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PRICE MARKUPS AND R&D INPUTS:

THE PHARMACEUTICAL INDUSTRY

IN FINLAND AND THE USA***

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ABSTRACT: The aim of this paper is to compare the price-cost margins in the pharmaceutical industry in Finland and USA. We employ data on the Finnish and the US pharmaceutical industry. The estimation is theoretically based on a modification of the conventional growth models and its extensions under imperfectly competitive markets. The results show that the estimated price-cost margin is 0.60-0.67 in Finland and 0.51-0.67 in the US with demand driven instruments and lagged R&D expenditure related instrument. When R&D stock is estimated and included as one production input in the model, the price-cost margin drops to 0.43-0.55 in Finland and 0.40-0.58 in the US. Therefore, differences in regulatory environments have not altered the price-cost margins in the pharmaceutical industry within these countries. Either this is due to the inefficient regulation system in Finland or it is due to the differences between market structures and competitive environment.

Keywords: competition, markup, pharmaceuticals, price regulation, R&D.

1 Introduction

There is a great need for international price comparisons of pharmaceuticals particularly those being utilized in regulatory planning activities. The price comparison studies provide direct information on international price levels of pharmaceuticals. Such information is conventionally combined with information on the costs of pharmaceutical production and R&D and then utilized in decision-making and regulatory planning.

Instead of comparing international prices directly, this article focuses on analyzing price-cost margins. There are some interesting price comparison studies (Danzon and Chao 2000; Berndt, Bui, Reiley and Urban 1995). They show that international price comparison studies may provide biased results if they are based on unrepresentative samples and unweighted indices of pharmaceuticals. Furthermore, there also seems to be a lack of indispensable information on factors affecting price levels. The price comparison studies describe the situation, but do not explain why price levels differ. Factors behind the price differences can be derived from the cost structures of firms, degree of competition, regulatory practices, or domestic income levels. In order to take into account these factors, this article measures the price-cost margins.

The aim of this article is to provide information on factors influencing price levels in pharmaceutical markets. To do this, the price-cost margin of the pharmaceutical industry is estimated in two countries, Finland and the USA. These differ from each other, for instance, in regulatory and competitive settings, and the size of the pharmaceutical industry.

This paper is divided into three main sections. The following section provides some background information on pharmaceutical markets in Finland and the US. The theoretical model is set up in Section 3 for the empirical analysis. Then Section 4 presents the data, and the results of the estimation are given. Section 5 discusses the results compared to other studies and in the perspectives of regulation and R&D activities in the pharmaceutical industry. Section 6 concludes the paper.

2 Regulation and market structure

The pharmaceutical market in Finland has experienced strict price regulation (see e.g. Rinta 2001). Before 1995, the approval of the pharmaceutical product for the public reimbursement system was linked with the institutionally-set price. Since 1995, drug prices have been deregulated in principle. However, if a company applies to have the drug accepted as part of the Finnish reimbursement system, the pharmaceuticals pricing board sets the price at twice the amount that will be refunded. In contrast, there has been no price regulation in the US market.

The size of the US market is 200 times larger than that in Finland. On the one hand, the large size of the markets could theoretically imply some closeness to the features of perfect competition. On the other, because there are many patent protected products with some monopoly power, one would expect that many US companies, without direct price regulation, would charge more than their counterparts in a more regulated setting.

One would expect that differences in the regulatory measures and size of the markets would cause a difference to the price-cost margin in the two countries taking into account economies of scale in production. If the industry could achieve increasing returns on the scale of its production processes, the average costs of production would decrease with higher volumes of production. However, marginal costs do not necessarily decrease together with the decrease in average costs if, for instance, the cost function is linear. However, if marginal costs also decrease along with production volume, then we could expect higher price-cost margins in the US than in Finland, and vice versa, if there are increasing marginal costs. There could also exist a certain point or points in production volumes in which the marginal costs begin to decrease or increase in a given time. This can be, for instance, due to additional costs of hiring new employees from other sectors.

The method in our study is based on Solow's (1957) seminal work. The estimation procedure consists of Solow's method for measuring technical change called Solow's residual. The model ignores the question of increasing returns to scale by assuming constant returns to scale in production. Hall (1988) and Domowitz, Hubbard and Petersen (1988) developed the model and analyzed Solow's residual in both perfect and imperfect

competition frameworks. They showed that Solow's residual is independent of the growth rate of the output-capital ratio if perfect competition prevails. However, if the market is imperfectly competitive, there appears a correlation between the two variables and the growth of the total factor productivity is pro-cyclical.

The estimation of price-cost margin can be based on the Solow's residual setting. The method was applied by Linnosmaa, Hermans, and Karhunen (2004). They estimated the price-cost margin of the Finnish pharmaceutical industry. The estimation employed time series data and provided a fixed price-cost-margin over time. The present paper extends that application and utilizes R&D expenditures and estimated R&D stock in order to take R&D stock into account as a productive input in the pharmaceutical industry. This modification is justified given the high R&D intensity of the pharmaceutical industry.

Finnish pharmaceutical markets have been highly regulated compared to US markets. On the other hand, the production capacity of the US pharmaceutical industry is over 200 times higher than the capacity in Finland. We restricted the sample to two countries because there was no further international data available which was plausible for measuring price-cost margins. We can also compare our results with other studies on the US markets (e.g. Scherer and Ross, 1990). It is also important to test the applicability of the method in two different countries with different data sourcesto see if the method could be utilized further in wide-scale international studies.

3 The model

The model is from Domowitz, Hubbard, and Petersen (1988) and Linnosmaa, Hermans, and Karhunen (2004). The production function is the form:

$$(1) \qquad Q(t) = A(t) f(L(t), S(t), K(t))$$

where Q signifies production, A is a measure for the technical change not captured by other factors of production, L, S and K denote labor, research and development, and capital inputs, respectively. The term t stands for time, implying that all the variables are

measured at a certain time. To simplify the notation, however, the time variable is dropped from the following analysis.

Solow (1957) derived a measure for technological process, sometimes called Solow's residual. Applying the same assumptions and principles to the above production function, Solow's residual can be shown to be:

$$(2) \qquad \frac{\dot{Q}}{Q} - \frac{\dot{K}}{K} - \tilde{b}_S\left(\frac{\dot{S}}{S} - \frac{\dot{K}}{K}\right) - \tilde{b}_L\left(\frac{\dot{L}}{L} - \frac{\dot{K}}{K}\right) = \frac{\dot{A}}{A},$$

where the dotted variables stand for derivatives with respect to time.

We denote the input shares simply as:

$$(3) \qquad \tilde{b}_S = \frac{P_S S}{cQ} \text{ and } \tilde{b}_L = \frac{P_L L}{cQ},$$

in which $\tilde{b}_S$ measures the share of research and development (R&D) costs of the value of output, and $\tilde{b}_L$ stands for the share of the total labor wages of the value of output. The industry is assumed to be perfectly competitive and hence the output is valued at marginal cost c.

Under imperfect competition a firm's output is not valued at marginal cost, but the price exceeds marginal cost. Under imperfect competition, the shares of labor and R&D can be rewritten as:

$$(4) \qquad \tilde{b}_S = \frac{p}{c}\frac{P_S S}{pQ} = \frac{p}{c} b_S \text{ and } \tilde{b}_L = \frac{p}{c}\frac{P_L L}{pQ} = \frac{p}{c} b_L.$$

The terms b_S and b_L stand for the ratio of R&D expenditure to value added of production and ratio of labor wages to value added of production, respectively. Substitution of the shares in equation 4 in Solow's residual in equation 2 provides:

$$(5) \qquad \frac{\dot{Q}}{Q} - \frac{\dot{K}}{K} - \frac{p}{c} b_S\left(\frac{\dot{S}}{S} - \frac{\dot{K}}{K}\right) - \frac{p}{c} b_L\left(\frac{\dot{L}}{L} - \frac{\dot{K}}{K}\right) = \frac{\dot{A}}{A}.$$

We define the Lerner index for monopoly power as follows:

$$(6) \qquad \lambda = \frac{p-c}{p} \text{ and } 1-\lambda = \frac{c}{p}.$$

Term λ stands for the Lerner index, that is price-cost margin, and 1- λ depicts the price-cost ratio. The generalized residual can be further rewritten as[1]

$$(7) \qquad \frac{\dot{Q}}{Q} - \frac{\dot{K}}{K} - (1-\lambda)^{-1} b_S \left(\frac{\dot{S}}{S} - \frac{\dot{K}}{K} \right) - (1-\lambda)^{-1} b_L \left(\frac{\dot{L}}{L} - \frac{\dot{K}}{K} \right) = \frac{\dot{A}}{A}.$$

Multiplying both sides of equation 7 by $(1-\lambda)$ and rearranging it, we get:

$$(8) \qquad \left(\frac{\dot{Q}}{Q} - \frac{\dot{K}}{K} \right) - b_L \left(\frac{\dot{L}}{L} - \frac{\dot{K}}{K} \right) - b_S \left(\frac{\dot{S}}{S} - \frac{\dot{K}}{K} \right) = \frac{\dot{A}}{A}(1-\lambda) + \lambda \left(\frac{\dot{Q}}{Q} - \frac{\dot{K}}{K} \right).$$

If λ is zero, firms have no market power and Solow's residual (the left-hand side of equation 3) is technical change. If firms can price their products over marginal costs, Solow's residual depends on the changes in production and it fluctuates pro-cyclically (the right-hand side of equation 8).

4 Data

The data on the US pharmaceutical industry was collected from the OECD Health data and OECD STAN database. R&D figures for both countries were taken from OECD ANBERD database. The data set for Finland was aggregated from the firm-level data in Statistics Finland. It contains all Finnish pharmaceutical firms, which have more than 20 workers. The firm-size restriction was made in order to avoid the problem of inconsistent data in the capital stock variable. The capital stock figures for the smallest places of business were assessed to be unreliable over time. Figures on pharmaceutical expenditures were obtained from OECD Health Data.

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[1] This also equals Hall's (1988) specification, which is the basis of his empirical estimation procedure.

The US data set covers the time from 1970 to 1997 and the Finnish data from1975-1999. The R&D information covers 1973-1997. The data set contains information on nominal and real output, nominal and real value added, working hours, the number of workers, labor costs, R&D investment, and capital stock. The capital stock series was constructed from data on capital stock per labor hours. Table 1 below presents the descriptive statistics of the growth rates of the original variables used in this study. Output, value added, wages, and capital stock variables are measured in Finnish Markkas (FIM) and in US dollars (USD).

Table 1. Descriptive statistics.

Percentage annual rates of growth in volumes (1995 prices)				
	Geometric mean	**Std. deviation**	**Minimum**	**Maximum**
Value added				
Finland	6.2 %	19.6 %	-14.9 %	82.9 %
USA	4.6 %	5.2 %	-4.7 %	18.4 %
Labor				
Finland (working hours)	1.9 %	5.4 %	-6.9 %	10.4 %
USA	2.7 %	3.0 %	-3.4 %	8.6 %
Capital stock				
Finland	7.6 %	15.1 %	-21.1 %	41.6 %
USA	3.1 %	6.8 %	-11.4 %	14.6 %
R&D expenditure				
Finland	6.9 %	7.9 %	-12.7 %	24.9 %
USA	7.4 %	5.8 %	-6.2 %	19.4 %
Estimated R&D stock				
Finland	7.4 %	2.7 %	3.2 %	13.8 %
USA	7.5 %	1.3 %	4.6 %	9.7 %
Domestic pharmaceutical expenditure (in current prices)				
Finland	11.0 %	4.1 %	5.3 %	21.8 %
USA	9.7 %	2.0 %	5.8 %	13.6 %
GDP				
Finland	2.2 %	3.1 %	-6.3 %	6.8 %
USA	3.1 %	2.3 %	-2.1 %	7.3 %

Table 1 presents the real growth rates of value added, labor, capital, R&D expenditures, estimated R&D stock, GDP, and nominal pharmaceutical expenditure.

Volume indices for output and value added were constructed in Statistics Finland and are presented in 1995 prices for the Finnish data. Excluding the instrument variables, we received ready-made data in both value and volume terms. As instruments we used the nominal expenditure on pharmaceuticals and gross domestic income. Data for the first instrument were obtained from the Social Insurance Institution of Finland while all the other data came from Statistics Finland. The volume indices for R&D data were constructed utilizing the GDP price indices. In the US data, the volume of production was estimated utilizing pharmaceutical prices that were used as a production price deflator. The capital stock volume was formed employing the price index for investments in the US chemical industry.

The first two instruments employed in models 1 and 2 - the growth rate of the nominal expenditure on pharmaceutical products and the growth rate of real GDP - can be held as indicators which are demand-driven and do not affect the total factor productivity. Instead, a third instrument, the growth rate of real R&D expenditures with a lag of one year, is more problematic. If most of the R&D activities concentrate on improving the production processes of pharmaceutical firms, they boost the productivity. In this case, the instrument is not valid due to the causal relation with the dependent variable. But, if the R&D activities were mainly channeled to long-term drug development, they would not be mirrored closely in the short-termfluctuations in productivity. Keeping this in mind, we add the growth rate of real R&D expenditure to one of our models as an instrument.

5 Variable construction

The variables are constructed straightforwardly in light of the theory. First, variables are converted from nominal to real terms. Then the annual changes are measured and contrasted to the growth rate of capital stock (equation 8). The new and most critical part in the variable construction is the formulation of R&D stock as part of the price-cost margin estimation procedure.

The idea of R&D stock is applied in this study, instead of employing R&D expenditures, because our theoretical model employs the growth of stocks. The development in the growth of stocks is smoother over time than the growth of expenditure. The concept of

knowledge stock is comparable to the capital stock presented in the original model. Second, R&D efforts seem to affect the knowledge stocks with lags. The stock is changing after a lag compared with R&D expenses.

About half the R&D expenditure is wages (Guellec and Ioannidis 1997). Part of the R&D costs is intermediate input and capital investment. Accordingly, half of the R&D expenditure is deducted from the total cost of labor compensation to avoid counting it twice. Part of the R&D related investment in equipment is possibly also documented in capital stock, which may lead to counting the same data twice. Unfortunately, the data on intermediate input and share of R&D-related capital stock were not available. If R&D stock and capital stock are counted twice, the Lerner index in the empirical model could even be negative. When these inputs are not reduced from the estimated figures this has two possible impacts. It can distort the growth rates of R&D stock and the share of R&D stock of the total value added. The first mentioned effect is restricted if the input changes symmetrically with the growth of the entire stock. However, the share of R&D stock can be overestimated, which in turn causes the Lerner index to be underestimated. However, when the data of both countries are treated similarly, the comparison is expected and uniformly reflects the reality. It is also illustrative to compare the results of both models, with and without R&D stock effect.

The R&D stock is created as follows. First, the R&D stock is calculated by conventional accounting standards. The R&D stock is formed by multiplying the R&D expenditure of the first period, 1973, by a factor of five. Five years is a conventional and cautious estimate for the range of the economic influence of the expenditure on R&D activities in conventional accounting standards. This is, the research and development activities this year are expected to affect the earning prospects of the industry during the next five years on average.

The ratio between R&D investments and R&D stock is approximately 1 / 5. In other words, the actual R&D expenditure is assumed to be the best estimator for the cumulative R&D stock. In order to fill this condition, we fix the annual depreciation rates of R&D stocks in both countries. The fixed depreciation rate of real R&D stock for Finland is estimated at 14.5% and the US at 14.0%. The GDP deflator has been employed as a proxy for R&D prices. Hence, the real R&D stock grows as much as the real annual R&D

expenditure and is depreciated by the fixed rate above. This corresponds to 7.4% real rate of growth of R&D stock in Finland and 7.5% in the US. In this setting, we can utilize the cumulative nature of knowledge, which is applied and formed in R&D activities.

6 Empirical model

The empirical estimation is based on equation 8. We estimate a linear regression model:

$$r_t = \alpha_1 + \alpha_2 q_t + u_t \quad (9)$$

The left-hand side equals the Solow's residual r_t and the independent variable corresponds output-capital ratio in the right-hand side of the equation 8. The independent variable is endogenous because the output-capital ratio appears on both sides of equation 8. We use the 2SLS estimation technique to estimate the above model.

7 Results

We first estimate the model (equation 9) without the R&D stock variable and then later add the variable to the model. We utilize the nominal growth of pharmaceutical expenditure and the real growth of the GDP as instruments in two regression models estimated using 2SLS techniques. Table 2 presents the estimation results of model 9 for both instrument variables. The estimates of the pooled regression model are also shown.

The results propose that Solow's residual (left-hand side of equations 11 and 12) is strongly pro-cyclical both in the US and Finnish pharmaceutical industries. The correlation between Solow's residual without R&D stock and the growth rate of the output-capital ratio is 0.978 ($p < .01$) in Finland and 0.919 in the US. The correlation between value added and factor productivity is 0.962 ($p < .01$) Finland and 0.880 ($p < .01$) in the US. All of the correlation estimates deviate significantly from zero. This implies the simultaneous determination of Solow's residual and the output-capital ratio. In other words, changes in both variables are pro-cyclical.

Table 2. The results of the Solow's residual 2SLS model with labor and capital inputs.

Dependent: Solow's residual	R^2 (adjusted R^2)	Constant (α_1)	Lerner index (α_2)
Instrument: growth of GDP / capital			
Finland	.8564 (.8499)	.0193 (.0162)	.5970*** (.1437)
USA	.8010 (.7927)	.0077 (.0060)	.5120*** (.0847)
Pooled data			
Fixed effects	.8405 (within groups)	.0127 (.0085)	.5766*** (.0926)
Instrument: growth of pharmaceutical expenditure / capital			
Finland	.9001 (.8956)	.0200 (.0135)	.6683*** (.0985)
USA	.8060 (.7979)	.0076 (.0059)	.5207*** (.0868)
Pooled data			
Fixed effects	.8792 (within groups)	.0126* (.0074)	.6382*** (.0697)
Instrument: growth of lagged R&D expenditures / capital			
Finland	.8663 (.8602)	.0194 (.0157)	.6114** (.1588)
USA	.8523 (.8449)	.0094* (.0047)	.6709*** (.1044)
Pooled data			
Fixed effects	.8710 (within groups)	.0145* (.0082)	.6212*** (.1058)
Method: 2SLS and on pooled data 2SLS fixed effect model			

Standard errors are in parentheses. The asterisk labels (*) stand for the level of the statistical risk of denying incorrectly the null hypothesis: the regression coefficient is zero.

* 10 per cent risk level.

** 1 per cent risk level.

*** 0.1 per cent risk level.

Table 2 presents the estimates of the Lerner index when Solow's residual does not include the growth of the R&D stock. Estimates for the price-cost margin in the Finnish pharmaceutical industry range between 0.597-0.668 and in the US between 0.512-0.671. According to the t-tests, any pair of Lerner indices, obtained by different instruments, do not differ from each other between Finland and the US ($p < .05$).

The results obtained from the Finnish pharmaceutical industry are equivalent to those of Linnosmaa, Hermans, and Karhunen (2002). The estimates for the Lerner indices in the US pharmaceutical industry are close to those obtained by Scherer and Ross (1990).

Table 3. The results of the Solow's residual model with labor, capital, and R&D inputs.

Dependent: Solow's residual (rt)	R2 (adjusted R2)	Constant (α_1)	Lerner index (α_2)
Model 1: growth of GDP / capital as an instrument			
Finland	.7125 (.6988)	.0073 (.0234)	.4424* (.2097)
USA	.6815 (.6671)	-.0029 (.0063)	.3963** (.1133)
Pooled data			
Fixed effects	.6032 (within groups)	.0007 (.0136)	.3878* (.1530)
Model 2: growth of pharmaceutical expenditure / capital as an instrument			
Finland	.8138 (.8049)	.0093 (.0187)	.5549** (.1361)
USA	.7130 (.7000)	-.0029 (.0060)	.4355*** (.1014)
Pooled data			
Fixed effects	.7067 (within groups)	.0015 (.0117)	.5091*** (.1108)
Model 3: growth of lagged R&D expenditures / capital as an instrument			
Finland	.6979 (.6836)	.0071 (.0240)	.4287 (.2496)
USA	.8336 (.8253)	.0005 (.0048)	.5823*** (.1055)
Pooled data			
Fixed effects	.6213 (within groups)	.0027 (.0145)	.3983* (.1947)
Method: 2SLS and on pooled data 2SLS (fixed effects)			

Standard errors are in parentheses. The asterisk labels (*) stand for the level of the statistical risk of denying incorrectly the null hypothesis: the regression coefficient is zero.

* 10 per cent risk level.

** 1 per cent risk level.

*** 0.1 per cent risk level.

Table 3 presents results of the model, which contains R&D stock in Solow's residual. The change in the R&D stock-capital ratio is now weighted by R&D expenditure per value added (R&D share) according to equation 8. Half the R&D share estimates are labor wages, which are, in turn, deducted from the total wages. The price-cost margins vary between 0.43-0.55 in Finland and 0.40-0.58 in the US. According to the t-tests, the Lerner indices do not differ significantly ($p < .05$) between Finland and the US. Despite some contradictions between the results of the models, the results of the R&D stock corrected models clearly show that the mark-ups are lower than the estimates from models which do not take into account R&D effects. However, t-tests show that the Lerner index decreases significantly only in Finland when we use pharmaceutical expenditure as an instrument and

the R&D stock effect is taken into account (Appendix 2). The values of the Lerner indices are lower in all cases when R&D stock is considered, but the differences are not significant ($p < .05$).

The results of model 1 state that the estimated Lerner indices differ significantly from zero and they are 0.44 in Finland and 0.40 in the US. This implies the approximated price-cost ratios to be 1.79 and 1.66, respectively. Instead, the constant term does not deviate significantly from zero. The constant term partially describes the effect of technical change without the estimation of the growth of R&D stock (see equation 11). When we add the growth of the R&D stock to the model, we can expect that the R&D effects capture much of the effect of technical change. Due to the inclusion of R&D stock in the model, it seems logical that the constant term does not differ significantly from zero.

Model 2 estimates the values of the Lerner indexes 0.55 in Finland and 0.44 in the US. Hence, the price-cost ratios are higher than in model 1 in both countries, 2.25 in Finland and 1.77 in the US. Models 1 and 2 imply that price-costs margins are higher in Finland than in the US. However, model 3 alters the relative ranks of the countries. The Lerner index of the Finnish pharmaceutical industry is 0.43, which equals the value of the price-cost margin of 1.75. The Lerner index of the US pharmaceutical industry is 0.58 and the price-cost margin is correspondingly 2.39.

In one case (Table 3, model 3, Finland), the Lerner index does not deviate significantly from zero. The correction of heteroscedasticity by White's robustness check altered the standard error and significance of the coefficient so that the Lerner's index became significant in this model ($p < .05$).

8 Discussion

The price-cost margins of the pharmaceutical industry seem to be at a same level in Finland and the US. This is interesting because there are some noticeable differences in the pharmaceutical market environments of these countries. For instance, Price regulation is stronger in Finland than in the US.

There can be two potential reasons for the similarity of price-cost margins in the pharmaceutical industry in Finland and the US. If the markets are otherwise identical in Finland and the US, but price regulation is applied in Finland, then the price regulation is not binding. In this case, Finnish authorities could either scrap the entire regulatory system or alternatively tighten price regulation. The first alternative could be optimal in the case of a costly regulatory system.

The other explanation for the result is that the markets are not otherwise identical. Market structure, technological advancement, or governmental interventions could be very different in the two countries. In this case, the price regulation may be binding. There are even other forms of regulation that have some effects on the market structure and prices. For instance, the differences in drug approval processes may imply a difference in markups.

Before 1994, price setting was linked to the market authorization of the pharmaceutical product (Rinta 2001). In Finland, price regulation used to be tied to the reimbursement system and it aimed at defining the reasonable wholesale and retail price of pharmaceuticals. If a company wanted to include its product in the reimbursement system, Finnish authorities set a maximum price level for the product. In contrast, prices are set by the market in the US system.

The US markets are divided into two parts. First, there are drugs that are patent protected and, second, there are generic drugs without patent protection or the patent has expired. The large marketplace implies higher potential returns in the first case with high market power. The second case of generic competition implies that there might be almost perfect competition due to the large number of suppliers and consumers. In Finland, the market was relatively closed. The Finnish companies produced many compounds under license, as well as their own brands. There has also been a tradition of branding even non-prescribed generic domestically produced pharmaceuticals for Finnish markets. In other words, there exist some kind of market dichotomy in both countries.

The nature of the markets can be a partial explanation for the similar price-cost margins. In other words, high mark-ups obtained from patent-protected products can be offset by low margins within severe generic competition in the US. In Finland, regulated prices of

prescribed products may imply relatively low mark-ups, which were offset by relatively high mark-ups of non-prescribed branded products in generic markets.

9 Conclusion

This study compared price-cost margins in the pharmaceutical industry in the US and Finland. The study applied a uniform estimation technique, based on Solow's residual, for the countries in order to get comparable results in the markets in which price regulation systems are different. According to the results, price-cost margins do not differ between Finland and the US.

This study also attempts to carry out the effects of changes in R&D expenditure. This allows us to assess the impact of specific features of R&D intensity in the pharmaceutical industry on its price-cost margin. The price-cost margin seems to decrease over 10 percentage units in Finland when R&D stock is included in the model. However, the difference is statistically significant only in Finland, as pharmaceutical expenditure is employed as an instrument. In the US, the absolute effect was under 10 percentage units. The notion is in accordance with the theory. It also shows that conventionally estimated price-cost margins can be generally higher without implementing the impact of R&D expenditure on the measures. This particularly holds true in R&D intensive industries, such as the pharmaceutical industry.

The results raise some questions about the efficiency of regulatory settings and the differences between the market structure. If the market structure is the same in both countries, then (price) regulation is not binding in Finland, and either the regulation should be tightened or eliminated. If there are also differences in market structure and competitive environment, as seems to be the case, the policy implication above is no longer so straightforward. For a more careful investigation of the market structure, for instance, the dichotomies in the domestic markets and the significance of foreign trade should be considered in further research.

There are some open technical questions following the above analysis. The availability of the firm-level micro-data would enhance the number of methods that could be applied when evaluating price-cost margins. If there were panel data available, the results of this study could be benchmarked by other methods. Another possible path could be an international comparison of the margins. This would be important in order to assess the impacts and efficiency of different regulatory systems. The panel data would also offer an opportunity to test the main assumptions of this study, for instance, the economies of scale. In further research, it would also be important to test the impacts of policy changes on the firms' price-cost margins over time.

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Appendix 1.

Table 1. The results of the Solow's residual OLS model with labor and capital inputs.

Dependent: Solow's residual	R^2 (adjusted R^2)	Constant	Lerner index
Finland	.9562 (.9542)	.0220* (.0089)	.8818*** (.0402)
USA	.8453 (.8389)	.0056 (.0052)	.6640*** (.0580)
Pooled data			
Fixed effects	.9331 (within groups)	.0120 (.0053)	.8492*** (.0321)
Method: OLS and on pooled data OLS fixed effect model			

Standard errors are in parentheses. The asterisks (*) denote the level of the statistical risk of denying incorrectly the null hypothesis: the regression coefficient is zero.

* 10 per cent risk level.

** 1 per cent risk level.

*** 0.1 per cent risk level.

Appendix 2.

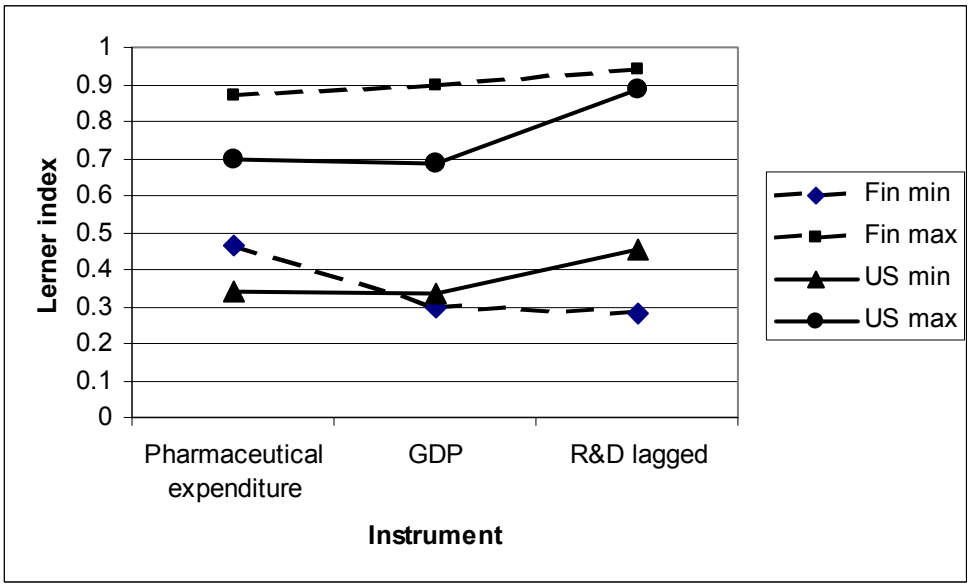

Figure A2.1. Confidence intervals (95%) of Lerner indices without R&D stock effect from Table 2.

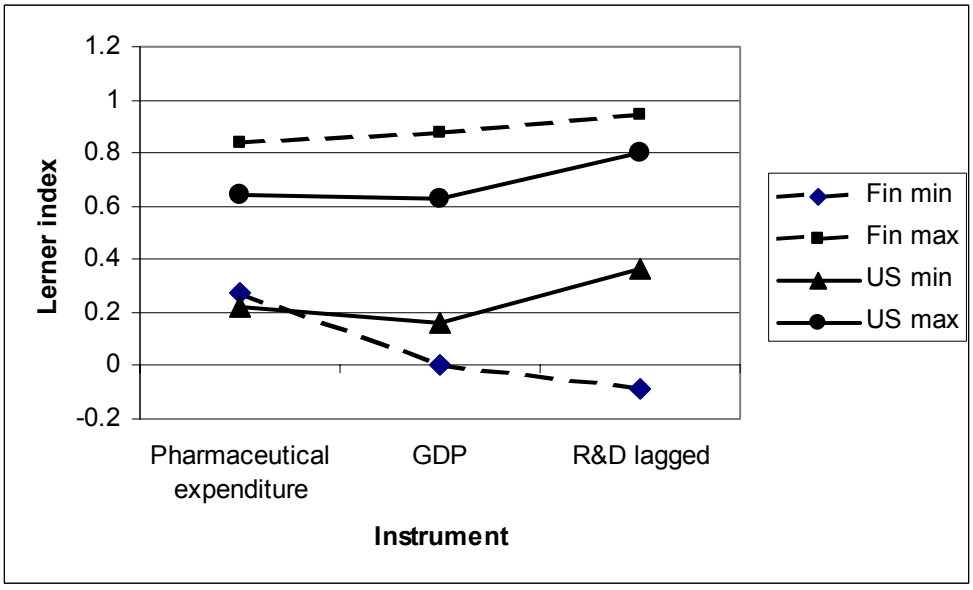

Figure A2.2. Confidence intervals (95%) of Lerner indices with R&D stock effect from Table 3.

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