to global than to local products.[16]

Countries also differ in the market share of generic versions of originator products and in the share of over-the-counter (OTC) versus prescription-bound (Rx) sales. The available data include all pharmaceutical products, including originator, generics, Rx, and OTC products; thus, separate estimates based solely on global products cannot be made. The markup of price over short-run

15. The market share of local products reflects insurance coverage and medical norms as well as regulatory requirements for proof of efficacy.

16. Systematic bias is plausible, even aside from regulatory favoring of local companies, if regulation focuses on high-priced products and global products have relatively high prices.

marginal cost is generally higher for research-based originator drugs than for generics, which incur minimal research or promotional expense. The marketwide average measure of value added should therefore be higher in countries with low generic market shares, ceteris paribus. Of the countries studied here, the United States, the United Kingdom, and Germany all have large generic market shares (over 30 percent of prescriptions), whereas generics are a negligible share in France and Italy. However, the low generic presence in these markets partly reflects lack of incentive for generic entry because of low price-cost margins on originator drugs by the time of patent expiration. Thus, on net, the expected sign of the correlation between generic market share and average value added marketwide is theoretically indeterminate.

Operations Mix

The functions undertaken by a pharmaceutical firm—R&D, primary production of the active ingredients, secondary processing and packaging, promotion and distribution—have very different input requirements. Functional mix may differ across countries, reflecting product mix and other real factors, in addition to possible reporting differences with respect to administrative personnel.[17] Such differences cannot be identified in the data and may contribute to the observed productivity differences.[18] Countries with relatively numerous primary production plants are expected to have relatively high value added because these primary production plants have low costs of bulk chemical inputs but the output is valued at transfer prices that reflect the intangible value of the embodied R&D.[19] Value added is expected to be much lower in the more numerous plants for processing and packaging, for which the transfer price of the active ingredient is an input cost.

Drug promotion has traditionally been predominantly through highly labor intensive detailing of individual physicians. Differences in optimal detailing effort therefore could affect observed levels of labor inputs and labor/capital ratios.[20] However, in a simple model of optimal promotion effort, sales force is increasing in the operating margin per unit sold and in the demand elasticity

17. We thank Ernie Berndt for noting this possibility of inconsistent reporting of central administrative and office personnel.

18. For the United States in 1987, production workers accounted for 46 percent of total employees and 35 percent of payroll. As a percentage of value of shipments, cost of materials, payroll, and new capital expenditures were 26 percent, 13 percent, and 4.7 percent, respectively (U.S. Census of Manufacturers, data for SIC 2833).

19. Multinational companies generally locate primary production of each compound in only one or two plants worldwide, with location generally determined by tax considerations. The output (transfer) price may be constrained by rules governing transfer pricing, including the price realized in the country of first launch. More generally, the value-added data used here may be contaminated by tax-induced transfers of profits across countries. This applies to all industries. Hence, comparisons between pharmaceuticals and other industries should be unbiased if the extent of such transfers is similar across industries.

20. Detailing entails frequent visits to individual physicians by sales personnel, to provide information and product samples.

with respect to detailing effort. Thus, if regulation depresses operating margins, it should decrease labor inputs to promotion, other things equal. The U.K. regulatory system specifically limits the expenditure on promotion that can be included in the rate base.

Unobserved R&D

Investment in R&D as a percentage of sales is higher for pharmaceuticals than for any other industry (U.S. Congressional Budget Office 1994). However, R&D stocks cannot be accurately estimated from the available data. The OECD-STAN data for labor and capital presumably include R&D inputs employed in in-house research facilities. However, R&D inputs are not identified separately and would in any case provide an incomplete measure of R&D investments. Omitted are payments to contractors engaged in clinical trials, license fees and royalties for compounds licensed from abroad, and public investments in R&D, which are a substitute for in-house research.

Estimates of R&D spending obtained from pharmaceutical trade associations' surveys of their members are reported here. These data should include payments to outside contractors but omit expenditures by nonmember firms, nonrespondents to the surveys, and public R&D expenditures. Expenditures on labor and capital are not reported separately. Thus, neither these trade-association data nor the OECD-STAN data provide a comprehensive, country-specific measure of R&D investment flows.

Even if country-specific investments in R&D could be accurately measured, conversion to a stock of knowledge available in each country, by year, would be problematic because of lags and international spillovers. The lag between initial investment in a target compound and final regulatory approval of a new drug averages about twelve years in the United States (DiMasi, Bryant, and Lasagna 1991). This cannot be extrapolated to other countries because of differences in product mix and regulatory systems. More generally, the international diffusion of knowledge through global products, sold under license or through multinational subsidiaries, severs any close link between a country's domestic R&D expenditure, the cumulative stock of knowledge in that country, and the technology underlying the production process. For these reasons, we do not attempt to construct a country-specific measure of R&D stock.[21] We discuss the effects of unobserved R&D stocks below.

13.3.3 Price Indexes

Country-Specific Inflation

Accurate measurement of real productivity growth requires accurate price indexes to convert the value-added data from current to constant local currency units. Price indexes for pharmaceuticals can diverge significantly from those

21. Cocks (1974) develops methods to estimate R&D stocks for a single firm in a single country.

for other goods and services because of regulation, insurance (which insulates consumers from price levels), and nontariff trade barriers. The country-specific GDP deflator reflects economywide inflation and hence can be interpreted as a measure of the opportunity cost of drug expenditures. We use the GDP deflators to deflate all inputs—labor, capital, and R&D expenditures—under the assumption that inputs are purchased in economywide markets. The GDP deflators are also used to adjust output measures for the nonpharmaceutical manufacturing industry.

For pharmaceutical output, we report results using the GDP deflator and two pharmaceutical price indexes. The ideal index would measure the rate of change of a quality-constant, representative basket of drugs sold through all relevant outlets since the expenditure data include both prescription and nonprescription drugs sold through retail pharmacies, hospitals, and other outlets. Given the rapid rate of technical change, the ideal index should use continually updated weights. The official PPIs for drugs may be imperfect because of lags in incorporating new products, inappropriate methods of incorporating new forms of old compounds, use of list rather than transactions prices, and nonrepresentative sampling. The U.S. PPI-drugs was upwardly biased by as much as 50 percent during the late 1980s (Berndt, Griliches, and Rosett 1993), primarily because of delay in incorporating new products. Similar or other biases may be present in the PPIs for other countries (Danzon and Kim 1996). For France, a national accounts price index for drugs is available only from 1988. For the prior years, we use a weighted average of manufacturer price indexes for reimbursable and nonreimbursable drugs reported in SNIP (1993).[22]

Our Divisia pharmaceutical price indexes are based on IMS data for prescription and nonprescription products sold through retail pharmacies. They incorporate new compounds in their second year on the market through chained weights. These indexes nevertheless provide an imperfect deflator for total pharmaceutical output because the indexes exclude sales through hospitals, mail order, supermarkets, and other outlets, they exclude multimolecule drugs, and they exclude discounts; hence, they may overstate the growth in net manufacturer prices in the United States.

Defining a unit of pharmaceutical output is problematic because of the large and continually changing range of compounds, forms, strengths, and pack sizes. For the Divisia indexes used here, the unit of observation is the average price per standard unit for a specific molecule. A standard unit is defined by IMS as one tablet, one capsule, five milliliters of a liquid, etc. It is a rough proxy for a dose and has the advantage that it is defined for all dosage forms, packs, etc. such that the indexes can be based on the universe of data. This measure implicitly assumes that all forms of a given molecule are perfect substitutes. To the extent that generics are in fact imperfect substitutes for origina-

22. These indexes presumably pertain only to outpatient drug sales. Hospital prices are not regulated in France and so may differ from outpatient prices. For the other countries, it is unclear whether the indexes include both prescription drugs and OTC sales and whether hospital sales are included.

tor drugs, these indexes understate price growth and overstate productivity growth; but, to the extent that line extensions and other new forms of old compounds offer real quality improvements, price growth is overstated and productivity growth downwardly biased.[23]

These three indexes are reported in table 13.1 for the years for which all three are available. For all countries except the United States, pharmaceutical prices declined in real terms. The PPI and Divisia indexes are more similar to each other than to the GDP deflator and, on theoretical grounds, are likely to be more accurate. The subsequent discussion focuses on the drugs-specific indexes.

Cross-National Comparisons

For currency conversion for cross-national comparisons, we use GDP PPPs for all input prices and for nonpharmaceutical output. Since GDP PPPs reflect consumer prices rather than producer prices, they are not ideal for comparing productivity at manufacturer prices but are probably the best available measure for the nonpharmaceutical manufacturing sector. However, for pharmaceuticals, conversion at GDP PPPs can lead to systematic bias owing to regulation of manufacturer prices and other factors.

For the cross-national comparisons of pharmaceutical productivity, we therefore also report results using a drugs-specific Fisher price index for the years 1981–91 based on IMS data at manufacturer price levels. For each country compared to the United States, these indexes include all compounds that are available in both countries (see app. B below; and Danzon and Kim 1998). Because these indexes necessarily omit nonmatching (local) drugs, they may be biased if prices for matching drugs, which include the global products produced by multinational corporations, differ systematically from prices for nonmatching local products.[24]

We do not use the medical care PPPs or the pharmaceuticals PPPs reported by the OECD because both have severe limitations for productivity comparisons. The medical PPPs, like the GDP PPPs, are intended to measure consumer price levels, whereas our output data are at manufacturer prices. Because government expenditures are excluded from the medical PPPs, they may be seriously biased as a measure of average price levels in countries where governments account for the majority of medical expenditures and may pay different prices from retail consumer prices.

Moreover, because many medical services are not reimbursed on a fee-for-service basis, the reported prices may not correspond even to list prices—for example, hospitals were paid global budgets in France, Germany, and the

23. These indexes are described in more detail in app. B and in Danzon and Kim (1996), which reports molecule and product indexes, using fixed weights and chained (Divisia) weights. Comparisons between these indexes, the official PPI-drugs, and the OECD price indexes for pharmaceuticals are also discussed.

24. Danzon and Kim (1998) compare price indexes constructed using IMS data to the OECD medical PPPs and GDP PPPs.

Table 13.1 **Measures of Pharmaceutical Price Inflation (1980 = 100)**

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
France[a]												
GDP price index[b]	100.0	111.3	124.7	136.8	146.7	155.3	163.5	168.5	173.8	179.8	185.2	191.0
Divisia price index[c]	100.0	105.5	112.8	117.4	124.1	128.8	133.6	138.2	142.8	146.9	149.0	149.7
PPI-drugs[d]	100.0	110.1	116.6	121.9	126.6	129.4	131.7	134.1	135.1	135.1	136.7	137.9
Germany[e]												
GDP price index[b]	100.0	104.1	108.8	112.4	114.8	117.4	121.2	123.6	125.6	128.8	133.2	138.7
Divisia price index[c]	100.0	104.0	107.0	112.4	116.6	117.6	118.7	118.4	118.1	118.0	115.3	116.0
PPI-drugs[d]	100.0	104.1	107.2	112.3	116.1	119.6	121.4	122.4	123.8	125.9	126.2	128.0
Italy[f]												
GDP price index[b]	100.0	118.9	139.4	160.4	179.1	194.9	210.3	222.8	237.6	252.4	271.3	291.0
Divisia price index[c]	100.0	113.3	128.4	145.4	157.5	170.3	184.0	191.4	199.0	202.5	205.7	216.7
PPI-drugs[d]	100.0	118.9	137.5	156.6	166.6	189.5	190.2	210.5	219.3	223.0	227.3	238.0
United Kingdom[g]												
GDP price index[b]	100.0	111.4	119.8	126.2	131.9	139.5	144.4	151.6	161.5	172.9	183.8	196.2
Divisia price index[c]	100.0	106.3	112.9	120.1	121.2	123.3	125.5	130.6	135.9	141.0	142.9	143.5
PPI-drugs[d]	100.0	107.0	115.5	121.0	124.8	131.4	128.5	134.2	135.9	136.8	141.4	144.7
United States[h]												
GDP price index[b]	100.0	110.0	116.8	121.6	127.0	131.6	135.1	139.5	144.9	151.3	157.9	164.2
Divisia price index[c]	100.0	111.3	123.7	137.8	151.5	161.8	172.8	182.1	191.8	206.7	227.9	247.0
PPI-drugs[d]	100.0	109.0	117.0	128.0	137.9	149.1	160.9	172.9	185.2	200.6	214.7	229.2

[a]SNIP (1993).

[b]From OECD HEALTH DATA (CREDES).

[c]1980 base imputed from average growth rates from 1981–82 and 1982–83. From Danzon and Kim (1996) using IMS data. See app. B.

[d]For Germany, Italy, and the United Kingdom, the 1980 base imputed from the average for 1981–82 and 1982–83. 1981 index imputed from growth rate for June–December 1981. 1980 index imputed from the growth rate for June 1981–December 1982.

[e]*Preise und Preisindizes fur gewerbliche Produkte,* Statistisches Bundesamt.

[f]*Bollettino mensile di statistica,* Istitute Nazionale di Statistica.

[g]*Annual Abstract of Statistics,* Central Statistical Office, H.M. Stationery Office, London.

[h]Bureau of Labor Statistics, Producer Price Index, http://www.bls.gov/ppihome.htm.

United Kingdom during much of this period, physicians in the United Kingdom are paid either a salary or a capitation per enrolled patient, etc. Even where physicians are paid fee for service, as in Germany, the duration and content of a "visit" tends to be reduced as the prices are reduced and may also change owing to technological change. Estimating an accurate, quality-constant price index is particularly difficult in medical care because of the rapid rate of technical change and hence in the real content of services that do not change in name. For example, the real content of a hospital day is very different today than twenty years ago, but this quality change is typically embedded in the reported measure of price change.[25]

In the case of the pharmaceutical PPPs, the sample is very small; retail prices may differ significantly from manufacturer prices;[26] the index is unweighted; it includes medical devices; and it includes imputed values where prices are unavailable, which is inappropriate if unavailability reflects systematic differences between the unavailable products and the available products, owing to preferences and regulation. The differences between the OECD PPPs and our pharmaceutical indexes based on IMS data are discussed further in Danzon and Kim (1998).

The Fisher indexes for the United States relative to each comparison country are reported in table 13.2. They show the differences that remain in pharmaceutical prices after converting at exchange rates. Prices are lowest in France and decline steadily for most of the period, consistent with the hypothesis of increasing regulatory stringency. Italy has the second lowest prices, with considerable variation over the period that reflects exchange rate fluctuations as well changing regulatory stringency. The United Kingdom is third lowest and also shows declining prices over time, relative to the United States, which again suggests increasing regulatory stringency in the United Kingdom. Germany's prices decline, relative to the United States, following the introduction of reference pricing in 1989.

These data indicate that regulation has constrained the level and growth of drug prices at the manufacturer level relative to the unregulated U.S. prices. This confirms the importance of using sector-specific prices indexes for cross-national comparisons of a heavily regulated industry such as pharmaceuticals. Note that the estimates of U.S. price levels and growth are upwardly biased owing to the omission of discounts to managed care and public purchasers, which increased during the late 1980s and 1990s.[27]

25. Cutler et al. (1996) discuss the upward bias in the U.S. CPI for medical care, relative to a true cost-of-living index.

26. Distribution margins account for up to half of purchaser price levels for pharmaceuticals in some European countries (Healy 1995).

27. The Fisher indexes conceal significant differences between the U.S.-weighted Laspeyres indexes and the foreign-weighted Paasche indexes. The Laspeyres indexes show Germany, Canada, and Japan with higher prices than the United States. The Paasche indexes show foreign prices uniformly lower than U.S. prices, by as much as 50 percentage points (see Danzon and Kim 1998; Danzon and Chao 1999).

Table 13.2 **U.S. Relative to Foreign Prices for Pharmaceuticals, Fisher Price Indexes,[a] Single Molecule Products, Retail Pharmacy: Matching by Molecule/Therapeutic Category**

	1981	1982	1983	1984	1985[b]	1986	1987[b]	1988	1989	1990	1991	1992
France	1.66	1.84	2.13	2.52	2.38	2.24	2.35	2.46	2.81	2.68	2.65	2.06
Germany	.87	.99	1.09	1.26	1.24	1.23	1.18	1.13	1.42	1.39	1.35	1.44
Italy	1.84	2.11	2.06	2.39	2.21	2.04	2.00	1.95	2.25	2.13	1.93	1.79
United Kingdom	1.04	1.20	1.41	1.67	1.68	1.68	1.54	1.39	1.56	1.66	1.66	1.71

[a]IMS data. See Danzon and Kim (1998).

[b]1985 and 1987 values were estimated by taking the average of 1984 + 1986 and 1986 + 1988, respectively.

13.4 Empirical Results

13.4.1 Pharmaceutical Production

In all countries, growth in production of pharmaceuticals has far outpaced total manufacturing in the 1980s, regardless of the price index used (table 13.3). Using the Divisia indexes, pharmaceutical production increased 170 percent in Italy, 90 percent in France, 96 percent in the United Kingdom, 55 percent in Germany, and 18 percent in the United States. Relative to this benchmark, the estimates based on the GDP deflator are downwardly biased by 40–50 percentage points for France, Italy, and the United Kingdom, but the U.S. estimate is upwardly biased by 52 percentage points. The slow growth in Germany, relative to the other European countries, supports the hypothesis that production has been diverted from Germany to countries whose regulatory environments specifically reward local production, such as France, Italy, and the United Kingdom.

13.4.2 Employment

Between 1980 and 1990, employment in pharmaceuticals grew almost three times as rapidly in France (15.8 percent) as in the United States (5.8 percent) and the United Kingdom (3.5 percent) (table 13.4). By 1990, pharmaceutical employment was 2.0 percent of total manufacturing employment in France, compared to 1.4 percent in the United Kingdom, 1.2 percent in Germany, 1.3 percent in Italy, and 0.95 percent in the United States excluding Puerto Rico. Although this evidence is consistent with the hypothesis that regulation has stimulated employment in France and the United Kingdom since production has also grown rapidly in France, the alternative hypothesis of demand-driven expansion of production and sales force cannot be dismissed without evidence on productivity. Whether the growth in pharmaceutical employment is a net gain, as intended by industrial policy, or simply a diversion from other sectors remains an open question.

13.4.3 Value Added

Trends in value added are similar to trends in total production, with much more rapid growth in pharmaceuticals than in other manufacturing industries (table 13.5). Again, results are very sensitive to the price index.

To provide a measure that is independent of the price index, we calculated the cumulative growth in value added relative to the cumulative growth in production between 1980 and 1990. This ratio is 0.58 in Italy and 0.87 in France; by contrast, the ratio is 1.06 in the United States, 1.12 in the United Kingdom, and 1.13 in Germany. Thus, the ratio of value added to output declined in countries with strict price regulation but increased in the other three countries. This is consistent with the hypothesis that biased price regulation reduced the rate of growth of productivity.

Table 13.3 **Growth in Production, 1970–90[a] (GDP deflator adjusted values unless noted; 1980 = 100)**

	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
France													
Total manufacturing	70.6	81.8	100.0	99.2	98.6	96.9	98.7	98.6	93.4	93.2	97.7	103.1	103.8
Chemical products	56.3	72.8	100.0	101.3	97.2	95.4	99.6	99.2	82.5	80.7	83.8	88.1	88.3
Drugs & medicines	71.5	87.4	100.0	107.2	108.6	113.7	116.2	121.6	125.2	126.6	138.2	145.3	152.6
Divisia price index	...	...	100.0	113.1	120.1	132.5	137.4	146.6	153.2	154.4	168.1	177.8	189.8
PPI-drugs	...	...	100.0	108.4	116.2	127.6	134.7	145.9	155.4	159.0	177.8	193.3	206.8
Germany													
Total manufacturing	81.1	85.1	100.0	100.1	97.2	96.7	101.0	104.8	101.2	99.5	103.5	109.2	113.1
Chemical products	61.8	73.9	100.0	104.6	99.5	99.9	106.4	109.0	93.1	89.7	93.5	98.9	99.8
Drugs & medicines	71.1	108.0	100.0	102.9	99.8	107.0	112.0	113.1	116.2	116.7	124.7	126.0	134.0
Divisia price index	...	...	100.0	103.0	101.5	107.0	110.3	112.9	118.7	121.8	132.6	137.5	154.8
PPI-drugs	...	...	100.0	102.9	101.3	107.1	110.7	111.1	116.0	117.8	126.5	128.9	141.4
Italy													
Total manufacturing	58.3	82.9	100.0	98.3	96.3	92.7	97.8	100.0	95.8	97.8	105.0	111.0	106.9
Chemical products	40.2	81.0	100.0	101.0	100.8	100.3	111.9	118.0	109.2	117.4	126.9	134.1	129.1
Drugs & medicines[b]	64.4	76.4	100.0	107.7	111.0	118.6	131.6	149.5	152.2	164.9	177.1[c]	207.5[c]	204.6[c]
Divisia price index	...	...	100.0	113.0	120.5	130.8	149.7	171.1	173.9	191.9	211.5	258.6	269.9
PPI-drugs	...	...	100.0	107.7	112.5	121.5	141.5	153.8	168.3	174.5	191.9	234.9	244.2

United Kingdom													
Total manufacturing[b]	96.2	105.2	100.0	90.7	89.6	91.4	97.1	98.5	94.8	101.3	104.8	106.7	104.3
Chemical products[b]	65.9	94.5	100.0	91.8	90.4	94.0	102.6	100.9	84.8	101.7	99.8	102.6	102.1
Drugs & medicines[b]	88.5	85.8	100.0	97.1	104.3	106.2	113.8	118.3	125.6	135.3	144.8	150.3	152.3
Divisia price index	...	...	100.0	101.8	110.7	111.6	123.9	133.8	144.6	157.1	172.1	184.3	196.0
PPI-drugs	...	...	100.0	101.1	108.2	110.8	120.3	125.6	141.2	152.9	172.1	190.0	198.0
United States													
Total manufacturing	71.1	80.6	100.0	99.3	90.1	92.0	98.2	95.9	93.4	96.0	100.2	102.1	100.6
Chemical products	49.8	67.5	100.0	102.2	91.0	88.8	90.1	85.3	74.2	79.0	82.5	84.8	87.7
Drugs & medicines[b]	69.5	81.9	100.0	101.6	105.5	113.0	114.6	119.1	127.2	140.2	151.3	161.7	169.5
Divisia price index	...	...	100.0	100.4	99.6	99.8	96.0	96.9	99.4	107.4	114.3	118.4	117.5
PPI-drugs	...	...	100.0	102.5	105.3	107.4	105.5	105.1	106.8	113.1	118.3	122.0	124.7

[a]Production is national accounts compatible (gross output).

[b]Survey-based data may not be national accounts compatible.

[c]Figures are estimated using the ratio of Drugs and Medicines to Other Chemicals for the closest year for which data are available.

Table 13.4 **Growth in Number of Employees, 1975–90 (1980 = 100)**

	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
France												
Total manufacturing	106.2	100.0	96.8	95.5	93.6	90.7	88.1	86.4	84.2	82.8	83.1	83.5
Chemical products	105.2	100.0	97.2	95.4	93.0	92.1	90.8	90.6	89.7	89.5	91.0	92.0
Drugs & medicines[a]	101.9[b]	100.0	102.4	102.9	104.2	105.6	106.8	107.8	107.2	108.6	112.2	115.8
Germany												
Total manufacturing	100.0	100.0	98.2	95.3	92.1	91.7	92.9	94.3	94.4	94.2	95.6	98.3
Chemical products	97.7	100.0	99.3	98.6	96.7	97.7	99.7	101.7	103.3	105.4	106.0	109.2
Drugs & medicines	105.1[b]	100.0	101.4	102.7	102.9	104.6	104.5	107.1	107.7	109.2	108.4	113.4
Italy												
Total manufacturing	94.7	100.0	96.4	93.9	90.2	86.1	85.0	84.5	83.7	84.8	85.2	85.2
Chemical products	99.0	100.0	93.4	90.2	88.1	86.4	86.2	88.3	91.0	92.9	94.7	94.5
Drugs & medicines[a]	101.4[b]	100.0	99.8	99.2	96.7	98.8	97.0	97.9	99.4	103.2	104.2[b]	104.2[b]
United Kingdom												
Total manufacturing	108.1	100.0	89.9	84.8	80.0	78.8	78.5	76.7	76.2	77.3	77.8	77.6
Chemical products	104.8	100.0	90.6	86.4	82.0	82.6	82.4	81.2	81.7	84.1	85.5	85.7
Drugs & medicines[a]	90.0	100.0	95.2	93.5	92.6	92.7	91.4	92.7	96.8	98.7	104.1	103.5
United States												
Total manufacturing	89.5	100.0	99.7	92.3	90.9	95.6	94.7	93.6	94.0	96.0	96.3	95.0
Chemical products	88.3	100.0	101.3	96.5	95.3	98.7	98.2	96.9	100.0	102.2	103.5	104.4
Drugs & medicines[a]	86.7	100.0	98.3	96.0	97.1	96.5	94.8	96.0	99.4	101.2	106.4	105.8

[a]Survey-based data may not be national accounts compatible.

[b]Figures are estimated using the ratio of Drugs and Medicines to Other Chemicals for the closest year for which data are available.

Table 13.5 **Growth of Value Added, 1970–90[a] (GDP deflator adjusted values unless noted; 1980 = 100)**

	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
France													
Total manufacturing	85.3	95.5	100.0	97.0	97.0	96.9	95.9	97.9	100.8	99.8	105.2	108.8	110.6
Chemical products	84.4	89.1	100.0	94.9	93.3	100.4	98.5	105.2	115.7	109.9	117.3	117.2	117.7
Drugs & medicines	64.7	79.2	100.0	103.7	101.9	113.1	105.6	106.1	117.0	122.6	126.4	123.7	132.8
Divisia price index	. . .	. . .	100.0	109.4	112.6	131.8	124.8	128.0	143.1	149.6	153.7	151.4	165.1
PPI-drugs	. . .	. . .	100.0	104.8	109.0	127.0	122.4	127.4	145.2	154.1	162.5	164.7	179.9
Germany													
Total manufacturing	90.8	90.4	100.0	98.0	95.7	97.0	99.2	103.5	107.5	106.1	109.1	111.8	116.4
Chemical products	84.0	89.6	100.0	99.9	95.6	102.5	106.6	109.2	117.5	106.7	114.8	116.7	117.0
Drugs & medicines	81.4	90.5	100.0	105.8	107.2	116.6	117.1	120.3	130.6	125.6	135.1	148.9	150.8
Divisia price index	. . .	. . .	100.0	105.9	109.1	116.6	115.4	120.0	133.4	131.0	143.6	162.6	174.3
PPI-drugs	. . .	. . .	100.0	105.8	108.8	116.7	115.8	118.1	130.4	126.8	137.0	152.4	159.2
Italy													
Total manufacturing	67.2	79.2	100.0	96.6	93.8	90.3	91.7	93.5	94.0	95.4	100.1	102.8	100.3
Chemical products	72.9	88.7	100.0	93.2	90.9	91.4	98.5	110.6	107.6	112.9	119.5	123.7	118.0
Drugs & medicines[b]	92.3	92.8	100.0	100.4	101.9	105.8	110.6	116.5	109.9	115.2	118.1[c]	127.2[c]	118.3[c]
Divisia price index	. . .	. . .	100.0	105.4	110.6	116.8	125.8	133.4	125.6	134.1	141.0	158.5	156.1
PPP-drugs	. . .	. . .	100.0	100.4	103.3	108.4	118.9	119.8	121.5	121.9	128.0	143.9	141.2

(continued)

Table 13.5 (continued)

	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
United Kingdom													
Total manufacturing	100.8	101.1	100.0	91.3	91.7	91.7	92.1	97.3	101.1	101.9	106.6	108.9	106.2
Chemical products	81.4	96.7	100.0	89.4	90.6	95.2	100.7	106.8	114.4	118.7	124.1	127.6	124.6
Drugs & medicines[b]	75.2	75.3	100.0	96.4	106.8	106.7	115.7	121.2	129.6	146.1	159.4	164.9	170.0
Divisia price index	...	...	100.0	101.0	113.4	112.2	125.9	137.1	149.2	169.6	189.4	202.2	218.7
PPI-drugs	...	...	100.0	100.4	110.8	111.3	122.3	128.6	145.7	165.0	189.4	208.5	221.0
United States													
Total manufacturing	88.3	89.4	100.0	100.7	93.6	96.7	104.5	103.3	104.6	105.4	109.0	109.1	106.0
Chemical products	84.9	91.8	100.0	105.8	106.3	113.3	118.7	116.6	125.8	126.9	139.0	139.7	140.2
Drugs & medicines[b]	77.5	86.6	100.0	100.3	107.8	118.1	120.1	128.0	133.9	149.6	158.7	168.3	179.5
Divisia price index	...	...	100.0	99.1	101.8	104.2	100.6	104.0	104.7	114.6	119.9	123.2	124.4
PPI-drugs	...	...	100.0	101.2	107.6	112.2	110.6	112.9	112.4	120.7	124.2	127.0	132.0

[a]Value added is national accounts compatible value added.

[b]Survey-based data may not be national accounts compatible.

[c]Figures are estimated using the ratio of Drugs and Medicines to Other Chemicals for the closest year for which data are available.

13.4.4 Value Added per Employee

The results for value-added per employee (table 13.6) again depend critically on the price index. The estimates based on the GDP deflator imply that labor productivity growth in France has been 50 percent lower in pharmaceuticals than in total manufacturing, despite (or because of) the more rapid growth in employment in pharmaceuticals than in total manufacturing. A similar pattern holds for Italy. By contrast, for the United Kingdom, Germany, and the United States, labor productivity growth in pharmaceuticals appears to have outpaced total manufacturing.

However, using either the PPI-drugs or the Divisia indexes increases the estimates of labor productivity growth for all countries except the United States, reflecting the decline in real drug price over time in all countries except the United States. With these indexes, labor productivity growth is roughly twice as high in the United Kingdom as in France, Germany, and Italy, which are similar. The United States lags the other four countries for pharmaceuticals, as it does for total manufacturing. These results seem inconsistent with the hypothesis that increasingly stringent price regulation in France and Italy has generated increased distortions of productivity over time. A possible confounding factor—and a plausible explanation for the apparently inconsistent results—is that the market share of global drugs has increased over time, relative to local drugs. Assuming that productivity is absolutely higher for global drugs, an increasing market share of global drugs in France and Italy could bias upward the estimates of productivity growth for each sector separately.[28]

Tables 13.7 and 13.8, which compare labor productivity levels relative to the United States, illustrate the sensitivity of international comparisons to the conversion index. Converting at GDP PPPs (table 13.7), value added per employee in pharmaceuticals is more than twice as high in the United States as in all European countries. Adding Puerto Rico to the United States widens the gap by 3–4 percentage points. Of the European countries, the United Kingdom leads with value added per employee of 47 percent of the United States, followed by Germany 33.2 percent, Italy 28.7 percent, and France 19.8 percent. This shortfall of labor productivity in Europe relative to the United States is much greater in pharmaceuticals than for total manufacturing, for which the 1990 figures are 92.7 percent for France, 79.4 percent for Italy, 77.2 percent for Germany, and 62.6 percent for the United Kingdom.

However, because the low estimates of labor productivity for pharmaceuticals in Europe relative to the United States partly reflect the lower prices in Europe (see table 13.2), table 13.8 reports labor productivity, relative to the United States, with all countries adjusted to U.S. price levels using the pharma-

28. Market shares of global and local drugs over time are not available. However, the decline in the number of pharmaceutical companies operating in France, from 507 in 1970 to 353 in 1991, is consistent with a declining market share of local products. In 1989, French companies accounted for 48 percent of sales (SNIP 1993).

Table 13.6 **Growth of Value Added per Employee, 1970–90[a] (GDP deflator adjusted values unless noted; 1980 = 100)**

	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
France													
Total manufacturing	83.3	90.0	100.0	100.2	101.5	103.6	105.7	111.1	116.7	118.6	127.0	131.0	132.4
Chemical products	87.4	84.6	100.0	97.6	97.7	107.9	106.9	115.9	127.7	122.4	131.1	128.8	127.9
Drugs & medicines[b]	. . .	77.8	100.0	101.3	99.0	108.5	100.0	99.4	108.6	114.4	116.3	110.3	114.6
Divisia price deflator	. . .	. . .	100.0	106.1	109.2	126.9	119.8	122.3	136.5	144.5	147.6	141.5	150.4
Germany													
Total manufacturing	81.6	90.4	100.0	99.8	100.4	105.3	108.2	111.5	113.9	112.4	115.8	117.0	118.4
Chemical products	82.7	91.7	100.0	100.6	97.0	106.0	109.1	109.5	115.6	103.3	108.9	110.1	107.2
Drugs & medicines	. . .	86.1[c]	100.0	104.4	104.4	113.4	112.0	115.1	121.9	116.6	123.7	137.4	133.0
Divisia price deflator	. . .	. . .	100.0	106.2	108.4	116.4	114.7	120.5	131.8	129.1	139.9	159.7	163.5
Italy													
Total manufacturing	74.2	83.6	100.0	100.3	99.9	100.1	106.4	110.0	111.3	114.0	118.0	120.6	117.7
Chemical products	81.3	89.6	100.0	99.9	100.8	103.7	114.1	128.4	121.9	124.0	128.6	130.7	124.8
Drugs & medicines[b,d]	. . .	91.5[c]	100.0	100.6	102.8	109.4	112.0	120.1	112.2	115.9	114.5	122.1	113.6
Divisia price deflator	. . .	. . .	100.0	107.5	115.7	128.0	138.1	151.8	144.0	152.9	156.3	175.4	174.2
United Kingdom													
Total manufacturing	84.3	93.6	100.0	101.6	108.1	114.6	116.9	123.9	131.9	133.8	137.9	139.9	136.8
Chemical products	75.8	92.2	100.0	98.7	104.9	116.1	122.0	129.6	140.9	145.4	147.5	149.2	145.4
Drugs & medicines[b,d]	76.7	83.7	100.0	101.3	114.2	115.2	124.8	132.6	139.8	150.9	161.5	158.5	164.2
Divisia price deflator	. . .	. . .	100.0	106.1	121.0	121.3	136.8	152.1	164.1	179.8	198.4	203.0	221.4
United States													
Total manufacturing	92.9	99.9	100.0	101.0	101.4	106.4	109.3	109.1	111.7	112.2	113.6	113.2	111.5
Chemical products	95.3	104.0	100.0	104.4	110.1	118.8	120.3	118.7	129.8	126.8	136.0	135.0	134.3
Drugs & medicines[b,d]	102.4	99.9	100.0	102.0	112.3	121.6	124.4	135.0	139.6	150.5	156.9	158.3	169.7
Divisia price deflator	. . .	. . .	100.0	101.6	107.4	109.9	107.4	113.5	113.1	120.2	124.2	122.1	125.4

[a]Value Added is national accounts compatible value added.

[b]Employment figures are survey-based data and may not be national accounts compatible.

[c]Figures are estimated using the ratio of Drugs and Medicines to Other Chemicals for the closest year for which data are available.

Table 13.7 **Value Added per Employee relative to United States, GDP PPP Conversion[a] (United States = 100)**

	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
France													
Total manufacturing	70.5	71.7	79.4	78.5	79.3	76.9	76.1	79.9	81.9	82.7	87.5	90.5	92.7
Other chemicals	46.6	45.7	63.2	62.5	53.5	53.4	48.1	48.6	47.8	49.0	49.8	51.5	53.4
Drugs & medicines[b]	. . .	23.2[c]	29.8	29.5	26.2	26.5	23.7	21.7	22.9	22.3	21.8	20.4	19.8
Drugs & medicines (including Puerto Rico)	. . .	. . .	. . .	. . .	23.7	. . .	. . .	. . .	. . .	20.5	. . .	. . .	. . .
Germany													
Total manufacturing	63.9	66.3	73.3	72.3	72.3	72.3	72.0	74.3	74.3	72.7	74.1	75.1	77.2
Other chemicals	43.7	48.1	45.7	59.4	49.8	51.4	49.1	48.8	49.0	45.2	46.9	48.2	46.2
Drugs & medicines	. . .	36.8[c]	42.7	43.6	39.5	39.7	38.2	36.2	37.1	32.8	33.4	36.8	33.2
Drugs & medicines (including Puerto Rico)	. . .	. . .	. . .	. . .	35.8	. . .	. . .	. . .	. . .	30.1	. . .	. . .	. . .

(continued)

Table 13.7 (continued)

	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Italy													
Total manufacturing	60.8	64.0	76.6	75.8	75.2	71.7	73.8	76.3	75.3	76.7	78.4	80.3	79.4
Other chemicals	56.7	48.5	65.9	56.2	50.1	46.3	50.2	54.1	46.1	47.5	48.7	52.6	46.9
Drugs & medicines[b,d]	...	39.9[c]	43.7	42.9	39.8	39.1	39.0	38.4	34.7	33.1	31.4[c]	33.2[c]	28.7[c]
Drugs & medicines (including Puerto Rico)	...	...	...	...	36.0	...	...	...	...	30.5	...	...	...
United Kingdom													
Total manufacturing	47.1	48.6	51.6	51.5	54.3	55.5	54.1	57.5	60.4	60.9	62.5	63.0	62.6
Other chemicals	27.7	29.4	37.1	34.4	32.5	31.5	32.5	34.7	34.9	35.0	36.3	36.4	35.2
Drugs & medicines[b,d]	37.0	41.3	49.1	48.4	49.3	46.5	48.3	47.4	48.7	48.7	50.4	48.6	47.0
Drugs & medicines (including Puerto Rico)	...	...	...	...	44.6	...	...	...	...	44.8	...	...	...

[a]Calculated using GDP PPPs.

[b]Survey-based employment data may not be national accounts compatible.

[c]Figures are estimated using the ratio of drugs and medicines to chemicals for the closest year for which data are available.

[d]Survey-based value-added data may not be national accounts compatible.

Table 13.8 **Value Added per Employee relative to United States, Fisher Price Indexes[a] (United States = 100)**

	1981	1982	1982[b]	1983	1984	1985	1986	1987	1987[b]	1988	1989	1990
Drugs & Medicines												
France[c]	50.7	43.5	39.3	46.3	44.2	38.0	50.2	59.2	54.4	60.5	60.1	64.2
Germany	39.2	37.1	33.5	38.7	37.8	34.0	46.7	47.3	43.5	46.1	58.6	59.6
Italy[c,d]	61.2	60.4	54.7	57.1	61.3	54.4	60.8	67.3	61.9	63.6[e]	74.8[e]	72.5[e]
United Kingdom[c,d]	52.3	55.0	49.7	52.6	58.1	56.2	66.2	68.9	63.3	71.3	73.3	83.6
United States[c,d]	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[a]For Fisher price indexes, see table 13.2, app. B below, and Danzon and Kim (1998).

[b]Figures in these columns use the United States and Puerto Rico as base.

[c]Survey-based employment data may not be national accounts compatible.

[d]Survey-based value added may not be national accounts compatible.

[e]Figures are estimated using the ratio of drugs and medicines to chemicals for the closest year for which data are available.

ceuticals-specific Fisher indexes. Although this dramatically improves the European productivity measures, Germany is still only 60 percent of the United States, France 64 percent, Italy 73 percent, and the United Kingdom 84 percent. All countries except the United Kingdom still show lower productivity for pharmaceuticals than for total manufacturing. This may understate the productivity shortfall in pharmaceuticals because of the exclusion of local products from these Fisher indexes. If local products, which are produced by local firms and have relatively low prices, are less stringently regulated than global products that are produced by multinational corporations and are generally higher priced, then the Fisher indexes understate foreign prices and overstate foreign productivity, relative to the United States.

For the United States, the OECD data exclude Puerto Rico, which accounted for roughly 14 percent of U.S. production and 9 percent of employment in the 1980s. Adding Puerto Rico (where available) raises U.S. value added by about 3 percentage points (1987 data), as expected given the tax incentives to locate high-value-added operations in Puerto Rico.

Note that, for purposes of comparing productivity cross-nationally, pricing the output of different countries at a common price level is appropriate. The table 13.8 estimates, with all countries compared at U.S. prices using the Fisher indexes, therefore provide a more accurate comparison of labor productivity in pharmaceuticals than the table 13.7 estimates that use GDP PPPs.[29] However, for purposes of evaluating the efficiency of resource allocation to drugs relative to other sectors within each country, each country's output should be valued at local prices; thus, for this purpose, the table 13.7 comparisons that use local prices and GDP PPP conversion are more appropriate. These show significantly lower labor productivity in pharmaceuticals than in other manufacturing in France and Italy, yet employment has grown more rapidly in pharmaceuticals than in other manufacturing in these countries. We return to this below.

13.4.5 Capital Investment

Between 1980 and 1990, fixed capital investment in pharmaceuticals increased 150 percent[30] in France, compared to roughly 60 percent in the United States and the United Kingdom and compared to 33 percent for total manufacturing in France (table 13.9). Investment per employee increased 116 percent in pharmaceuticals in France, compared to 59 percent in total manufacturing (table 13.10), consistent with the hypothesis of biased regulation. The more

29. The use of the United States as the benchmark price level does not affect the results because the Fisher indexes are the geometric mean of the Laspeyres and Paasche indexes, which, respectively, use consumption patterns in the United States and the foreign country as weights. Ideally, inputs should also be measured at common price levels. This adjustment cannot be made with the available data.

30. The 1990 figure of 250 appears to be above trend; the three-year average for 1989–91 is 237. Using this lower figure would not affect the conclusions.

Table 13.9 **Growth in Gross Fixed Capital Formation, 1975–90[a] (GDP deflator adjusted values; 1980 = 100)**

	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
France												
Total manufacturing	83.3	100.0	93.3	88.4	85.3	86.2	94.4	97.9	102.6	113.3	120.7	132.6
Chemical products	79.3	100.0	91.3	82.0	76.9	72.7	85.1	85.7	91.8	96.6	105.7	117.9
Drugs & medicines[b]	. . .	100.0	114.1	141.5	131.3	135.4	156.7	183.7	204.9	205.6	232.5	250.1
Germany												
Total manufacturing	76.2	100.0	94.2	85.4	86.1	84.8	96.4	103.0	107.7	109.7	120.1	132.6
Chemical products	97.2	100.0	97.6	89.9	88.7	85.9	95.7	105.3	117.1	116.9	127.7	137.9
Drugs & medicines	. . .	100.0	105.6	100.4	112.0	115.5	119.5	134.4	132.3	111.1	125.3	136.2
Italy												
Total manufacturing	82.2	100.0	89.2	80.9	71.9	75.6	69.6	70.3	77.7	85.2	92.7	. . .
Chemical products	199.1	100.0	86.1	80.1	73.0	77.1	78.0	74.8	89.4	102.0	88.0	
Drugs & medicines	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
United Kingdom												
Total manufacturing	95.9	100.0	76.8	74.4	73.9	87.7	100.8	93.7	99.1	105.7	114.8	108.3
Chemical products	89.8	100.0	75.0	69.2	72.8	80.6	100.2	94.3	103.3	99.6	104.2	102.0
Drugs & medicines[b]	76.2	100.0	113.5	93.0	94.6	97.8	131.5	135.1	136.0	153.6	158.1	161.9
United States												
Total manufacturing	75.3	100.0	106.2	96.0	73.9	85.3	93.4	80.2	86.1	85.2	100.6	101.7
Chemical products	93.0	100.0	110.7	113.5	80.0	80.5	84.2	68.2	76.7	86.5	107.3	106.2
Drugs & medicines[b]	76.8	100.0	106.1	118.9	108.7	125.1	123.9	109.5	139.3	157.8	175.7	160.4

[a]Gross fixed capital formation is national accounts–compatible gross fixed capital formation (land, buildings, machinery, and equipment).

[b]Survey-based data may not be national accounts compatible.

Table 13.10 **Growth in Gross Fixed Capital Formation per Employee (GDP deflator adjusted values; 1980 = 100)**

	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
France												
Total manufacturing	78.5	100.0	96.4	92.6	91.1	94.9	107.2	113.3	121.9	136.8	145.3	158.8
Chemical products	75.4	100.0	93.9	85.9	82.7	78.9	93.8	94.6	102.3	108.0	116.1	128.2
Drugs & medicines[a,b]	...	100.0	111.5	137.5	126.0	128.3	146.8	170.4	191.2	189.3	207.2	215.9
Germany												
Total manufacturing	76.1	100.0	95.9	89.6	93.4	92.4	103.8	109.2	114.1	116.4	125.6	134.9
Chemical products	99.5	100.0	98.3	91.1	91.7	87.9	96.0	103.6	113.4	110.9	120.5	126.3
Drugs & medicines	...	100.0	104.2	97.7	108.8	110.4	114.3	125.5	122.9	101.7	115.5	120.1
Italy												
Total manufacturing	86.8	100.0	92.5	86.1	79.7	87.7	81.9	83.1	92.9	100.4	108.7	...
Chemical products	201.1	100.0	92.2	88.8	82.9	89.3	90.5	84.8	98.2	109.7	93.0	...
Drugs & medicines[b]	...	...	...	...	...	...	...	...	...	...	...	...
United Kingdom												
Total manufacturing	88.8	100.0	85.4	87.8	92.4	111.3	128.3	122.1	130.1	136.7	147.4	139.7
Chemical products	85.7	100.0	82.8	80.1	88.7	97.7	121.7	116.0	126.4	118.5	121.9	119.0
Drugs & medicines[a,b]	84.4	100.0	119.2	99.5	102.1	105.4	143.9	145.7	140.4	155.6	151.9	156.3
United States												
Total manufacturing	84.1	100.0	106.5	104.0	81.3	89.2	98.7	85.7	91.6	88.7	104.4	107.1
Chemical products	105.3	100.0	109.2	117.5	83.9	81.6	85.8	70.3	76.7	84.7	103.7	101.8
Drugs & medicines[a,b]	88.6	100	107.9	123.9	112	129.6	130.7	114.1	140.1	156	165.2	151.7

[a]Survey-based data may not be national accounts compatible.

[b]Employment figures are survey-based data and may not be national accounts compatible.

rapid growth in labor productivity in the French pharmaceutical industry relative to other French manufacturing (measured using the Divisia indexes) may thus in part reflect the increasing capital/labor ratio.

Between 1980 and 1990, the United Kingdom also experienced more rapid growth in capital investment, both absolutely and per employee, in pharmaceuticals than in total manufacturing, consistent with the predicted effects of rate-of-return regulation. The growth in capital/labor ratios may have contributed to the growth in value added per employee in pharmaceuticals relative to total manufacturing (64 vs. 37 percent) in the United Kingdom.

Lower capital/labor ratios in France and Germany may contribute to their lower labor productivity relative to the United States in pharmaceuticals.[31] Capital formation per employee in pharmaceuticals, relative to the United States, is 57 percent for France, 49 percent for Germany, and 99 percent for the United Kingdom (table 13.11). By contrast, capital formation per employee for total manufacturing relative to the United States is 125 percent in France, 84 percent in Germany, and only 65 percent in the United Kingdom. For Germany, whereas capital formation per employee in total manufacturing has increased relative to the United States (from 61 percent in 1975 to 84 percent in 1990), for pharmaceuticals the trend is reversed, dropping from 79 percent of the U.S. level in 1975 to 40 percent in 1988 and 49 percent in 1989. These results are consistent with the hypothesis that pharmaceutical investments have been diverted from Germany to other European Union countries.

13.4.6 R&D

Table 13.12 reports estimates of R&D expenditures, using survey data from pharmaceutical trade associations (Centre for Medicines Research 1993). R&D expenditures in constant local currency units have grown most rapidly in the United States, both absolutely and relative to labor, and most slowly in Germany since the mid-1980s. R&D investment per employee is roughly twice as high in the United States as in other countries (table 13.12, panel C). As noted earlier, country-specific R&D stocks cannot be directly calculated from R&D investment flows because of lags in launch and international diffusion. However, assuming that R&D stocks are positively correlated with investment flows, these data suggest that stocks of unobserved R&D capital are significant and are probably larger in the United States than in other countries.

13.5 Multifactor Productivity Growth

Estimates of multifactor productivity growth require measures of output elasticities. As discussed earlier, the conventional use of factor shares as prox-

31. We compare capital formation rather than the estimated capital stock per employee because the capital stock estimates depend on the assumed life of capital for which we have no accurate data. With our base-case assumption of a ten-year life of capital in all countries, the capital formation and capital stock estimates are highly correlated.

Table 13.11 **Gross Fixed Capital Formation per Employee, 1975–90, Relative to the United States[a] (GDP PPP conversion; United States = 100)**

	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
France												
Total manufacturing	79.9	85.4	77.1	75.8	95.3	90.1	91.8	111.5	112.0	129.8	117.1	124.5
Other chemicals	68.4	59.3	60.7	54.7	66.0	57.8	63.7	77.6	59.3	71.6	66.8	78.6
Drugs & medicines[b,c]	. . .	40.8	42.0	45.1	45.6	40.0	45.3	60.1	54.8	48.8	50.4	57.0
Drugs & medicines (including Puerto Rico)[b,c]	. . .	. . .	. . .	43.2	. . .	. . .	. . .	. . .	51.8	. . .	. . .	. . .
Germany												
Total manufacturing	61.1	67.4	60.6	57.8	77.2	69.3	70.4	85.4	83.1	87.7	80.4	84.3
Other chemicals[b]	66.0	67.1	57.4	47.6	57.5	54.8	62.7	78.3	62.8	57.9	61.9	64.0
Drugs & medicines[c]	. . .	62.1	59.9	48.8	60.2	52.5	53.9	67.9	53.9	40.1	43.1	48.8
Drugs & medicines (including Puerto Rico)[c]	. . .	. . .	. . .	46.8	. . .	. . .	. . .	. . .	51.0	. . .	. . .	. . .
Italy												
Total manufacturing	118.3	114.9	99.4	94.7	111.9	111.9	94.3	110.0	114.7	128.1	117.8	. . .
Other chemicals	. . .											
Drugs & medicines[c]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Drugs & medicines (including Puerto Rico)[c]	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
United Kingdom												
Total manufacturing	53.6	50.6	40.3	42.1	57.4	61.9	64.7	71.5	71.1	77.7	70.5	65.3
Other chemicals	57.4	57.4	48.4	44.5	52.9	51.3	65.5	70.0	57.4	52.7	52.5	52.6
Drugs & medicines[b,c]	93.1	97.2	106.7	77.0	88.5	77.6	105.3	123.1	96.5	96.7	88.4	99.2
Drugs & medicines (including Puerto Rico)[b,c]	. . .	. . .	. . .	73.9	. . .	. . .	. . .	. . .	91.2	. . .	. . .	. . .

[a]Gross fixed capital formation is national accounts–compatible gross fixed capital formation (land, buildings, machinery, and equipment).

[b]Figures are survey-based data and may not be national accounts compatible.

[b]Employment figures are survey-based data and may not be national accounts compatible.

Table 13.12 Growth in Drugs and Medicines R&D

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total R&D expenditures[a,b]											
France	100.0	111.2	120.9	133.9	149.8	154.2	176.0	184.0	203.5	218.3	201.6
Germany	100.0	102.5	119.0	139.9	165.1	168.8	159.6	150.9	158.1	174.5	188.2
Italy	100.0	106.0	108.3	107.1	124.5	130.6	149.7	169.2	194.8	208.6	217.6
United Kingdom	100.0	105.6	119.9	131.2	143.6	156.9	155.5	184.2	200.8	210.1	220.6
United States	100.0	114.8	129.8	139.5	153.2	171.6	194.0	217.3	239.9	254.4	276.2
R&D per Employee[b,c]											
France	100.0	110.6	118.7	129.8	143.6	146.5	168.1	173.4	185.6	192.9	181.0
Germany	100.0	101.1	117.3	135.5	160.1	159.7	150.2	140.0	147.8	155.9	161.7
Italy	100.0	106.7	111.8	108.3	128.2	133.1	150.4	163.7	186.7	199.8	. . .
United Kingdom	100.0	107.5	123.2	134.7	149.6	161.0	152.9	177.7	183.6	193.2	. . .
United States	100.0	117.6	131.3	142.1	158.8	175.7	191.8	211.1	221.6	236.4	. . .
R&D per employee, relative to the United States[c,d]											
France	63.2	59.4	57.0	57.3	56.6	52.1	54.7	51.3	52.2	50.8	. . .
Germany	77.4	66.3	69.0	73.3	77.5	69.9	60.1	50.9	51.2	50.7	. . .
Italy	49.3	44.7	41.9	37.4	39.5	37.0	38.2	37.8	41.1	41.1	. . .
United Kingdom	66.6	60.5	62.8	62.4	62.1	60.8	52.9	56.3	54.9	54.2	. . .
United States	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	. . .

[a]R&D data from national trade associations (Center for Research in Medicines 1993).

[b]GDP deflator adjusted values; 1981 = 100.

[c]Number of employees for France, Italy, the United Kingdom, and the United States are survey-based data and may not be national accounts compatible.

[d]GDP PPP conversion; United States = 100.

ies for output elasticities for pharmaceuticals is potentially biased for several reasons. First, patent protection could lead to prices that exceed long-run marginal cost (including a competitive return to R&D), in which case factor shares of revenue or value added would be downwardly biased estimates of output elasticities (Hall 1988, 1990). On the other hand, if regulation constrains prices below long-run marginal cost, revenue-based factor shares will exceed output elasticities. Second, factor shares are upwardly biased measures of output elasticities for labor or physical capital if price regulation induces excessive factor inputs (see eq. [2″]). Third, if the output elasticity for physical capital is estimated as the complement of the labor share, this estimate will be upward biased since it includes the unmeasured returns to the stock of intangible R&D capital, and MFP growth will be downward biased. Assume that there is no bias in prices, that both the stock of intangible capital M and its return s_M are unobserved, and that s_K is estimated as $1 - s_L$. In that case, the Solow residual reflects conventional TFP plus the contribution of this unobserved input:

$$\dot{Q} - s_L\dot{L} - s_K\dot{K} = \dot{A} + s_M\dot{M}. \tag{11}$$

Since R&D investments are the main source of technical change in this industry, distinguishing between production function shifts due to A and M is conceptually problematic as well as infeasible given the data.

To illustrate the severity of potential measurement bias, table 13.13 reports revenue-based and cost-based estimates of factor shares for labor and physical capital. Labor share s_L is labor compensation divided by either value added (revenue based) or estimated total variable cost (cost based). The first estimate of the share of capital s_K is a residual income measure $(1 - s_L)$. The second estimate of s_K is a cost-based estimate of the rental cost of capital, $(\rho + \delta)K$. The real cost of funds ρ is assumed to be 10 percent, and the depreciation rate δ is also assumed to be 10 percent, assuming a ten-year life of capital.[32]

The revenue-based factor shares imply a much larger share of labor in France (71–92 percent, depending on the price deflator for value added), compared to 23–29 percent for the labor share in the United States, 30–36 percent in the United Kingdom, and 43 percent in Germany. The cost-based estimates are much closer, ranging from 82 percent in the United States to 86 percent in France. The two alternative estimates of s_K are fairly similar for France. However, for other countries, the residual income measure of s_K exceeds the rental cost measure; for the United States, this difference is greatest (77 vs. 5 percent). The difference presumably reflects the ex post return to unobserved R&D capital and other unmeasured services, including contractual payments for R&D services and license fees that are appropriately subsumed into

32. Strictly, the rental price of capital reflects tax offsets as well as the real cost of funds and the depreciation rate (Hall 1990). Since we lack country-specific data on tax offsets, these are ignored here. Myers and Shyam-Sunder (1996) estimate beta of roughly one and a real cost of capital of 9.9–10.7 percent for the period 1980–90. This is consistent with previous estimates (Grabowski and Vernon 1990).

Table 13.13 **Share of Labor and Capital**

	Value-Added-Based Shares									Cost-Based Shares[d]					
	Labor Share (s_L)[a]			Capital Share (s_{K1})[b]			Capital Share (s_{K2})[c]			Share of Labor (s_L)[e]			Share of Capital (s_K)[f]		
	1976–80	1981–85	1986–90	1976–80	1981–85	1986–90	1976–80	1981–85	1986–90	1976–80	1981–85	1986–90	1976–80	1981–85	1986–90
France															
Total manufacturing	.66	.69	.62	.34	.31	.38	.26	.27	.26	.72	.72	.70	.28	.28	.30
Chemical products	.46	.51	.44	.54	.49	.56	.29	.31	.27	.62	.62	.62	.38	.38	.38
Drugs & medicines	.94	.94	.92	.06	.06	.08	.12	.19	.20	.88	.83	.82	.12	.17	.18
PPI-drugs	...	.84	.71	...	.16	.29	...	.17	.16	...	.83	.82	...	.17	.18
Germany															
Total manufacturing	.66	.69	.67	.34	.31	.33	.21	.22	.21	.76	.76	.76	.24	.24	.24
Chemical products	.50	.54	.55	.50	.46	.45	.24	.23	.22	.68	.70	.71	.32	.30	.29
Drugs & medicines	.48	.46	.43	.52	.54	.57	.20	.18	.16	.70	.72	.73	.30	.28	.27
PPI-drugs	...	.46	.43	...	.54	.57	...	.18	.16	...	.72	.73	...	.28	.27
Italy															
Total manufacturing	.60	.57	.54	.40	.43	.46	.37	.37	.34	.62	.61	.62	.38	.39	.38
Chemical products	.64	.58	.55	.36	.42	.45	.93	.75	.52	.41	.43	.52	.59	.57	.48
Drugs & medicines	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
PPI-drugs	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

(continued)

Table 13.13 (continued)

	Value-Added-Based Shares									Cost-Based Shares[d]					
	Labor Share (s_L)[a]			Capital Share (s_{K1})[b]			Capital Share (s_{K2})[c]			Share of Labor (s_L)[e]			Share of Capital (s_K)[f]		
	1976–80	1981–85	1986–90	1976–80	1981–85	1986–90	1976–80	1981–85	1986–90	1976–80	1981–85	1986–90	1976–80	1981–85	1986–90
United Kingdom															
Total manufacturing	.78	.77	.72	.22	.23	.28	.25	.27	.24	.76	.74	.75	.24	.26	.25
Chemical products	.72	.71	.66	.28	.29	.34	.44	.46	.37	.62	.61	.64	.38	.39	.36
Drugs & medicines	.36	.38	.36	.64	.62	.64	.19	.20	.18	.65	.66	.67	.35	.34	.33
PPI-drugs	. . .	.36	.30	. . .	.64	.70	. . .	.19	.15	. . .	.66	.67	. . .	.34	.33
United States															
Total manufacturing	.71	.72	.68	.29	.28	.32	.21	.23	.22	.77	.75	.76	.23	.25	.24
Chemical products	.59	.57	.50	.41	.43	.50	.40	.37	.29	.60	.61	.63	.40	.39	.37
Drugs & medicines	.30	.27	.23	.70	.73	.77	.11	.11	.09	.73	.72	.71	.27	.28	.29
PPI-drugs	. . .	.29	.29	. . .	.71	.71	. . .	.11	.12	. . .	.72	.71	. . .	.28	.29

[a] $s_L = L/Q$ where L = labor compensation (real), Q = value added (real).

[b] $s_{K1} = 1 - s_L$.

[c] $s_{K2} = K(r + d)/Q$ where K = capital stock (real), r = real cost of funds 10 percent, and d = depreciation rate 10 percent.

[d] Total cost $= L + K(r + d)$.

[e] $s_L = L/[L + K(r + d)]$.

[f] $s_K(r + d)/[L + K(r + d)]$.

R&D.[33] Note that, using the more appropriate rental cost of capital, the shares of labor and physical capital sum to more than one in France, implying a negative return to intangible capital, whereas the sum of these shares is 52 percent or lower in all the other countries.

Table 13.14 reports estimates of total factor productivity growth for 1975–90, with alternative factor share proxies for output elasticities. The results are very sensitive to the price deflator and, to a lesser extent, to the estimates of output elasticity. Using the GDP deflator for value added, TFP growth in France is lower than in total manufacturing in France and much lower than pharmaceuticals in the United States or the United Kingdom. In other countries, TFP growth is higher in pharmaceuticals than in total manufacturing.[34] Using the PPI-drugs estimates of value added reverses the conclusions for France and the United States.

13.6 Conclusions

This paper has demonstrated some of the problems in estimating productivity growth and cross-national comparisons for an industry such as pharmaceuticals, which has a high rate of investment in R&D that is subject to cross-national diffusion, hence large stocks of unmeasured, intangible capital and a high rate of technological change. In addition, the pharmaceutical industry is subject to price regulation and safety and efficacy regulation; as a result, prices and product mix differ significantly across countries. Country-specific rates of price change, as measured by either the official PPI-drugs or our Divisia indexes, diverge significantly from economywide inflation. These two drugs-specific price indexes are more similar to each other than either is to the GDP deflator; however, they differ by enough to make estimates of productivity growth extremely tentative. The divergence of pharmaceutical prices cross-nationally means that the GDP PPPs do not provide an accurate basis for cross-national productivity comparisons. The drugs-specific Fisher price indexes used here are more accurate but are also imperfect.

Because of these measurement problems, conclusions on the cross-national comparisons are tentative. The evidence is generally consistent with the hypothesis that labor productivity is lower in the French pharmaceutical industry than in the French manufacturing sector generally, as predicted by the theory that biased regulation leads to excessive input use and suboptimal productivity. The relatively large market share of local drugs, which may have lower productivity than global drugs, may be a contributing factor. For the United Kingdom, although capital investment has been very rapid, TFP growth in pharmaceuti-

33. Cocks (1974) estimates that $s_L = 0.6$ and $s_K = 0.4$ for a single U.S. firm for the period 1967–71, before adjusting for R&D; these are both revised to 0.5 after netting out labor that is devoted to R&D.

34. Unfortunately, TFP estimates are not available for Italy because data on labor compensation and capital are unavailable.

Table 13.14 **Growth in Value Added, Number Employed, Capital Stock, and Total Factor Productivity (percentage changes)**

							% Change in Total Factor Productivity					
							Value-Added-Based Shares					
	Value Added		Number Employed		Capital Stock		With s_{K1}[a]		With s_{K2}[b]		Cost-Based Shares	
	1976–85	1981–90	1976–85	1981–90	1976–85	1981–90	1976–85	1981–90	1976–85	1981–90	1976–85	1981–90
France												
Total manufacturing	−4.0	8.4	−9.7	−9.6	1.4	5.5	2.1	12.8	2.2	13.2	2.6	13.6
Chemical products	−4.6	17.4	−8.0	−3.4	3.0	3.2	−2.3	17.3	−1.6	18.0	−.8	18.3
Drugs & medicines	18.9	17.3	3.9	5.7	80.1	28.3	10.4	10.1	2.6	6.5	4.1	7.7
PPI-drugs	. . .	36.6	3.9	5.7	. . .	28.3	. . .	25.6	. . .	27.6	. . .	26.9
Germany												
Total manufacturing	−.6	11.6	−4.6	1.4	4.4	8.5	1.0	8.0	1.6	8.9	1.9	8.5
Chemical products	2.5	11.5	1.3	6.8	−.9	5.6	2.3	5.2	2.1	6.5	1.9	5.0
Drugs & medicines	12.7	21.9	2.9	5.8	1.3	6.6	10.7	15.6	11.1	18.2	10.3	15.9
PPI-drugs	. . .	24.9	2.9	5.8	. . .	6.6	. . .	18.6	. . .	21.2	. . .	18.9
Italy												
Total manufacturing	−.8	5.7	−7.7	−6.2	−.5	−4.1	3.9	11.0	3.9	10.6	4.1	11.1
Chemical products	−1.6	20.0	−11.8	3.9	−20.6	−17.9	13.6	25.6	23.0	29.0	15.3	27.5
Drugs & medicines	17.2	10.0	−1.5	3.5	. . .							
PPI-drugs	. . .	19.2	−1.5	3.5	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .

United Kingdom												
Total manufacturing	−12.5	13.1	−20.7	−6.4	−3.8	1.1	4.4	17.6	4.5	17.6	4.0	17.6
Chemical products	−8.7	26.2	−17.9	−1.4	−4.6	.2	5.5	27.1	6.2	27.1	4.1	27.0
Drugs & medicines	15.3	40.8	−1.3	6.5	18.2	25.3	4.3	22.4	12.2	33.8	9.8	28.0
PPI-drugs	. . .	62.1	−1.3	6.5	. . .	25.3	. . .	42.8	. . .	55.9	. . .	49.3
United States												
Total manufacturing	−2.3	7.1	−4.5	.4	7.0	.6	−1.1	6.6	−.7	6.7	−.6	6.7
Chemical products	7.6	19.8	−.9	3.5	1.7	−5.8	7.4	20.6	7.4	19.8	7.4	19.9
Drugs & medicines	19.4	37.6	2.8	5.4	15.1	19.3	7.8	21.7	16.9	34.4	13.2	28.3
PPI-drugs	. . .	13.2	2.8	5.4	. . .	19.3	. . .	2.1	. . .	9.4	. . .	3.9

Note: Percentage changes for 1976–85 are between the mean values for the two five-year periods 1976–80 and 1981–85. Percentage changes for 1976–90 are between the mean values for the two five-year periods 1981–85 and 1985–90.

[a] $s_{K1} = 1 - s_L$, where $s_L = L/Q$, where L = labor compensation (real), Q = value added (real).

[b] $s_{K2} = K(r + d)/Q$, where K = capital stock (real), r = real cost of funds 10 percent, and d = depreciation rate 10 percent.

cals is as high as in the United States and higher than in other manufacturing in the United Kingdom. Value added per employee, relative to the United States, is higher for pharmaceuticals in the United Kingdom than for other manufacturing. One plausible explanation is that rate-of-return regulation in the United Kingdom has permitted high returns to R&D investments and that any tendency for excessive investment has therefore been in more productive forms of capital.

Appendix A
Data Sources and Definitions

The primary source for this analysis is the OECD's 1994 Structural Analysis (STAN) industrial database. STAN draws on the OECD's Industrial Structure Statistics (ISIS) and four other databases, using national accounts–compatible data where available, supplemented by other industrial surveys. For the four-digit drugs and medicines category, the data for most countries are from industrial surveys, so strict comparability across countries is not assured. The R&D data from national trade associations may also not be strictly comparable.

Variable Definitions

Production. National accounts–compatible production (gross output), at producer prices, excluding VAT.

Value added. Gross output, less the cost of materials, fuels, electricity, and other supplies, contract and commission repair, and maintenance work done by others.

Exports. From the OECD's Compatible Trade and Production database, which contains flows by ISIC revision 2 category. It has been converted from the Standard International Trade Classification (SITC) using a converter developed by the OECD. These trade data are compatible across countries but may not be strictly comparable to trade flows published in other sources. Values f.o.b.

Imports. See *exports.* Values c.i.f.

Employees (number engaged). Annual average number of workers, full-time and part-time, including employees, self-employed, owner-proprietors, and unpaid family members. For France, data are from SNIP. The SNIP definition of the industry probably leads to downwardly biased counts of employees, compared to the STAN measures of production.

Gross fixed capital formation. National accounts–compatible gross fixed capital formation (land, buildings, machinery, and equipment). No data are reported for Italy for drugs and medicines.

Labor compensation. National accounts–compatible labor costs, including wages and employers' compulsory contributions to pension, medical care,

etc. This presumably omits voluntary employer contributions to pensions and health insurance in the United States and tax-financed medical care in the United Kingdom.

Research and development expenditures. National trade associations, as reported by Centre for Medicines Research (1993).

Appendix B
Pharmaceutical Price Indexes

Fisher Index of Cross-National Price Differences

The methodology used to construct the Fisher indexes is described in Danzon and Kim (1998). Although that study pertains to cardiovascular drugs only, the same methods are applied to all therapeutic categories for the indexes used here. The indexes include all single-molecule drugs that are available in pharmacies in both the United States and the other country under comparison. Products are designated as matching across countries if they have the same active ingredient (molecule) and are in the same therapeutic category.

For each pair of countries, we computed four indexes: using U.S. quantity weights and foreign quantity weights and using price per gram of active ingredient and price per standard unit (a tablet or capsule etc.) as the unit of measurement. For each pricing measure—per gram or per standard unit—the Fisher indexes are the geometric mean of the indexes based on U.S. and foreign weights. Here, we use the arithmetic average of these two Fisher indexes. The Fisher index is transitive and has other desirable theoretical properties (Diewert 1981).

Although these indexes provide a more accurate measure of relative prices than GDP PPPs, they are not perfect measures of pharmaceutical prices for several reasons. First, the price data for the United States overstate true transactions prices to manufacturers owing to omission of discounts and rebates, particularly in the most recent years. Second, because the cross-national indexes necessarily include only products that are available in both of the two countries, this may introduce bias if prices for these matching, global drugs are not representative of all drug prices. To the extent that regulation is biased against the global products that are included, either because they are produced disproportionately by foreign firms or because they have high potential prices or volumes, these indexes based only on matching products may understate overall price levels in countries with price regulation. If so, use of these indexes will lead to upwardly biased estimates of the U.S. dollar value of production in price-regulated countries.[35]

35. We use weights based on the sample included in the indexes rather than reweighting to reflect shares in overall drug consumption (van Ark and Pilat 1993). Such reweighting implicitly assumes that included products are representative of all products, which may not be true for

Divisia Price Indexes

The methodology used to construct the country-specific Divisia indexes is described in Danzon and Kim (1996). The sample includes all single-molecule drugs sold through retail pharmacies. The unit of observation is the standard unit for the molecule. Chained weights permit the incorporation of new compounds in their second year on the market. Line extensions and generic forms of existing molecules are incorporated in their first year on the market. The indexes for the United States are upwardly biased to the extent that discounts and rebates, which are omitted, have become more prevalent over time.

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drugs. Moreover, since the indexes reflect over 50 percent of sales in all countries (and over 80 percent in the United States and the United Kingdom), the case for reweighting is weaker here than in the van Ark and Pilat study, where the unit value ratios reflected less than 25 percent of sales in all countries.

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Comment Ernst R. Berndt

Over the last few years, Patricia Danzon has contributed significantly to our empirical understanding of intercountry price comparisons for prescription pharmaceuticals and of the difficulties in interpreting differentials. In this paper, Danzon and Percy extend this price research in a different direction—analyzing the effects of differential price regulation among countries on the productivity of domestic pharmaceutical operations.

There are a great deal, indeed, almost an overabundance, of empirical findings in this paper; the paper includes, for example, fourteen tables summarizing detailed calculations. This is also an ambitious paper for it falls in between two traditional genres of international comparison studies—one very aggregated at perhaps the national or sectoral level and the other much more detailed, almost at the case-study level of specificity. Danzon and Percy pursue a middle ground, conducting an international comparison of the pharmaceutical industry among five countries: France, Germany, Italy, the United Kingdom, and the United States.

Drawing on the theory of regulation, Danzon and Percy structure their paper by outlining hypotheses that are then examined empirically. Specifically, Danzon and Percy hypothesize that price regulation biases upward levels of labor intensity (reduces average labor productivity), that price regulation also biases upward levels of capital intensity (reduces average capital productivity), and therefore that price regulation reduces levels of multifactor (capital and labor) productivity (MFP). Whether price regulation has a differential effect on capital than on labor is also considered; to the extent that the United Kingdom has price regulation that is more like traditional rate-of-return regulation, Danzon and Percy conjecture and find some evidence tending to suggest that the U.K. productivity is more capital biased than labor biased. Finally, although Danzon and Percy are somewhat silent on this, their hypotheses and expectations appear to refer more to levels of productivity than to their growth rates.

The data used in this paper come from several sources. Aggregate employment, capital formation, and revenue data are taken from OECD-STAN (which

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may not be consistent with national income and product account data), as are aggregate GDP PPP data series; country-specific aggregate producer price indexes for pharmaceuticals are also drawn from OECD sources. However, Danzon and Percy have also undertaken a painstaking set of calculations to compute bilateral price comparisons for literally thousands of drugs (chemical compounds, not just brands) that are sold in both countries, for each pair of bilateral comparisons. This research has been reported on elsewhere. Finally, Danzon and Percy also address a difficult problem with U.S. data concerning offshore manufacturing in Puerto Rico.

Danzon and Percy find reasonable support for their hypotheses involving productivity levels for labor and capital, but the multifactor productivity (MFP) results, both in level and in growth-rate form, are much more ambiguous and in particular are found to depend critically on the choice of deflator.

In attempting to interpret Danzon and Percy's findings, I would have found it useful had the paper contained a bit more discussion on three questions; these questions may have been addressed in other papers by Danzon.

First, what types of drug medications are produced in the five countries, and how does this composition vary among countries? What it is that constitutes a prescription drug, and what an over-the-counter product, can vary considerably across countries, except perhaps for psychotropic drugs. Do the countries differ in the relative proportions of patent protected and generic drugs, or what variations are there in "world" and primarily local drugs? Is there a systematic difference in the proportion of herbal and homeopathic medications (more prevalent in Germany and the United Kingdom)? Finally, do pharmaceutical operations differ considerably among the five countries in terms of manufacturing and (re)packaging? Although some of these issues are briefly noted, I would have found it helpful to have found a greater discussion of these issues as background to interpreting the observed productivity differentials.

Second, concerning the aggregate employment, capital formation, and revenue data by country, it is my impression that such data derive ultimately from establishment data and that what constitutes an establishment may differ across countries. In particular, in the United States, the establishment data taken from annual surveys of manufacturing refer only to production and manufacturing activities, not to central administrative and office (CAO) personnel. For the U.S. pharmaceutical industry, which is both research and development (R&D) and marketing intensive, the possible exclusion of CAO employees may have a critical effect on labor productivity findings. For example, how one interprets Danzon and Percy's finding that the average number of employees per establishment is about half as large in the United States as in France depends on what constitutes an establishment.

Third, some information on the size distribution of firms or establishments would also have been useful. Is the size distribution much more skewed in the United Kingdom and Italy than in the United States and France? How different are means from medians?

Let me now turn to some more specific comments. As always, MFP calcula-

tions depend on estimates of capital and labor shares. Danzon and Percy find substantial differences in MFP growth depending on whether one calculates the capital cost share using a residual property income notion or a measure of capital expenditures dependent on a rental price of capital.

Given that the MFP results are somewhat ambiguous and fragile, we might ask what else we know about manufacturing efficiency in the pharmaceutical industry. An MIT colleague in chemical engineering, Charles Cooney, has recently published results of a benchmarking study comparing manufacturing operations of pharmaceutical and biotech firms in several countries (see Cooney and Raju 1996). Cooney and Raju find significant variations among firms and countries, with one of the most significant sources of differences being practices involving inventories of chemical materials—while some firms follow "just-in-time" protocols, a surprising number instead appeared to follow the less efficient "just-in-case" practice. Unfortunately, Cooney and Raju cannot reveal the identities of the establishments and the countries in which they operate owing to confidentiality restrictions.

How else might one think of interpreting the productivity of pharmaceutical firms in various countries? One possible way is to compare them on the basis of the extent to which their products have worldwide markets or, related, on the basis of successful patent applications. While such comparisons could be informative, one should remember that, even within the United States, there are some very successful (in terms of stock price growth) pharmaceutical firms who have had few innovative new products. There are a variety of ways in which one might want to envisage productivity, and they could well be quite inconsistent with one another.

In summary, this paper brings into sharp focus the notions that international comparisons are quite difficult and are likely to render somewhat inconclusive findings when not all major differences can be properly taken into account. In the present context, Danzon and Percy are surely correct in noting that differences in R&D among countries could have a significant effect on the interpretation of their results. It would be interesting to see if related problems emerge when other industries are compared across countries, such as the telecommunications industry, which also has very high sunk costs and relatively small marginal costs.

Reference

Cooney, Charles L., and G. K. Raju. 1996. "Benchmarking" pharmaceutical manufacturing performance. Working paper. Massachusetts Institute of Technology, Program on the Pharmaceutical Industry, February.