

Kuhlmann, Andreas

**Research Report**

## Essays on network industries: privatization, regulation, and productivity measurement

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## **ifo Beiträge zur Wirtschaftsforschung**

### **Essays on Network Industries: Privatization, Regulation, and Productivity Measurement**

by

Andreas Kuhlmann



Institut für  
Wirtschaftsforschung  
an der Universität München

Herausgegeben von Hans-Werner Sinn  
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26

ifo Beiträge  
zur Wirtschaftsforschung

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## **Preface**

This study was prepared by Andreas Kuhlmann, while he was working with the Ifo Institute for Economic Research. It was completed in September 2006 and was accepted as a Ph.D. thesis by the Economics Department of the University of Munich. The subject of this study is the analysis of network industries with particular emphasis on privatization in this field in general and regulation and productivity measurement of the German electricity industry in particular. The methodological approach is threefold. The chapter on privatization is based on a theoretical model, followed by a chapter on the institutional and politico-economic background of the German and the US electricity industries. The following two chapters provide empirical productivity analyses based on a growth accounting framework. A major share of the data that are utilized for this exercise is taken from a new database of the Ifo Institute which has been built up in the last two years for the purpose of productivity analyses.

**Keywords:** Network industries, privatization, wage bargaining, price cap regulation, productivity analysis, growth accounting, TFP, electricity.

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*Andreas Kuhlmann*

# **Essays on Network Industries: Privatization, Regulation, and Productivity Measurement**

**Inaugural-Dissertation  
zur Erlangung des Grades**

**Doctor oeconomiae publicae (Dr. oec. publ.)  
an der Ludwig-Maximilians-Universität München**

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vorgelegt von

Andreas Kuhlmann

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## 1 Introduction

Network industries are typically public utilities that require a fixed network to deliver their services. They include gas, electricity, water, rail, and fixed-line telephony. They are economically of high importance – in terms of market value the privatized UK network utilities had a share in GDP of 15 percent in 1995 (Newbery, 1999). Beyond that they are crucial for generating economic growth and increasing international competitiveness. For the developing world they are key for alleviating poverty (Kessides, 2004). The networks of these utilities are classic natural monopolies. They create rents that are fought over.

### 1.1 Common characteristics of network industries

The capital of a network is generally large and sunk, resulting in extensive economies of scale and scope, which in turn lead to market concentration and inhibit competition. The sunk costs cannot be eliminated even by ceasing production, which imposes considerable risks that discourage entry by new service providers. Furthermore, the long-term cost-minimizing capacity of a firm with such a cost structure (which determines the optimal firm size) is relatively large with respect to market demand. Therefore one supplier can serve the entire market to lower costs than several suppliers could do. It is economically *efficient* to have just one network for the whole market. This is why the term “natural monopoly” is used.

In general the durable, fixed network is directly linked to consumers, who cannot choose between different networks. This gives the network-owner potentially large exploitative power and persisting economic rents. However, a competitive market mechanism, as the obvious solution for the achievement of allocative goals, seemed (for several decades) to be not enforceable – not only due to the specific cost structure in network industries. Beside the technical properties determining the natural monopoly characteristics and providing the main reason for the view that competition is not *feasible*, competition has also been judged as not *desirable*. The reason is that it apparently undermines universal service goals. New entrants would only want to serve low-cost, high-demand customers in profitable (urban) regions. Existing cross-subsidies taken from such profitable regions for investments in unprofitable (rural) regions would thus be undermined by competition.

These are the main reasons that in most countries network utilities were for much of the 20<sup>th</sup> century (in particular after world war II) vertically and horizontally integrated state monopolies under ministerial control. Reflecting infrastructure’s strategic importance and concerns about monopoly power, it was widely believed that these sectors could not be entrusted to the signals, motivations, and penalties of free markets. Most governments also relied on this public utility paradigm because they were convinced that state resources

were required to finance large investments in service coverage. However, in recent decades this consensus has changed, resulting in far reaching restructuring and privatization programmes.

## 1.2 Privatization

From a theoretical, economic perspective the theory of contestable markets (Baumol, Panzar, and Willig, 1982) has probably had the largest influence in challenging the old view. This theory assumes that every potential competitor can enter and leave the market without entry or exit costs. This potential market entry suffices to discipline the monopolist who sets prices equal to average costs, the second-best optimum.<sup>1</sup> A price below average costs would entail losses for the monopolist. With higher prices new entrants would enter the market and capture the whole market demand by setting the price slightly lower than the incumbent's price.<sup>2</sup> This threat of market entry leads to the allocative second-best optimum – without any governmental intervention. Even if the strong conditions for contestability are rarely fulfilled in reality,<sup>3</sup> and even if the related literature is still very controversial, this theory has certainly contributed to a paradigm shift and an associated changed policy – at least in the US.

From a technological perspective the last two to three decades have generated new technologies that have significantly reduced the minimum efficient scale of parts in the value chain for several network industries (e.g. power generation or long distance telephony). These changes have further favored a dissolution of the old public utility paradigm and cleared the way for privatizations all over the world.

The trigger for one of the first, large-scale privatization programs in Europe was actually a budgetary problem of the UK government (Kay, 2001), resulting in the sale of 51 percent of British Telecom in 1984. The divestiture was driven by the government's desire to remove telecommunications investment from its balance sheet in order to meet its targets for public borrowing. The subsequent privatization of other utility industries was accompanied by radical regulatory reforms and the creation of several new regulatory bodies. New tasks were assigned to existing agencies such as the Monopolies and Mergers Commission (Armstrong, Cowan, and Vickers, 1994).<sup>4</sup> In the European Union several members increas-

---

<sup>1</sup> The first-best-solution requires a price equal to marginal costs, which in turn leads to losses due to the cost structure in a natural monopoly.

<sup>2</sup> This “hit and run” strategy requires the assumption that the incumbent monopolist can only react with delay and that new competitors can easily and costlessly leave the market when this price reaction of the incumbent finally occurred.

<sup>3</sup> Market entry and exit must be costless in order to have the described effect, but whenever market entry requires large (sunk-cost-) investments (e.g. in infrastructure) this is not the case.

<sup>4</sup> These privatizations comprehend British Gas (1986), British Airways and the British Airport Authority (1987), water and sewage companies (1990), electricity companies (1990), British Rail (1995), and British (nuclear) Energy (1996).



ingly came to see state-owned monopolies as hindrances to international trade in goods and services. Thus in the 1990s a series of directives was issued to create a single market where goods, services, people, and capital could move freely. These directives spelled out rules for telecommunications (1990), railways (1991), electricity (1996), and natural gas markets (1998) across EU member states. The major goals were to have a common regulatory framework and to liberalize these industries.

In the 1990s a powerful privatization process began – in developing as well as in industrialized countries. Global privatization proceeds rose from US\$40 billion in 1988 to a peak of US\$180 billion in 2000, before sliding back to less than US\$50 billion in 2003 followed by a rebound in 2004 (Megginson et al., 2005). Theoretical as well as technological changes have paved the way for the *possibility* to end the governmental “supremacy” in network industries. However, these preconditions are not necessarily sufficient for the *willingness* of politicians all over the world to privatize to such an enormous extent. After all, privatization entails the loss of control over the firm’s investment and employment decisions, which is certainly a political disadvantage. So, why did politicians actually want to give up control? Several empirical studies suggest that ownership can have an effect on performance (Megginson, Netter, 2001), but why is this the case? The related literature is still very controversial on the question whether privatization might actually be useful or not (see for example Sheshinski, López-Calva, 2003). *Chapter 2* of this study is concerned with this question. Using a wage bargaining approach, a new explanation is found that complements the existing literature. It turns out that the impact of an imperfect labor market might influence the governmental decision whether or not to privatize. Privatization combined with subsequent price cap regulation can weaken the union’s bargaining position, which leads to lower wages. Anticipating this effect the government’s revenues from privatization are higher than the firm’s profits if the firm remains state owned. Whether or not privatization is a worthwhile option depends in the end on the respective bargaining power of the government and the union.

### 1.3 Regulation

Markets with natural monopoly characteristics are thought to lead to a variety of *economic performance problems*, including excessive prices, costly duplication of facilities, poor service quality, production inefficiencies, and to have potentially undesirable distributional impacts (Joskow, 2005). Independent from the question of whether it is useful to have state ownership as a predominant setting in network industries, it is undisputed that a state-supervision and regulation is indispensable. Whenever competition is introduced in services that have lost their natural monopoly characteristics (e.g. power generation and marketing in electricity), the new entrants typically have to use the incumbent’s network (e.g. the transmission and distribution network in electricity or the local loop in fixed telephony). The incumbent provider (the former monopolist), who provides all business activities including the competitive services, has apparently no interest to offer the access to his net-

work for competitors. The non-discriminatory access to the network therefore has to be guaranteed and supervised by a regulator; the access price has to be regulated. Basic goals of regulation should include the following: rent extraction, supply- and demand-side efficiency, revenue adequacy, and fairness (Kessides, 2004). There is a whole strand of literature concerning the optimal design of natural monopoly regulation, covering several associated problems.

Much of the *traditional literature* (e.g. Boiteux, 1960 (1949), 1971 (1956), Braeutigam, 1989) assumes implicitly that regulators are perfectly informed about the regulated firm's cost and demand patterns implying that the regulator can effectively enforce cost minimization on the regulated firm. The literature then focuses on second-best pricing of the services provided by the regulated firm given defined cost functions, demand attributes and budget balance constraints (e.g. Ramsey-Boiteux pricing). Consequently, this strand of literature has not focused on incentives to minimize costs or to improve other performance aspects as service quality.

However, in reality regulators indeed have imperfect information about firms and market conditions and it is typically the regulated firm that has more information about the relevant attributes compared to the regulator. The firm can thus strategically exploit its informational advantage (for example to increase profits) generally to the disadvantage of consumers. The situation is characterized by asymmetric information, which creates, according to Joskow (2006), potential moral hazard (e.g. too little managerial effort for cost efficiency) and adverse selection (e.g. prices that are too high relative to production costs). The *recent theoretical literature* on the theory of regulation focuses on regulatory mechanism design and addresses these problems of moral hazard and adverse selection (e.g. Armstrong and Sappington, 2003; Laffont and Tirole, 1993).

A solution to the moral hazard problem consists in setting ex ante a fixed price that the regulated firm will be permitted to charge in the future, or (in a dynamic setting) a pricing formula starting with a particular price that is adjusted for exogenous cost drivers (e.g. input prices). This mechanism is better known as *price cap regulation*. In such a regime either prices or revenues are capped and grow with the inflation rate minus a factor  $X$ , which accounts for productivity differences between the sector and the rest of the economy. This mechanism provides incentives to induce efficient levels of managerial effort and cost reduction and is therefore known as incentive- or performance-based regulation. It is called such as the firm and its managers can keep 100 percent of any cost reductions they realize by increasing effort. However, this mechanism is very poor at extracting rents for the benefit of consumers and society (given that there is no periodical regulatory review that fixes a new price cap). In other words, this mechanism does not address the adverse selection problem.

With a *cost of service* (or rate of return) regulatory contract where the firm is only compensated for all production costs, the second problem can be addressed. There is no rent left to the firm in the form of excess profits. It is obvious that this second form of regulation is inconsistent with the first – it provides no incentives for optimal managerial effort. Managers now retain 0 percent of any cost savings they achieve and have no incentive to exert cost-reducing effort. Averch and Johnson (1962) show that a rate of return regulation induces the regulated firm to have a higher capital stock compared to a situation without any regulation coupled with associated cost inefficiencies. Accordingly, consumers may now be paying higher prices than they would have to pay if the management could be induced to exert more effort to reduce costs. It is this kind of managerial slack and associated X-inefficiencies that policymakers have in mind when they discuss the inefficiencies of regulated firms.

Obviously there is a trade off between a pure price cap on the one hand, where costs and profits do not enter into the regulatory contract, which provides efficiency, and a cost of service regime on the other hand, which is suited to avoid excess profits. Part of the solution is to review the price cap after a stipulated period and to adjust a so called X-factor that controls for productivity gains (a more detailed description of a price cap regime can be found in Chapter 5). The shorter the period for the regulatory review, the more this price cap system looks like a rate of return regulation. Beside a regulatory review one can directly include aspects of a rate of return regime in a price cap. Such a hybrid regime (known as profit sharing or sliding scale, see Joskow, 2006) includes provisions for adjusting prices if the rate of return falls outside a given range. In order to encourage efficiency as well, this price adjustment is only partial. The firm and its consumers share both risks and rewards.

#### **1.4 Main focus of the dissertation**

A major part of the present work is focused on current regulatory problems of the German electricity industry, in particular concerning the introduction of an incentive- or performance-based regulatory regime. Despite this very specific topic, many of the analyzed issues are transferable to different countries and partially to different network industries. *Chapter 3* gives both an introduction to the particularities and economic problems of the electricity industry in general and an overview of the current situation in Germany with respect to market characteristics and the regulatory framework in particular, also in comparison to the US. The crisis of 2000/2001 in California, which is shortly described, exemplifies the sensibility of this sector with regards to regulatory failure and external shocks. Another focus of this chapter is the new German Energy Law of 2005, which entailed the introduction of a sector-specific regulatory agency and a new incentive based regulatory regime.

This builds the bridge to a subsequent determination of a specific element of incentive based regulatory regimes – the X-factor. This factor is needed for an ex-ante determination

of the authorized price that the regulated firm is permitted to charge in the future. The factor comprises the productivity differential of the regulated industry with respect to the rest of the economy. In case of the German electricity industry the method of productivity measurement is not self evident as data on the firm-level are not available yet (the regulatory authority has just recently started to collect data on the firm-level). Consequently an assessment has to be done with industry-level data, which constrain the possible choice of methodology. In this study a new, detailed productivity database is used for productivity and growth analyses, which contains industry-level and asset-specific capital data.

*Chapter 4* provides a detailed growth and productivity analysis of the German economy for the years 1970 – 2003 (including labor productivity projections). For this purpose the new *Ifo Productivity Database* is used and the growth accounting methodology applied, as in Jorgenson et al. (2003). The chapter contributes to the question of why Europe is lagging behind the US and was not able to replicate the US growth resurgence of the past 15 years. The role of information and communication technology (ICT) is an important component in this puzzle and is therefore analyzed separately. Labor productivity growth is projected for the coming decade with an average growth rate of 1.62 percent. This analysis serves also as a basis for the productivity comparison of the total economy with respect to the electricity sector, which is the essence of the subsequent X-factor determination in 5. Therefore 4 is only indirectly related to all the previously addressed questions of network industries.

In *Chapter 5* an X-factor for the German electricity industry is derived using the Ifo Productivity Database and the growth accounting methodology. The paper first gives a conceptual overview on the X-factor determination and on productivity measurement methods. The historical X-factor average from 1992 – 2003 of 0.48 is in principle suited for the use in a first regulatory period. However, several underlying assumptions of the conceptual approach are violated in practice due to market imperfections. In order to account for these violations several modifications, following the conceptual approach of Bernstein, Sappington (1999), are proposed. These modifications yield a final X-value of 2.15.

## 2 Privatization Incentives – A Wage Bargaining Approach<sup>5</sup>

### 2.1 Introduction

During the past decade economic policy in many countries focused on privatization of large, traditionally state owned firms. While empirical evidence suggests that privatization induces greater economic efficiency, this observation alone can hardly explain why governments rely on privatization as a policy instrument.<sup>6</sup> With perfect information and perfect factor markets, a government giving up control over a firm's investment, employment and pricing decisions loses influence on potentially relevant economic measures. Any efficiency gains from privatization must hurt the government in as much as it could have imitated the decisions of a private management. As Williamson (1985) asked, why would it not be possible for the state to mimic a capitalist firm and to intervene in a discretionary way only in cases when the government thinks this is necessary.

A part of the answer is certainly fiscally induced – the state owned enterprises (SOEs) often neither yield a profit nor do they meet the goal of increasing social welfare in an adequate way. This is mainly due to the fact that the government cannot offer an incentive-compatible contract to the managers – it has a commitment problem.<sup>7</sup> Schmidt (1996) showed that even for a benevolent government, privatization is advantageous as it enables it to credibly commit to a hard budget constraint, which removes the bailout disincentive.<sup>8</sup>

Beside such incomplete contracts approaches, there is another strand of literature that deals explicitly with the different incentives in public and private firms. Corneo (2001) for example analyzes two types of working incentives that are differently treated in public and private firms. He differentiates between individual tasks, which are mainly promoted in private firms, and cooperative tasks, primarily promoted by a public firm.<sup>9</sup> It is theoretically unclear whether privatization entails productivity improvements (due to tougher work

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<sup>5</sup> This Chapter relies on a former joint work with Pio Baake, see Kuhlmann (2005). It has been presented at the European Meeting of the Econometric Society in Madrid 2004, at the 60th Congress of the International Institute of Public Finance in Milan 2004, and at the Verein für Socialpolitik in Dresden 2004. I would like to thank participants at these events for helpful comments.

<sup>6</sup> For an extensive survey on empirical studies see Megginson/Netter (2001).

<sup>7</sup> The possibility of discretionary intervention allows the government to extend the infrastructure beyond a profit-maximizing optimum and this might invalidate any incentive contract based on profit sharing.

<sup>8</sup> See also Boerner (2004). Shirley and Xu (1998) find that the representative contracts used in state owned monopolies provide only weak incentives and thus lead to high inefficiencies.

<sup>9</sup> The outcome of individual tasks can be assessed, albeit imperfectly. In a cooperative task it is almost impossible for the management to assess the contribution that one particular worker makes to the solution of the collective task. A particular feature of the latter is that workers derive some utility from social interaction with their colleagues when accomplishing a collective task.

incentives) or deteriorations. The privatized firm may set incentives that divert too much effort away from the cooperative tasks. In such a case, the workforce in the private firm displays a lack of collegiality.

Another strand of literature dealing with reasons for privatization comprehends political economy models as the one by Boycko et al. (1996), which suggest that privatization is an effective instrument to alleviate corruption and to foster restructuring. However, the question of why a government cannot implement the corresponding incentive mechanisms for state owned firms and why it actually may want to privatize is not explicitly addressed. Bias and Perotti (2002) analyze politically motivated privatization in a bipartisan environment. They argue that privatization combined with a broad distribution of shares may induce the median voter to shift her political preferences towards a right-wing government.<sup>10</sup>

In this paper I take a different approach and depart from the assumption of perfect factor markets by assuming that the labor force is unionized and that wages are determined by Nash bargaining between either the government or a privatized firm and the union. Furthermore, allowing for a simple price cap regulation shows that the government can in fact benefit from privatization. Since privatization can lower the negotiated wage markup and since the government's privatization revenues are positively correlated with the firm's profits, the government can be better off with privatization.

This approach is in a way similar to the one of Schmidt (1996), as it is concerned with the commitment problems a government may face in enforcing efficient investment and labor employment. However, this mutuality the commitment problem which we analyze is, in contrast to Schmidt who sets the focus on the incomplete contract problem, due to an imperfect labor market where wages have to be negotiated between the government and a union. Analyzing these relations more carefully it turns out that the union's bargaining power has a non-monotone impact on the government's gains from privatization. Privatization tends to be especially worthwhile if the union's bargaining power is moderate rather than high. This is due to the fact that price cap regulation implies that a privatized firm cannot reduce its output and that its labor demand is rather inelastic. Thus, with a high bargaining power of the union the difference between the negotiated wages with and without privatization tends to be small and privatization becomes a less attractive instrument for the government. Considering different investment opportunities to alter the firm's short run technology does not change this result qualitatively. Regardless of whether long-run investments increase the firm's productivity or the elasticity of substitution between labor and capital, the government's gains from privatization are highest if the union's bargaining power is moderate rather than high.

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<sup>10</sup> Bortolotti and Pinotti (2003) provide some empirical evidence for these results. In Denmark, however, the largest privatization have been done by the center-left government of Poul N. Rasmussen (1993-2001), see Paldam and Chistoffersen (2004).

In the next section we set up the model. In section 3 we first analyze the wage bargaining with and without privatization. We then characterize the investment decisions under both regimes. Section 4 presents a numerical example that illustrates the different effects determining the government's incentives to privatize. A short conclusion is provided in section 5.

## 2.2 The Model

Our analysis is based on the following model with one firm producing just one good  $x$ . There are three production factors: labor  $l$  and two kinds of capital  $k$  and  $I$ . While  $l$  and  $k$  are variable factors,  $I$  represents investment determining the firm's short-run production technology. We will distinguish the cases in which  $I$  increases factor productivity and in which it mainly affects the elasticity of substitution between  $l$  and  $k$ . The production possibility set is strictly convex containing all  $(x; l; k; I)$  satisfying

$$F(x, k, l, I) \leq 0, \text{ with: } F_x > 0 > F_l > F_k > F_I. \quad (1)$$

Consumer surplus  $CS$ , the firm's profits  $\Pi$  and the union's utility  $U$  are given by

$$CS(x) := \int_0^x p(\tilde{x}) d\tilde{x} - p(x)x \quad (2)$$

$$\Pi(x, l, k, I, \Delta, w, r) = p(x)x - (w + \Delta)l - r(k + I) \quad (3)$$

$$U(\Delta, l) = \Delta l \quad (4)$$

where  $p(x)$  with  $p'(x) < 0$  and  $p''(x)x + 2p'(x) < 0$  denotes the inverse demand function,  $w$  and  $r$  are the (given) market prices for labor and capital and  $\Delta$  denotes the wage markup to be determined in the wage bargain between either the government or the privatized firm and the union. The government's aim is to maximize the weighted sum of  $CS$ ,  $\Pi$  and of a convex combination of  $U$  and the employment level  $l$ :<sup>11</sup>

$$W = CS + (1 + \mu)\Pi + \nu[\gamma l + (1 - \gamma)U] \quad (5)$$

$$\text{with: } 0 < \mu, \quad 0 < \nu < 1, \quad 0 \leq \gamma \leq 1 \quad (6)$$

With  $0 < \mu$  we implicitly assume that the government has to rely on distortionary taxation in order to finance other not explicitly modeled expenditures. Assuming  $0 < \nu < 1$  and  $0 \leq \gamma \leq 1$  allows us to capture some basic aspects from the political economy literature.<sup>12</sup>  $\nu > 0$  and  $\gamma = 1$  imply that the government is also interested in a high employment level

<sup>11</sup> For ease of exposition we omit the arguments of the functions where this does not lead to any confusion.

<sup>12</sup> See for example the probabilistic voting models discussed in Persson/Tabellini (2000).

which may increase its re-election probability. The union's influence acting as an interest group can be modeled by assuming  $\gamma < 1$ .

Assuming that the firm is initially state owned, we analyze the following four stage game. In the first stage the government can decide whether or not to privatize the firm. If the firm remains state owned the government can control all subsequent decisions of the firm and gets the firm's profits. With privatization the government's (privatization) revenues are again determined by the firm's profits. However, we will assume that the government imposes a simple price cap regulation such that the privatized firm has to offer a quantity

$$x \geq \bar{x} := p^{-1}(\bar{p}) \quad (7)$$

where  $\bar{p}$  denotes the price cap. Instead of analyzing the optimal price cap we focus on the simpler case in which  $\bar{x}$  is such that the consumers cannot be worse off under privatization. That is, we assume that  $\bar{x}$  is equal to the quantity offered if the firm remained state owned. While this assumption reduces the government's incentives to privatize the firm, it does not alter the strategic effects which price cap regulation has on the investment decisions and the wage bargaining under privatization. Investment  $I$  is chosen in the second stage. Wage bargaining between either the government or the privatized firm and the union takes place in the third stage. In both cases we focus on the Nash solution, i.e., we assume that the wage markup is determined by

$$\Delta^s = \arg \max W^\alpha U^{1-\alpha} \text{ if the firm is state owned} \quad (8)$$

or

$$\Delta^p = \arg \max \Pi^\alpha U^{1-\alpha} \text{ if the firm is privatized} \quad (9)$$

where  $1 - \alpha$  with  $0 \leq \alpha \leq 1$  measures the union's bargaining power. In the final stage output  $x$  and the quantities of the inputs  $l$  and  $k$  are chosen. Without privatization  $x$  can be chosen according to the government's objective function (5). With privatization the firm can only choose  $l$  and  $k$  – given that (7) is binding.

Solving the game by backward induction we analyze the government's incentives to privatize the firm by comparing the government's utility (5) with and without privatization.

### 2.3 Wages and Investments

We first analyze the last two stages of the game and determine the optimal solutions for  $x$ ,  $l$  and  $k$  for both the state owned and the privatized firm. Analyzing the wage bargaining reveals that price cap regulation tends to increase the markup under privatization. This result



is more pronounced the higher the bargaining power of the union. This also implies that the government's incentives to privatize the firm should be low if the union's bargaining power is high.

With respect to the investment decisions it turns out that both the state owned as well as the privatized firm will distort their investment according to its impact on the negotiated wage. The direction of these distortions is likely to be the same with and without privatization. Underinvestment tends to be optimal if investment is productivity enhancing. Overinvestment will occur if investment increases the elasticity of substitution between  $l$  and  $k$ .

### 2.3.1 Supply, Factor Demand and Wage Bargaining

We start by characterizing the solutions for the case in which the firm is state owned and in which it is privatized. Comparing the solutions allows us to discuss the government's incentives to privatize the firm.

*State Owned Firm* Using (1) and (5) the Lagrangian for government's optimization problem is given by

$$L^S = CS + (1 + \mu)\Pi + \nu[\gamma l + (1 - \gamma)U] + \lambda F \quad (10)$$

Evaluating the first order conditions with respect to  $k$ ,  $l$  and  $x$  shows that the solutions  $l^s(x, \Delta, I)$ ,  $k^s(x, \Delta, I)$  and  $x^s(\Delta, I)$  satisfy  $F(x^s(\Delta, I), l^s, k^s, I) = 0$  and<sup>13</sup>

$$\frac{w + \Delta - \phi}{r} = \frac{F_l}{F_k} \quad \text{with} \quad \phi := \frac{1}{1 + \mu} \nu[\gamma + (1 - \gamma)\Delta] > 0, \quad (11)$$

$$p(x^s) - c_x = -\frac{\mu}{1 + \mu} p'(x^s) x^s \quad \text{with} \quad c_x := rk_x^s + (w + \Delta - \phi)l_x^s. \quad (12)$$

Equation (11) reveals that the government distorts its input decisions according to the weights it puts on labor and the union's utility. Equation (12) simply reflects the inverse elasticity rule based on the distorted input decisions and on  $w + \Delta - \phi$  as the wage rate relevant for the government.

Turning to the third stage and using  $l^s$ ,  $k^s$  and  $x^s$  let  $\tilde{W}^s(\Delta, I)$  and  $\tilde{U}^s(\Delta, I)$  denote the reduced objective functions of the government and the union, respectively. Using (8), employing the envelope theorem and evaluating the first order condition with respect to  $\Delta$  implies that the negotiated wage markup  $\Delta^s(I, \alpha)$  satisfies  $\Delta^s(I, 1) = 0$  and

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<sup>13</sup> Subscripts denote partial derivatives. We focus on interior solutions which are guaranteed as long as  $F(x, l, k, I)$  satisfies the usual INADA conditions.

$$\frac{\alpha((1+\mu)+\nu(1-\gamma))}{\tilde{W}^s} = \frac{1-\alpha}{\Delta^s l^s} \left[ 1 + \frac{\Delta^s}{l^s} \left( \frac{\partial l^s}{\partial \Delta^s} + \frac{\partial l^s}{\partial x^s} \frac{\partial x^s}{\partial \Delta^s} \right) \right] \quad (13)$$

for  $0 \leq \alpha < 1$ . With  $\alpha = 1$  the union has no bargaining power, which leads to the government's preferred markup equal to 0. With  $0 < \alpha < 1$  the negotiated markup simply equates the weighted marginal loss of the government and the weighted marginal utility of the union. Note that the union's marginal utility depends inter alia on how the government's optimal supply  $x^s$  reacts to an increase of  $\Delta^s$ . Using (11) and (12), simple comparative statics reveals  $\partial x^s / \partial \Delta^s < 0$ . Furthermore,  $\partial x^s / \partial \Delta^s$  decreases c.p. with the elasticity of the demand,  $x'(p)p / x(p)$ . Therefore, the markup tends to be lower the more elastic the demand function.

*Privatized Firm* Assuming that the price cap regulation is binding and maximizing (3) with respect to  $l$  and  $k$ , the firm's input decisions  $l^p(\bar{x}, \Delta, I)$  and  $k^p(\bar{x}, \Delta, I)$  satisfy

$$\frac{w + \Delta}{r} = \frac{F_l}{F_k}, \text{ and } F(\bar{x}, l^p, k^p, I) = 0 \quad (14)$$

As usual, (14) indicates that price cap regulation does not distort the firm's input decisions. Employing  $l^p$  and  $k^p$ , let  $\tilde{\Pi}^p(\Delta, I)$  and  $\tilde{U}^p(\Delta, I)$  denote the firm's reduced profit function and the union's reduced utility function. Using (9), the envelope theorem implies that the wage markup  $\Delta^p(I, \alpha)$  which is negotiated between the privatized firm and the union satisfies  $\Delta^p(I, 1) = 0$  and

$$\frac{\alpha}{\tilde{\Pi}^p} = \frac{1-\alpha}{\Delta^p l^p} \left[ 1 + \frac{\Delta^p}{l^p} \frac{\partial l^p}{\partial \Delta^p} \right] \quad (15)$$

for  $0 \leq \alpha < 1$ .

*Comparison* Assuming that the investment  $I$  is given, holding  $\Delta$  constant and using  $\bar{x} = x^s$ , (11) and (14) show that – from the government's perspective – the privatized firm employs too little labor. Thus, the government will privatize the firm only if privatization induces higher profits and thus lower wage markups (recall that  $\Delta^s(I, 1) = \Delta^p(I, 1) = 0$ ). With  $\alpha > 0$ , (13) and (15) indicate that the difference  $\Delta^s(I, \alpha) - \Delta^p(I, \alpha)$  depends on two main effects. First, the RHS of (13) is lower than the RHS of (15) as long as

$$\frac{\tilde{\Pi}^p}{\tilde{W}^s} < \frac{1}{(1+\mu)+\nu(1-\gamma)} < 1. \quad (16)$$

That is, the more the government weighs the union's utility, i.e., the lower  $\gamma$ , and the higher the consumer surplus, the more the markup tends to decrease with privatization. On the other hand, price cap regulation generally leads to an increase of  $\Delta^p(I, \alpha)$ . Since the privatized firm is not allowed to reduce its output,  $l^p(\Delta, \cdot)$  is ceteris paribus less elastic than  $l^s(\Delta, \cdot)$ . Furthermore, with (13) and (15) this effect is more important the higher the bargaining power of the union, i.e., the lower  $\alpha$ . Focusing on the polar case of  $\alpha = 0$  define

$\Theta := \frac{\partial l^s}{\partial x^s} \frac{\partial x^s}{\partial \Delta^s}$  and let  $l^c(\Delta^c(\theta))$ ,  $k^c(\Delta^c(\theta))$  and  $\Delta^c(\theta)$  satisfy the following equations

$$\frac{w + \Delta^c - (1 - \theta)\phi}{r} = \frac{F_l}{F_k}, \quad F(\bar{x}, l^c, k^c, I) = 0 \quad (17)$$

$$l^c + \Delta^c(l^c)' + (1 - \theta)\Theta = 0. \quad (18)$$

With  $\theta$  increasing from 0 to 1 the comparative statics of  $l^c$ ,  $k^c$  and  $\Delta^c$  mirror the comparison between  $l^s$ ,  $k^s$  and  $\Delta^s(\cdot, 0)$  and  $l^p$ ,  $k^p$  and  $\Delta^p(\cdot, 0)$  (see (11), (14) and (13), (15)). Differentiating (18) with respect to  $\theta$  and taking into account that  $\Delta^c(\theta)$  maximizes the union's utility we get

$$\Delta^c' > 0 \Leftrightarrow \Theta < \frac{\phi}{\phi(1 - \theta) + \Delta^c} \left[ \Delta^c l^{c''} - \frac{l^c}{\Delta^c} \right]. \quad (19)$$

Using  $\Theta < 0$  and  $\phi = \nu / (1 - \mu) [\gamma + (1 - \gamma)\Delta^s] > 0$  (see (11)), (19) shows that privatization leads to an increase in the markup if  $\Theta$  and  $\nu$  are low enough: The lower  $\Theta$  the more elastic is the government's labor demand compared to the labor demand of the privatized firm; the lower  $\nu$  the less the government weighs employment and/or the union's utility. Both effects imply that the government's option to reduce output and thus employment induces a lower markup if the firm remains state owned.

Summarizing the analysis, privatization and price cap regulation leads to an efficient factor allocation which ceteris paribus hurts the government. The effects on the (negotiated) wage markup are less clear cut. On the one hand, privatization tends to reduce the markup since privatization decreases the relative weight that the union's marginal utility has in the wage bargaining. On the other hand, the imposed price cap regulation strengthens the union's bargaining position. This effect is more important the higher the union's bargaining power and the more the government is willing to decrease output and thus employment if the markup increases.

### 2.3.2 Investments

Turning to the second stage of the game we again start by characterizing the investment decision if the firm remains state owned. We then analyze the investment of a privatized

firm. Investment is distorted in both cases as the government as well as the privatized firm anticipate the effects of their investments on the negotiated wage markups.

*State Owned Firm* Employing (10), substituting  $l^s$ ,  $k^s$ ,  $x^s$  and  $\Delta^s$  and using the envelope theorem, the optimal investment  $I^s(\alpha)$  of a state owned firm is implicitly determined by

$$\frac{dL^s}{dI} = -(1 + \mu)(r + \Delta_I^s l^s) + \nu(1 - \gamma)\Delta_I^s l^s + \lambda F_I = 0 \quad (20)$$

$$\Leftrightarrow 1 + \frac{1 + \mu - \nu(1 - \gamma)}{r(1 + \mu)} \Delta_I^s l^s = \frac{F_I}{F_k} \quad (21)$$

where (21) follows from the optimality condition for  $k^s$ . Therefore, we get

$$\text{sign } \Delta_I^s = \text{sign} \left[ \frac{F_I}{F_k} - 1 \right] \text{ for } I = I^s \quad (22)$$

which immediately implies that investment is inefficiently low (high) if  $\Delta_I^s > 0$  ( $\Delta_I^s < 0$ ) holds. Comparative statics of (13) with respect to  $I$  reveals (assuming  $0 < \alpha < 1$  and evaluating  $\Delta_I^s$  at  $I^s$ )

$$\text{sign } \Delta_I^s = \text{sign} \left[ \Delta^s l^s \frac{d}{dI} \frac{dl^s}{d\Delta^s} - \frac{dl^s}{d\Delta^s} - \frac{dl^s}{dI} \left( l^s + 2\Delta^s \frac{dl^s}{d\Delta^s} \right) \right] \quad (23)$$

$$\text{with: } \frac{dl^s}{d\Delta^s} := \frac{\partial l^s}{\partial \Delta^s} + \frac{\partial l^s}{\partial x^s} \frac{\partial x^s}{\partial \Delta^s}, \quad \frac{dl^s}{dI} := \frac{\partial l^s}{\partial I} + \frac{\partial l^s}{\partial x^s} \frac{\partial x^s}{\partial I}.$$

Ignoring the second order effects, i.e., the first term on the RHS of (23), the sign of  $\Delta_I^s$  is determined by the sign of the second term on the RHS. Considering first the last term, i.e.,  $l^s + 2\Delta^s \frac{dl^s}{d\Delta^s}$ , and using (13) shows that this term is negative if the bargaining power of the union is high, i.e., if the negotiated markup is close to the union's optimal markup. The sign of  $\frac{dl^s}{dI}$  depends on the effects which  $I$  has on the firm's technology. With  $I$  mainly

affecting the marginal rate of substitution between  $l$  and  $k$ ,  $\frac{dl^s}{dI}$  is negative while  $\frac{\partial x^s}{\partial I}$  and

thus  $\frac{\partial l^s}{\partial x^s} \frac{\partial x^s}{\partial I}$  tend to be rather small. Combining these observations implies that the gov-

ernment has an incentive to overinvest, i.e., to choose  $I$  such that  $0 > F_I > F_k$ , if the union's bargaining power is relatively high and if investments mainly increase its possibility to substitute labor by variable capital. Underinvestment is more likely to be optimal if the

union's bargaining power is low and if investment is productivity enhancing such that the optimal labor employment would decrease.

*Privatized Firm* With privatization, the same calculations as above reveal that the firm's optimal investment  $I^p(\alpha)$  is given by

$$1 + \frac{1}{r} \Delta_I^p I^p - \frac{F_I}{F_k} = 0 \Rightarrow \text{sign } \Delta_I^p = \text{sign} \left[ \frac{F_I}{F_k} - 1 \right] \text{ for } I = I^p \quad (24)$$

Comparing (24) and (22) shows that the privatized firm has basically the same strategic incentives to distort investment as the government. Similarly, considering the sign of  $\Delta_I^p$  I comparative statics with respect to  $I$  leads to (assuming  $0 < \alpha < 1$  and focusing on  $I = I^p$ )

$$\text{sign } \Delta_I^p = \text{sign} \left[ \Delta^p I^p \frac{d}{dI} \frac{\partial I^p}{\partial \Delta^p} - \frac{\partial I^p}{\partial I} \left( I^p + 2\Delta^p \frac{\partial I^p}{\partial \Delta^p} \right) \right]. \quad (25)$$

Again, the higher the union's bargaining power and the more investment allows to substitute labor by capital the more the privatized firm will tend to over invest. Underinvestment is likely to be optimal if investment is productivity enhancing.

These results show that the strategic incentives to distort investment are the same with and without privatization. Therefore, government's gains from privatization will mainly be determined by its bargaining power and by its objective function, i.e., by its weights on profits, employment and on the union's utility. Whether investment is productivity enhancing or primarily affecting the substitutability of  $l$  and  $k$  should not alter the government's incentives for privatization.

## 2.4 A Numerical Example

In order to illustrate the above results and to analyze the government's privatization decision more carefully, we now analyze a simple example. The inverse demand function is given by

$$p(x) = 2 - x \text{ with: } 0 \leq x \leq 2. \quad (26)$$

With respect to the firm's production technology we consider the following two cases:

$$i) \quad x = I^{1/2} \left[ I^{0.5} + k^{0.5} \right]^2 \quad (27)$$

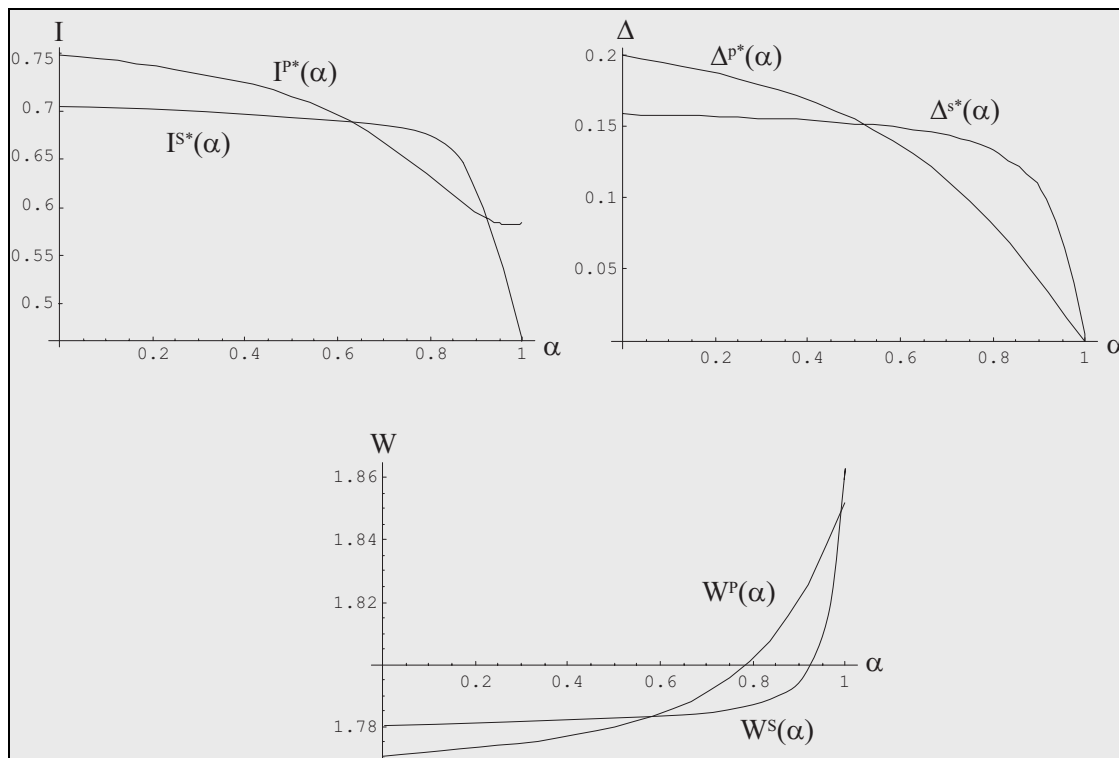
$$ii) x = \left[ (1-\kappa)l^{0.5} + (1-\kappa)k^{0.5} \right]^2 \text{ with: } \kappa := \frac{I}{1+I}. \quad (28)$$

In case *i)*  $I$  increases the productivity of  $l$  and  $k$  but does not affect the marginal rate of substitution between  $l$  and  $k$ . In case *ii)* investment decreases the elasticity of substitution  $\eta_{lk} = -(1-\kappa)/(1-\kappa)(l/k)^{0.5}$ . In both cases we focus on the effects of a varying  $\alpha \in [0,1]$  while holding the other parameters constant, i.e., we assume  $r = w = \mu = \nu = 0.1$  and  $\gamma = 0.5$ .

Solving the example shows that the government will privatize only if  $\alpha$  is relatively large (but strictly smaller than 1). These results hold for both cases *i)* and *ii)* which confirms that the union's bargaining power has a non-monotone impact on the government's gains from privatization and that different kinds of investments do not change this observation qualitatively.

To see this more clearly, consider first case *i)*. Figure 1 shows the graphs for the optimal investments  $I^i(\alpha)$  with  $i = s, p$ , the implied wage markups  $\Delta^i(\alpha)$  and the government's utility with and without privatization  $W^i(\alpha)$ .

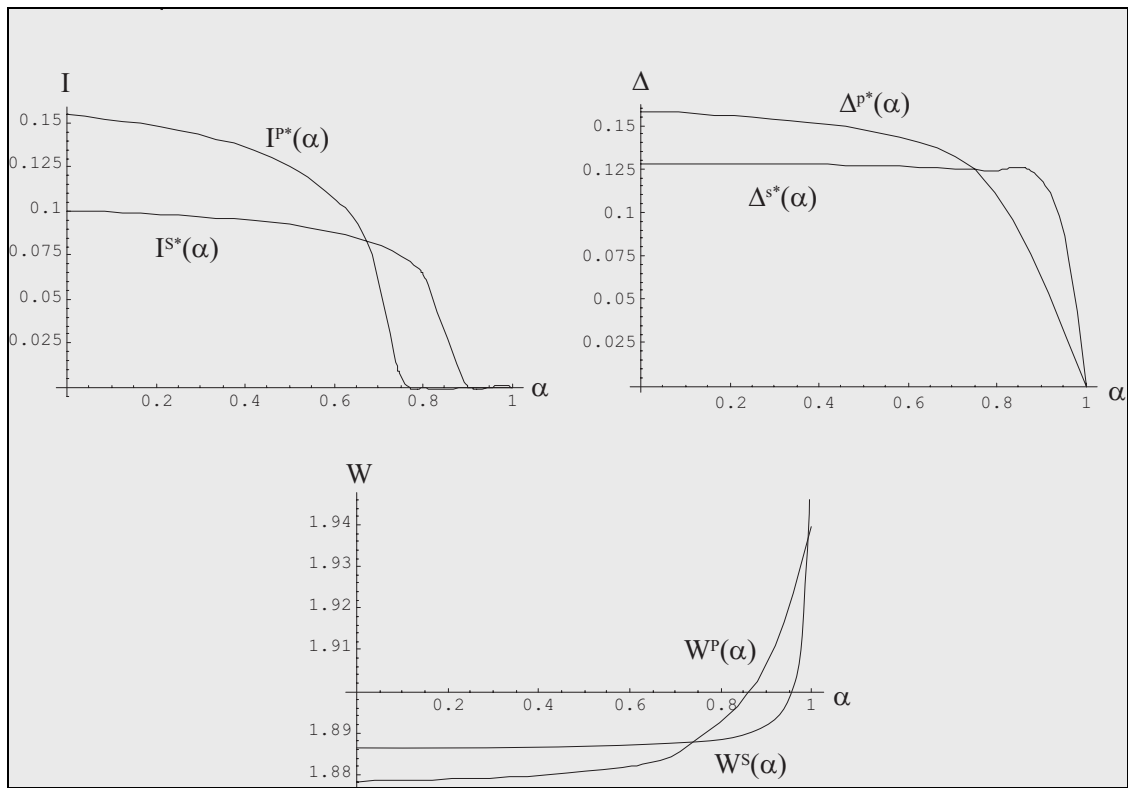
Figure 1 – Numerical Example - Case *i)*: Investments and Markups with  $\gamma=0$



Analyzing  $I^s$ ,  $I^p$  and  $\Delta^s$  and  $\Delta^p$  note first that investment is productivity enhancing which implies that the optimal investments of the state owned and the privatized firm increase c.p. with the corresponding wage markups. However, since  $\alpha = 1$  leads to

$\Delta^{s*}(1) = \Delta^{p*}(1)$  and since the government puts more weight on labor we get  $I^{s*}(1) < I^{p*}(1)$ . Considering  $\alpha < 1$  we obtain  $\Delta_i^i > 0$  for  $I = I^{i*}(a)$  and  $\tilde{W}^S(a) > \tilde{\Pi}^P(a)$ . Thus, while both the state owned and the privatized firm underinvest, lowering  $\alpha$  (starting with  $\alpha = 1$ ) implies that the optimal investment and the induced markup increase faster if the firm remains state owned. With relative low values of  $\alpha$  the effect of  $\tilde{W}^S - \tilde{\Pi}^P > 0$  on  $\Delta^s - \Delta^p$  vanishes whereas the government's option to reduce output becomes relatively more important. Both effects lead to  $I^{s*} < I^{p*}$  and  $\Delta^{s*} < \Delta^{p*}$ . Employing these results and calculating the government's utility with and without privatization shows that the government will gain from privatization only if  $0.57 < \alpha < 0.99$ .<sup>14</sup>

Figure 2 – Numerical Example - Case ii): Investments and Government's utility with  $\gamma=0$



In case *ii*) we get the same qualitative results with respect to the government's gains from privatization. Using (28) shows that investment serves as an instrument to reduce the markup by increasing the elasticity of substitution between  $l$  and  $k$ . While both the state owned and the privatized firm overinvest, Figure 2 shows that with high values of  $\alpha$  the higher markup without privatization also induces higher investment if the firm remains state owned.<sup>15</sup>

<sup>14</sup> Obviously, with  $\alpha = 1$  the government will never privatize the firm.

<sup>15</sup> With  $\Delta = 0$  the efficient investment is 0.

For low values of  $\alpha$  the same arguments as in case *i*) imply that the markup and thus investment is higher if the firm is privatized. Evaluating the government's utility reveals that privatization is worthwhile only for high values of  $\alpha$ , i.e, for  $\alpha \in [0.73, 0.99]$ , which confirms that the government's incentives for privatization are qualitatively the same as in case *i*) in which productivity enhancing investment was considered.

## 2.5 Conclusions

The late 1990s have experienced a downright privatization wave all over the world. Large-scale divestitures of state owned enterprises, most importantly of network industries, have largely contributed to the enormous growth of the world stock market capitalization and trading volume. However, the understanding of the underlying reasons for this development is still unsatisfactory. Eventually, politicians give up control over a firm's investment, employment and pricing decisions. These are all relevant policy instruments, which get lost when a privatization policy is pursued. This chapter contributes to the understanding of the politicians' motives for privatizing a state owned enterprise.

Analyzing a government's gains from privatization we focused on the potential impact of an imperfect labor market. In a model with a unionized labor force and wage bargaining we showed that privatization combined with price cap regulation can in fact be a worthwhile policy measure for the government. Privatization alters the union's bargaining position and can lead to lower wages. Anticipating this effect the government's revenues from privatization are higher than the firm's profits if the firm remains state owned. However, since this positive effect is not monotonically correlated with the union's bargaining power, the government's incentives to privatize the firm turns out to be especially high if the union's bargaining power is rather low (but positive). The analyzed example shows that a government can indeed suffer from privatization if its own bargaining power is low.

These results do not depend on the investment opportunities of the firm. They are due rather to the assumption that a privatized firm is constrained by price cap regulation. While price cap regulation implies an efficient factor allocation, it also reduces the elasticity of the (privatized) firm's labor demand which tends to increase the wage markup under privatization. Thus, regulating the firm's prices in order to ensure high output entails the negative drawback of improving the union's bargaining position. Alternative, hybrid regulatory mechanisms that combine the advantages of rate of return regulation with those of the price cap regime may alter this trade off.<sup>16</sup> If unionized labor markets are considered a pure price cap regulation may therefore not be the optimal regime. The government's incentives for privatization, however, would only increase if properly adapted regulatory schemes were

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<sup>16</sup> Examples for hybrid regimes as banded rate of return and sliding scale profit sharing are given in Kes-sides (2004), p.119.



used. The advances in the design of regulatory regimes may therefore have contributed to the privatization wave of the 1990s. A shrinking bargaining power of the unions that arose in the course of an increasing globalization may give an additional explanation to the phenomenon.

### **3 The German Electricity Sector – Finally on the Move?<sup>17</sup>**

#### **3.1 Introduction**

The media have frequently maintained that the liberalisation of electricity could have a dangerous impact on the security of supply, grid investments, and the system, as well as on the price stability of this crucial and sensitive sector. In the summer of 2003, when the liberalisation and regulation of electricity had just entered a new round in the EU, several European countries suffered from power blackouts. Two years before it was California, which involuntarily gained negative publicity for its recently liberalised power sector.

In contrast blackouts have rarely been a serious issue in Germany so far. But in this country, which is supposed to form the centre of a common European electricity market, where the network usage costs are currently 70 percent above the EU average and electricity retail prices among the highest in the EU, a new energy law is on the verge of being enacted. The question that arises here is whether this law (which is overdue according to EU legislation) has the ability to perform the balancing act between the retention of a stable and sustainable system and the containment of excessive market power on the part of the incumbent players. At the moment it seems that the latter aspect is more urgent – but nevertheless both problems should be solved simultaneously.

In this article we analyze the recent developments in the German electricity sector and relate them to experiences gained in the US. Initially we give a short overview to the special characteristics of this exceptional sector.

#### **3.2 Particularities of the electricity sector**

The electricity sector exhibits several distinctive properties as compared to most other markets. Some of these properties are presented here in brief.

##### **3.2.1 Natural monopoly**

Traditionally the whole electricity sector was regarded as unsuitable for competition. In particular, high sunk capital costs predominated in all areas of the sector, creating economies of scale over the entire range of output. In this case the long-term cost minimising capacity and size of the firm is relatively large in comparison to market demand. There are also strong economies of scope between generation, transmission and distribution. With

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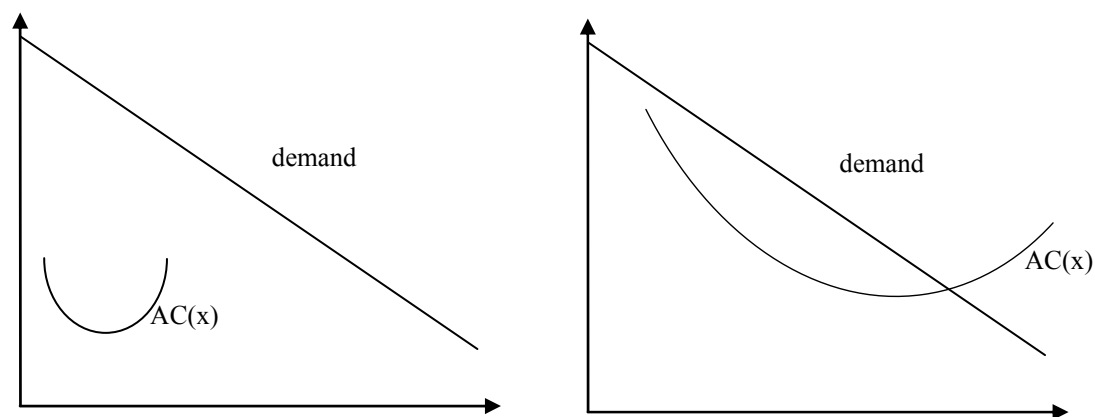
<sup>17</sup> This Chapter relies on a joint article with Ingo Vogelsang (Professor of Economics at the Boston University), see Kuhlmann, Vogelsang (2005).

such economies of scale and scope it is optimal for one operator to serve the entire market – the case of a natural monopoly.

The traditional view is that a natural monopoly exhibits monotonous falling average costs due to high fix and relatively low (and constant) variable costs, implying large economies of scale. But falling average costs are only a sufficient, but no necessary condition for a natural monopoly. Figure 3 illustrates market demand and the respective cost structure in case of competition (on the left) and of a natural monopoly (on the right) with a subadditive (U-shaped) cost structure.<sup>18</sup> The vertical axes represent price and average costs respectively and the horizontal axes represent the respective output quantity.

Although market demand intersects with the average cost curve in the ascending part (in the right picture, representing the natural monopoly), it is not possible to supply the equilibrium quantity (where the curves intersect) at lower total costs by dividing the production to more than one firm. The crucial difference to a competitive market is the relation of average costs to market demand.

Figure 3 – Competition vs. natural monopoly



Source: Weimann (2001)

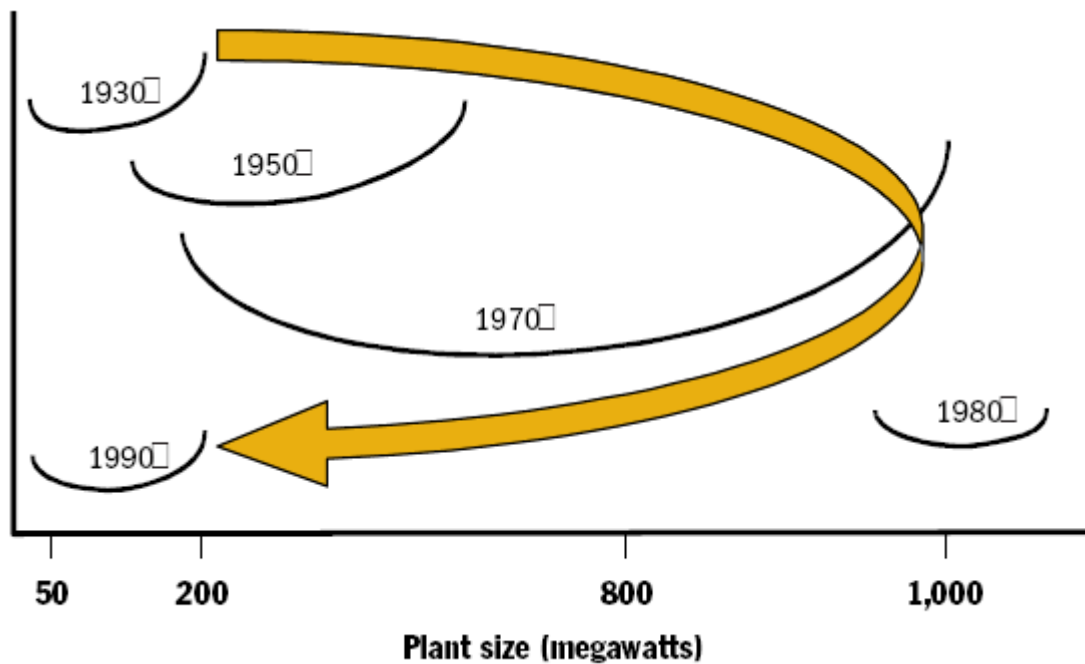
In this context publicly owned entities seemed to be a sensible way of securing the benefits of size – and the required large-scale financing – without suffering the drawbacks of monopoly pricing. At the same time, the vertical integration of generation and transmission and often of generation, transmission and distribution would capture economies of scope. In countries (such as Germany) with traditionally multiple local private energy providers it was common for the government to license regionally protected monopolies, which in Germany were regulated only slightly.

Over the past two to three decades new technologies have significantly reduced the minimum efficient scale of generating plants, the investment costs of new units, and the time

<sup>18</sup> In case of multi-product-enterprises economies of scope may lead to a subadditive cost structure with a U-shaped average cost curve. For a market demand as in Figure 3, the firm is then also a natural monopoly, see Weimann (2001).

needed to plan and build new plants, while economies of scale for transmission and distribution networks persisted. Figure 4 illustrates the development of the optimal size of power generating plants. Due to this development competition between electricity generators seemed feasible and efficiency improving, provided economies of scope between generation and transmission networks were not too great. The extent of those economies was not well known at the time electricity restructuring occurred in several countries, and we are still unsure about them.

Figure 4 – Average generation cost (US dollars per megawatt)



Source: Bayless (1994).

One reason for the large economies of scale in transmission and distribution is due to the properties of electricity itself. In periods of low demand electric power can hardly be stored for peak load periods.<sup>19</sup> In an integrated network different regions are interconnected and the respective peak load periods, which rarely overlap completely, can be balanced against each other. In other words, without a supra-regional integrated network every region would need higher capacities in order to respond to the respective demand in peak periods. For the same reason reserve capacities (and some ancillary services, such as voltage control) can be of reduced size in a larger network.

### 3.2.2 Vertical Separation

The feasibility and desirability of competition in generation, along with the continued persistence of natural monopoly in transmission and distribution networks calls for the establishment of independent generation companies and possibly independent marketers. These

<sup>19</sup> In principle it is possible via pump storage power stations – but only at very high costs or energy losses.

competing companies would either have access rights to transmission and distribution grids of vertically integrated electric utilities, or the grids themselves would be vertically separated. In any case, access of generators and other electricity suppliers to transmission and distribution grids is an essential facility without which competition among generators (and marketers) would not be feasible.

Table 1 illustrates the noncompetitive and competitive components of electricity and five other major network industries.

*Table 1 Noncompetitive and Competitive Components of Network Industries*

| <b>Industry</b>    | <b>Activities that are usually not competitive</b> | <b>Activities that can be and sometimes are competitive</b>                  |
|--------------------|--|--|
| Electricity        | High-voltage transmission and local distribution   | Generation and supply to final customers                                     |
| Gas                | High-pressure transmission and local distribution  | Production, supply to final customers, and storage                           |
| Telecommunications | Local residential telephony or local loop          | Long-distance, mobile, and value added services                              |
| Railways           | Short-haul track and signaling infrastructure      | Train operations and maintenance facilities                                  |
| Water              | Local distribution and local wastewater collection | Production, long-distance transportation, purification, and sewage treatment |
| Air services       | Airport facilities                                 | Aircraft operations, maintenance facilities, and commercial activities       |

*Source: Gonenc, Maher, and Nicoletti (2001).*

Transmission grids connect generating plants with consumption centres, using high-voltage networks that are typically meshed in countries with a large number of power stations and consumption centres. These grids are characterized by loop flows (Kirchhoff's Law), which means that their total capacity depends in a complicated way on the capacity of the individual links. Also, the networks have to be in equilibrium at any moment in time. Transmission grids therefore exhibit both economies and diseconomies of scope, and those can change by the hour. Their scheduling is simple only if no links are congested. In this case, the efficient electricity prices at all network nodes (both generation nodes and consumption nodes) have to be the same. In contrast, in a congested network the price differences between nodes should reflect the costs of congestion. They represent the scarcity value of transmission along all possible paths between nodes. These nodal price differences would, at the same time, be efficient real-time prices of network usage (Hogan, 1992).

Distribution grids convert high-voltage power received from transmission grids into low-voltage power and deliver the electricity to end-users. Loop-flow problems in such grids are usually less pronounced than in transmission grids. In contrast to transmission grids,

which are best managed on a regional basis covering the entirety of a country like Germany, distribution grids are typically many with each one forming a natural monopoly. Once vertical separation is chosen, it therefore makes sense to separate transmission and distribution companies vertically by management and ownership. Benchmark or yardstick regulation, which bases regulatory performance criteria and pricing on the performance of other regulated firms would be ideal for the many distribution companies but hardly feasible for the single transmission companies.

### **3.2.3 Market clearance and market power in generation**

As described above electricity supply and demand have to be in equilibrium at any time. Unfortunately power demand fluctuates quite substantially depending on time of day and season. Demand fluctuations cannot effectively be smoothed at this time, because intelligent metering and consumption scheduling devices – although technically feasible – are still lacking in Germany and elsewhere. In order to adjust the supply adequately to these demand fluctuations the power providers (or the generating companies) need to have several different types of power plants. Base load plants (hydro power, nuclear and lignite), which combine high fix and low variable costs, have to be mixed with shoulder plants (coal, natural gas and combined heat and power generation) and peaking plants (oil, gas, and pump storage power stations). The latter ones are only used for periods of high demand, as they combine low fixed and high variable costs.

But these complex capacity requirements are not easy to adjust to a higher (medium- or long-term) demand. The production of power plants is not only capital intensive but also characterized by substantial indivisibilities. Technological progress has indeed diminished the optimal firm size, but building a new power plant with an average economic life-time of 30 years is still associated with substantial cost and scheduling effort. Therefore those markets are not contestable – using the terms of Baumol, Panzar and Willig (1982) – and this favors inherently the high price-cost margins of the incumbent players. This phenomenon is amplified by the low price elasticity of demand for electricity. In fact, due to the lack of sophisticated metering, short-term demand is almost perfectly inelastic. Recurrent interaction of the market players also allows them to develop subtle strategies of communication and collusion and the short-term capacity constraints (as described above) prevent deviations from a strategy of collusion from being profitable.

### **3.2.4 Energy as an essential input for every economy**

It is not only due to technical and market features that electricity takes on a special position among all bulk products. For every industry (and every household) it is also one of the most important input factors that are necessary for the functioning of almost every other activity. This is expressed by the low demand elasticity with respect to price and the almost unitary elasticity with respect to income. As we have seen in California, an electricity crisis certainly has the ability to disturb the economic processes substantially.

Under a private-sector environment the long term goal “security of supply” would be dominated by short-term profit orientation – and an inflexible price system cannot align these goals. It is therefore obvious that a stable and incentive-based regulatory framework is very important to avoid investment backlogs in generation, transmission and distribution of electricity. Whether such a framework is in place or will emerge in Europe’s largest economy, namely Germany, will be discussed after including some lessons from the US.

### **3.3 Lessons from US electricity sector reforms**

For a better understanding of the German legislative process it seems helpful to recall the problems that have hurt the US in its process of electricity restructuring. We will first give a brief description of the crisis in California in 2000/2001, which was the largest one of that kind in the US history, and then discuss some further features of the US electricity sector.

#### **3.3.1 The California crisis**

In the early 1990s it was in California where US electricity prices were highest. This situation was the result of failures in the existing system of vertically integrated monopolies. High investment costs for nuclear power plants, overcapacities and many expensive long-term contracts are some aspects that describe the situation at that time. In addition the interaction of the federal (FERC) and regional (CPUC) regulatory authority was inefficient and costly. It was somewhat obvious that the existing framework was inappropriate to solve the current problems, and therefore California tried a new way and became precursor in the US electricity liberalization. In 1998 the bill that combined complicated ingredients that have never been mixed together before (Vogelsang 2004) became effective.

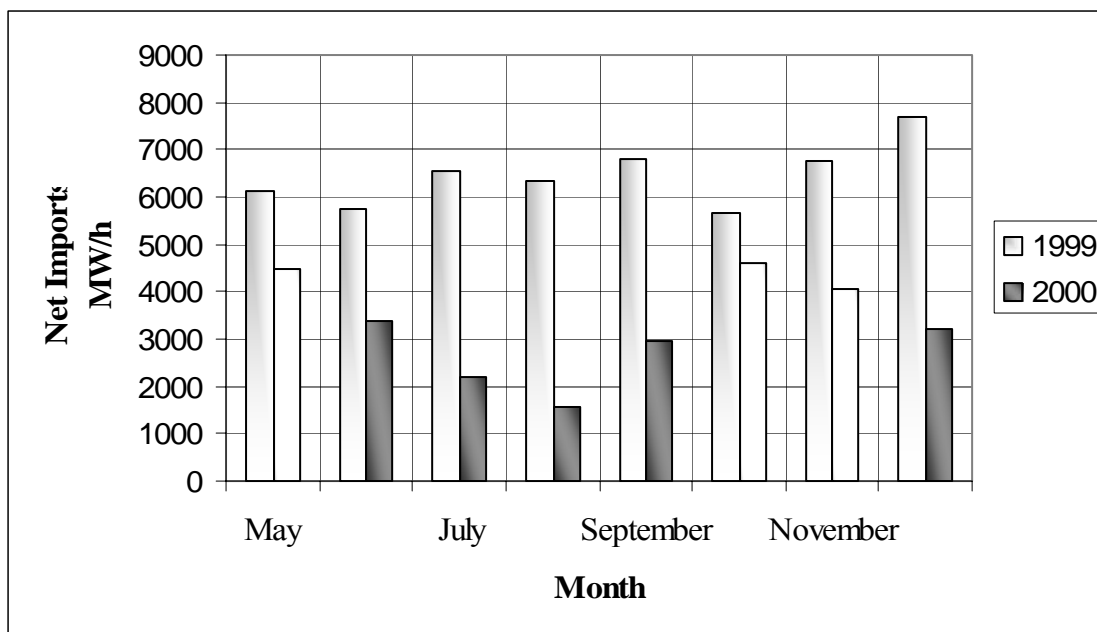
At the beginning of the reforms slightly more than 80 percent of the generation capacity in California was owned by three private electricity companies. In order to create a competitive wholesale market the distribution companies were forced to divest themselves of at least half of their generation facilities (Joskow 2001, 376). An independent system operator (ISO, in California: CAISO) was established to serve as a platform for wholesale and retail market trading and to supervise the transmission grid (which includes running various energy balancing, ancillary service, and congestion management markets). In addition the California Power Exchange (CALPX) was created to run day-ahead and hour-ahead hourly public wholesale markets for sales of energy. Both are non-profit corporations.

Despite the new possibilities of changing their energy provider, few customers took that option. At the same time retail prices of the incumbents were lowered by 10 percent and then fixed by law (until stranded assets were fully paid off or, at the latest, until 2002). All this happened under the assumption that wholesale power prices would always stay significantly below the regulated retail price. The three big providers were still serving about 88 percent of total demand, but they had divested the majority of their generating capacities

before. They were thus obliged to buy a large fraction of the electricity that was needed to serve all the customers at CALPX and CAISO. This situation in comparison with fixed retail prices made them vulnerable for any price shock at the wholesale market. And this was exactly what was going to happen.

The slow process of licensing and completion of new power plants drove reserve capacities down by 1999. Then came the extremely hot summer of 2000. As a consequence, the electricity imports from the northern neighboring states decreased dramatically (to a large extent the imports consisted of weather depending hydro power – see Figure 5). At the same time, electricity demand rose due to the increased use of air condition as well as a booming economy.

Figure 5 – Net Electricity Imports to California



Source: Joskow (2001), Table 4, own adaptation

As a consequence of rising demand and decreasing supply the electricity wholesale prices increased dramatically (from April to December 2000 about 1300 percent) – and at the same time the providers had to serve the customers at lower and legally fixed retail prices.<sup>20</sup> In addition the early onset of winter pushed the price for gas substantially and induced a further increase in electricity prices. A simultaneous increase in the price for emission certificates accelerated the whole process.

All these (mainly exogenous) adverse factors, emerging in combination, were certainly very problematic – nevertheless a well-developed regulatory framework probably would have been able to deal with these problems. In California this was not the case. The regula-

<sup>20</sup> For an illustration of the changing demand and the price developments, see Kuhlmann (2004), 59-60.



tory institutions were not able to mitigate the sector-intrinsic problems of market power (as described above) and this finally turned the balance. According to Borenstein et al. (2002) 59 percent of the electricity price increase between summer 1999 and summer 2000 was due to problems with market power. Wolak (2003) has calculated that market power (measured via the Lerner Index) of the five largest generators had quintupled between 1999 and 2000. Congestions in the grid had aggravated the “normal” market power problems.

As a result of all these factors the reserve capacities declined in summer 2000 below 5 percent; at the end of the year they were below 1.5 percent. This caused several emergencies of highest priority, but energy savings were still able to avert blackouts. Shortly thereafter the two largest providers went bankrupt and could not buy the necessary electricity to serve their customers. This finally triggered several huge blackouts in January 2001. Shortly thereafter CALPX went bankrupt as well and California was in the middle of its deepest electricity crisis, which has no analogy elsewhere – so far.

### **3.3.2 General features and institutions of the US electricity market**

Although the California disaster was due to a combination of adverse weather, fuel markets and a booming economy, it is clear that it would not have happened without electricity restructuring. It is therefore worth looking at other US jurisdictions for better solutions. This particularly concerns the US federal level represented by the Federal Energy Regulatory Commission (FERC). The FERC was unable or unwilling to interfere in California to prevent the crisis. However, the FERC responded by constraining wholesale electricity prices through price caps and by trying to establish regional transmission organizations (RTOs) and a standard market design for highly centralized electricity markets.<sup>21</sup> The RTOs (which have not yet been established throughout the country) typically cover areas beyond single states and fulfill the same functions as ISOs including the function that used to be fulfilled by CALPX. RTOs and a skilful market design are particularly important in order to help avoid crises such as California’s as well as blackouts like in the north-eastern US in 2003. They require the adherence to consistent rules and an expansion of the transmission system. The latter has been particularly difficult in the US. Environmental concerns have been one reason. The other, however, is that additional transmission capacity can hurt areas with excess electricity supplies, which they would like to keep to themselves and thereby lower electricity prices in those areas. This has particularly hurt California, because it could not access eastern states for cheaper electricity.

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<sup>21</sup> The FERC only has jurisdiction over transmission networks and wholesale transactions so that distribution companies are regulated by state public utility commissions only.

### 3.4 The German electricity sector

Germany possesses a closely meshed electricity grid, where congestions or breakdowns are a rare exception and events like the ones in California (in 2001) or the northeastern US and some European countries (in 2003) seem quite unlikely at the moment. The German market for electricity was opened for competition in 1998 – in theory even to 100 percent, which means that all (industry and private) customers can choose their individual provider. At that time this went far beyond the EU guidelines and Germany seemed to be a precursor as regards electricity liberalization.

Currently the market is still dominated by the originally dominant providers, who have merged from six to four since the liberalization.<sup>22</sup> They have an aggregate market share of about 80 percent in electricity generation (without accounting for any cross-shareholding) – another 10 percent is produced by roughly 900 regional and municipal providers and the remaining 10 percent is produced by Deutsche Bahn AG and the manufacturing industry for their own electricity requirements. The same four dominant companies own the transmission grid. The regional providers and municipal utilities are very numerous, and one might think this should be enough to initiate competition, but in many cases the big four hold major shareholdings in these utilities. Between 2000 and 2002 RWE Energie and E.on acquired new stakes in about 40 utilities without causing an intervention of the German competition authority (Leprich 2002, 4).

#### 3.4.1 The Energy Law of 1998

Whether competition in the electricity sector of an economy can emerge or not critically depends on the design of the market rules. This is particularly the case for the rules concerning network access. As described above in the section on natural monopoly,<sup>23</sup> the grid continues to represent an essential facility or monopolistic bottleneck. The access to this facility is crucial for potential and actual competitors and thus also for efficient competition.

The European electricity directive that was in force at that time (96/92/EG) gave member states the choice between negotiated<sup>24</sup> or regulated<sup>25</sup> third party access (TPA) and the sin-

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<sup>22</sup> VEBA and VIAG have merged to E.ON in 2000, and VEW has been acquired by RWE. Apart from that there are ENERGIE BADEN-WÜRTTEMBERG (ENBW, which is mainly owned by ÉLECTRICITÉ DE FRANCE) and VATTENFALL – a Swedish state owned enterprise, which is also active in Finland and Poland.

<sup>23</sup> See the paragraph on the Natural Monopoly properties in electricity.

<sup>24</sup> Under negotiated TPA producers and consumers of electricity will contract supplies directly with each other, but they will have to negotiate access to the network with its operator.

<sup>25</sup> In case of regulated TPA the price for the use of the transmission and distribution systems can, however, not be negotiated. It is regulated by a national regulatory agency (NRA).

gle buyer<sup>26</sup> procedure. Germany was the only country choosing the negotiated TPA – which was actually implemented in several trade association agreements (“Verbändevereinbarung”) between energy producers and industrial consumers – where it was quite easy for the “old bulls” to make life hard for their competitors. Many of these competitors have vanished since then. These agreements were quite favorable to the incumbent network operators. This comes as no surprise, as not a single stakeholder of the potential competitors was involved in the proceedings. In the *first agreement* (concluded in May 1998) transmission was defined as point-to-point delivery and every electricity trader had to place a contract on the precise wheeling of power, which was obviously quite obstructive for effective competition. Therefore in December 1999 the associations approved a *second agreement*. This time the involved parties (in the meantime there were 6 instead of 3) assured simplified network access and created the preconditions for trades in a power exchange. This was aided by the so-called connection-point model (“Anschlußpunktmodell”). In this scheme the end-customer paid an access fee to the distribution-network provider to whom he was immediately connected. He thereby obtained access to the entire German electricity network (at all voltage levels) and could then freely choose his provider. In other words, he had to sign two new contracts and bear some additional switching charges if he wanted to change his provider. Moreover there was no regulator in charge of monitoring whether the switching process was delayed deliberately by the respective incumbent. All these direct costs and indirect obstacles certainly played a decisive role in the decision of customers to change their provider. Less than four percent of the German households changed their energy provider after the liberalization – an absurdly small number compared to 40 percent in the UK.

Finally in a *third attempt* (or rather an addendum to the second) in December 2001 the double-contract-model was abolished, but the pricing principles became more complicated than before. *Another supplement* was added in April 2002, where a cost-based real pre-tax return on equity was fixed at 6.5 percent, which has been widely criticized for its inflating effect on the net user fees.

The price development can serve as an indicator for the effectiveness of all these agreements. The electricity tariff fell initially (between 1998 and 2000) a little for households (1.8 percent per year) and quite considerably for the industry (13.7 percent per year), but in the following three years this process was inverted and the prices rose again (10.6 percent for the industry and 4.6 percent for households per year; BMWA 2005c). The ecotax (introduced in 1999 and further increased in four steps) inflated this price increase, but this

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<sup>26</sup> The single buyer has been defined in the Directive as a legal person who is responsible for the unified management of the transmission system and/or for centralized electricity purchasing and selling. This means that the single buyer would normally also be the transmission system operator but not necessarily.

did not change the story.<sup>27</sup> In June 2003 the European Commission finally abolished the possibility of negotiated TPA and decided that in all member states a national regulator had to be established by July 2004 (Directive 2003/54/EC). From that moment the German “special way” was officially designated a dead-end street.

### 3.4.2 The new Energy Law of 2005

Soon it became obvious that the deadline for the enactment of a new law would elapse without any new legislation being enacted. Finally, in July 2004, the federal cabinet agreed upon a first draft of the new energy bill. But it took another nine months of negotiating before a concrete law with all its prescriptions entered the final legislative process. On 15 April 2005 the Bundestag (the German Parliament) finally passed a new energy law. Among the important alterations or improvements of the new law are the following.

First of all there is the legal and operational unbundling of generation and the networks. This measure should ensure that there are no incentives for the grid operator to discriminate against other network users in favor of its own subsidiaries. All vertically integrated electric power companies with more than 100,000 customers have to unbundle their network activities from generation and marketing – legally and operationally but not in terms of ownership. For transmission companies (the big four) this rule will become effective immediately – the deadline for distribution companies is July 2007.

The German regulatory authority for telecommunication and postal services (RegTP) will inherit the supervision of the electricity and gas sector (as well as for the railway sector) and will be renamed “Federal Network Agency” (“Bundesnetzagentur”). A major task of this agency will be to set (or to specify the details of) the terms and conditions for network access, including price regulation, and to monitor the compliance with these rules. It will further have some monitoring duties, a voice in the unification of contractual obligations and the task of settling disputes. Its discretionary power or ex-ante competencies, however, are quite limited. Some examples of the discretion it lacks are given below.

At any time the incumbent can – without previous notice – terminate the contract with the competitor who needs access to the grid. As explanatory statement such a measure should be “upon good cause”, but this is a discretionary decision by the respective network operator, with no exertion of influence by the regulator. This gives the incumbent again a strong position.

Concerning the transaction costs associated with the network access, it is intended that the incumbent network operators create standardized rules, but here again the regulator has no

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<sup>27</sup> Even after a deduction of the tax the average yearly price increase for households between 2000 and 2002 was three times higher than in the eight years preceding the liberalization. In the industry, where price increases were even larger, 80 percent of the tax is remitted.

say in this matter. Its influence is also limited in the access to distribution networks, where the regulator can only affect the settlement procedure and the corresponding specification of a uniform price that has to be paid for deviations from predetermined load profiles.

Nevertheless, following several complaints of the energy-consuming industry and the Länder (Federal States) on the draft bill, the federal government, in the bill passed by the Bundestag, has somewhat enlarged the discretion of the regulator, in particular, with respect to the introduction of incentive regulation. After all the fierce criticism voiced in the course of the legislative process, the federal government has authorized the regulatory agency to further develop and to implement the concept for a price-cap or revenue-cap approach. Furthermore the regulator has a say in determining the conditions and notice periods, which are relevant for a change of the energy provider.

For the starting phase of the legislation a rate-of-return provision will prevail with an allowed return on equity of 6.5 percent real pre tax. This will be replaced after one year by a new calculation provided by the regulator or by incentive regulation. The incentive regulation can come either in the form of price caps or revenue caps. The cap period has to be between two and five years. The scope of each cap is left open and can be restricted to certain voltage levels and networks. Adjustment factors include automatic pass-through of exogenous cost changes (e.g., due to tax changes), inflation adjustments and incentive factors (known as “X”- factor in the literature on price caps). If price caps are chosen, they should include some adjustment for quantity changes. The incentive factors for each cap period should be based on benchmarking relative to cost calculations for peer networks. The incentives can be set for each network individually or for groups of networks. Most of the details for the methods to be used in implementing the incentive provisions will be developed in bylaws enacted by the government, while the execution and decisions about individual networks or groups of networks will be made by the Federal Network Agency. At this point the new price regulation only refers to changes proposed by the grids for existing prices, but the political debate may form an ultimate compromise that would establish starting prices for all network access based on the new law.

Proposed bylaws to the Energy Law cover the pricing approach in detail. Network services are to be priced on the basis of maximum demand of a user during the relevant pricing period combined with a kWh price, which itself depends on annual load duration. This leads to a refined maximum demand tariff, where the total payment of a user is the sum of the maximum demand payment and the kWh used times the kWh fee, which itself depends on the relationship between peak and average use. As an alternative for users without maximum demand metering possibilities, grid access prices may be based on kWh usage alone.

Quite similar to the former framework are the rules concerning benchmarking, system responsibility, and network access in terms of a single-point market. This means that network companies will continue to be responsible for the system integrity and are therefore

entitled to take measures at their own discretion against any malfunctioning of the grid. This function is aided by the duty of generators to form balancing units (“Bilanzkreise”), which guarantee balancing of generation and load for each generator or groups of generators at any point in time (on a fifteen minute basis).<sup>28</sup> This simultaneously means that generators self-schedule, while the grid is responsible for back-up capacity, spinning reserves and generation to cover line losses. The purchase of such capacity has to occur in scheduled auctions.

The new law obliges transmission and distribution network owners to regularly report to the regulator about network capacity utilization, physical condition and capacity expansion plans. They also have to report expected demands for network capacity in the future and plans for dealing with those demands and the expected capacity utilization resulting from expansion plans.

### 3.4.3 Critique of the German approach

The proposed new German energy law is moving the electricity sector from the trade association agreements of network access to the regulation of electricity networks. In doing so, Germany complies with EU Directives without making a full break with the past. So far Germany has no experience with federal electricity regulation and it is thus appropriate to criticize it so that areas of possible improvements can be identified early on.

A feature distinguishing this law substantially from the American tradition is the limited amount of discretion given the regulator under the law. While American regulators are provided with fairly broad rules of law but constrained by tight rules of procedure (plus control by the courts), the new German energy law goes into the nitty-gritty of regulatory decision making by prescribing methods and outcomes in great detail. This is why an overhaul in the near future may become necessary. The overhaul would have to achieve what otherwise would have been done by an expert regulator. Because such an overhaul depends on the same legal process that has been so incumbency-friendly in the past, it could be a bad omen for future developments and may hinder the development of truly new competition which would depend on infrastructure investments that require stability in the regulatory environment and confidence in the pro-competitive nature of regulation. The lack of regulatory discretion has been justified with constitutional constraints on the actions of civil servants and administrations, but the current bill and proposed bylaws clearly constrain the regulator more than the German Telecommunication Act of 2004 does with respect to telecommunications regulation.

Beyond the establishment of regulation by agency, the most important break with the past is that the new energy law proposes separating the network parts of vertically integrated

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<sup>28</sup> They fulfil similar functions to the Balancing and Settlement Code in the UK. See ELEXON (2004).

electric utilities from the generation and marketing parts. This separation will occur with respect to their legal status, their operation and informational links. It is, however, not a separation of ownership. It will take several years to gain sufficient experience to find out if the separation will lead to true independence such that the new network entities act neutrally towards outside generators and marketers. In particular, network expansion decisions may well continue to be influenced by the owners as generators who could favor their own generating plants. However, separation as planned may create enough distance from the former company so that the common interest subsides. For this to happen and in the interest of efficiency and innovation it would be important for the new network companies to develop into a viable and interesting business. For this to happen, the generation section would have to be unbundled from transmission and distribution in terms of ownership – which may raise further problems. In this kind of arrangement it is not so much problematic that economies of scope are lost (this would already happen in operational unbundling), but legal questions of interference with private property rights may arise.

The sections of the proposed law and its bylaws on price regulation are highly detailed and certainly will keep economists and lawyers (and the Federal Network Agency) busy for a long time. They include very specific rules for rate-of-return regulation (including the allowed return on equity of 6.5 percent real pre tax), and two long sections each on incentive regulation and cost comparisons between companies. Thus, there is substantial room devoted to benchmarking as a means for incentive regulation, but it is not made clear how those rules will give the firms possibilities for developing innovative business strategies. In particular, by not distinguishing the rules for distribution companies from those for transmission companies the impression is given that both will be treated equally. However, there are about 900 distribution companies, which is an ample set for benchmarking, but only four transmission companies (which, in addition, should actually be run as a single entity). The last-minute inclusion of international benchmarking was therefore direly needed. A similar provision has proved to be very effective for the regulation of access and interconnection in telecommunications. Even if one does not like rate-of-return (or cost-plus) regulation because of its lack of efficiency properties, it may be appropriate to provide a starting point for tariffs that assures viability of the regulated firm and that could lead into incentive regulation. Also, rate-of-return criteria could be called for, when incentive regulation needs to be adjusted after a number of years. The price caps or revenue caps allowed by the law as incentive devices are framed with sufficient flexibility so that they could become effective and efficient devices in the hands of a skilled regulator. This flexibility, however, could also lead to weak or distorted incentives, depending on the strength of the bylaws to be enacted by the government and on the expected interference of administrative courts with the regulator.

The bill leaves open whether price caps or revenue caps should be used for incentive regulation. Revenue caps have been used elsewhere as a means to constrain total network output. The idea behind this is that electricity generation and electricity networks are envi-

ronmentally detrimental so that output should be constrained. At the same time, electricity users should not have to pay too much for electricity services. This may be a laudable combination of values. However, it is well known that two rather divergent objectives cannot usually be achieved with a single instrument. Revenue caps, in particular, can lead to an inefficient reduction of output. Price caps are generally more efficient for electricity users, while environmental goals have to be achieved with other instruments than network pricing.

It is unclear at this time whether cross subsidization of generation companies by grid companies under common ownership remains a possible option under the new law. The regulated prices themselves are unlikely to allow for cross subsidies. However, siting and scheduling decisions may favour affiliated generation companies. Only full ownership separation can avoid such conflicts of interest.

The law will give the network companies system responsibility, meaning that they will actually have substantial regulatory functions for the electricity market. Whether this is preferable to the Independent System Operators (ISOs) in the US remains to be determined empirically. US ISOs are nonprofit institutions run by experts and now supervised by independent bodies. From an economic efficiency perspective they may be influenced by professional engineering standards rather than by economic incentives. In contrast, the German network companies may be subject to overcapitalization biases from the rate-of-return regulation aspects of the proposed law, although this danger should subside if the regulator moves quickly to incentive regulation.

The use of balancing units as a tool for achieving system-wide balance of generation and consumption at any time is an interesting compromise between individual self-scheduling of generating units and aggregate scheduling by the network operator based on short-term bidding of all generation. Instead, the German system requires bidding only for backup generation, spinning reserves, line losses and ancillary services. Experiences with balancing units have been favorable in the past.

A very important and questionable feature of the German law is its insistence on viewing networks geographically as single-point markets. This is quite appropriate for distribution networks that are typically restricted in geographic size and for which customers requiring special access lines or additional capacities could be accommodated on an individual basis. High-voltage transmission networks, however, not only extend geographically but also have a certain geographical structure. While there is some consensus that, except for star-shaped transmission networks, distance is not an appropriate measure of transmission costs, the analysis of network costs suggests that network congestion is typically not evenly distributed geographically and neither are transmission losses. This means that it is either best to view transmission as occurring point-to-point or as using congestible transmission links based on Kirchhoff's law. In contrast, the single-point view of a transmission



network would only be appropriate for short-term dispatch if there is no congestion at all in the network or if the nodal price differences are the same between all the relevant generation nodes and consumption nodes. Even if one of these two conditions is satisfied for some time, the single-point view of the network gives no guidance for the efficient geographic distribution of transmission capacity expansion investments. While excess transmission network capacity may prevail in Germany at this time, such excess may vanish in the future, due to increased competition in generation or to environmental problems in siting new transmission lines. Whether excess capacity is efficient or not depends on the effect of transmission capacity on competition. In principle, excess capacity in transmission increases the market size for competing generators. However, the costs of excess capacity can be high, while the benefits of increased competition in generation are in the nature of Harberger triangles, which tend to be small.

Investment and usage decisions could also be adversely affected by the pricing approach for network services taken in the proposed legal prescriptions, based on maximum demand tariffs. Maximum demand tariffs have well-known efficiency problems if users are heterogeneous in the time profile of their demands. They are efficient only if peaks are coincident for all users. This is, however, quite unlikely. As a result, there will always be users whose peak demand falls outside the network peak. They would be induced by maximum demand tariffs to reduce consumption at off-peak periods and would face a zero price at the network peak. Refinements in the German maximum demand tariff may help avoid some of the peaking problems because the likelihood of coincident peaks increases in the ratio between average and peak load and because usage prices are not zero. However, the incentives to spread the load more evenly and move it away from the peak are definitely muted under the German system. Also, nonzero usage prices are inefficient at times of excess capacity.

Combining the potential inefficiencies from the single-point view of the network and the maximum demand tariffs can lead to inefficient investment decisions of generators in terms of location and peaking economies. This is something that the regulator may discover from the reports on capacity utilization and expansion plans that the network owners have to deliver. If the utilization figures are based on distorted prices this would bias expansion plans based on them. However, although the resulting capacities could be inefficient, this would not necessarily lead to major congestion problems.

Having criticized the German approach to pricing of transmission network services it is worth conceding that the simplicity of having a single price schedule and a single service could save transactions costs and avoid price fluctuation and geographical price dispersion. This advantage, however, is paid for by potentially serious inefficiencies that are expressed in high costs of backup power and ancillary services needed to balance and stabilize the networks and in inefficient investment and usage decisions.

Eventually the enlarged influence of the regulator with regard to changing providers is definitely an important improvement. All the past delays and uncertainties were certainly an important reason for many customers to refrain from changing their providers and therefore an impediment for effective competition.

### 3.5 Conclusions

While we have provided a highly critical view of the German electricity sector reforms, they clearly mark a distinct progress over the status quo. Furthermore, Germany is unlikely to fall into the same traps as California. Neither is there constraining end-user price regulation nor are network bottlenecks likely any time soon. However, in spite of the progress, Germany and California share market power problems in generation. In California (and the US in general) market power persists in spite of small market shares of individual generators. It is the result of short-term transactions in very open markets that facilitate strategic decisions. The US response has been largely price caps for short-term wholesale transactions. In Germany, market power in generation is associated with high market shares and – until now – with vertical integration of generation, transmission and (partially) distribution. The latter cause of market power is likely to vanish if the new law is applied vigorously. However, market concentration can only be reduced either by rigorous application of competition policy or by increasing the electricity markets beyond the German borders. None of the German generating companies is big enough to warrant divestiture. Thus, competition policy can only prevent further increases in concentration via mergers. Increasing the geographic scope of electricity markets requires sufficient transnational transmission capacity in neutral hands. It also requires sufficient generation capacity in neighboring countries.

One reason for market power among generating companies in California has been the lack of long-term contracts for electricity. The availability of such contracts in Germany should therefore reduce market power. However, long-term contracts signed under unfavorable terms by German communities with Eon very recently, show that long-term contracts do not always have this property.<sup>29</sup> They also make one pessimistic about the view of those communities about the market power reducing effects of the new legislation.

The potential benefits of electricity sector reforms include cost savings and demand responsiveness in generation, a better mix of generating facilities and a reduction in markups for final users. In the US, cost savings and a better mix in generation facilities have been realized. Market power has not prevented this because of fairly easy entry into generation. Whether high market concentration in Germany prevents such entry remains to be seen. High markups over costs seem to prevail in Germany for transmission and distribution as

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<sup>29</sup> For these contracts see Hummel (2005).

well as for generation. The newly established regulation may reduce the former markups but only increased competition can reduce the latter.

## 4 German Productivity – A Reassessment via the new Ifo Productivity Database<sup>30</sup>

### 4.1 Introduction

One of the most puzzling economic developments in the late 1990s is the acceleration of US economic growth (associated with very low inflation rates) paralleled with economic stagnation or growth decline in Europe. The ensuing debate on the sustainability of this outstanding US economic performance generated a strong demand for detailed productivity studies – not only for the US but also for Europe and other OECD countries. Meanwhile there is a broad consensus that information technology (IT) is the key to understand the American growth “resurgence”<sup>31</sup> and several studies have compared the American case with European and other OECD countries.<sup>32</sup>

Since the mid 1990s the average growth rates of real GDP, labor productivity and total factor productivity in the European Union have fallen behind those in the United States. This is remarkable as for the EU these performance measures have (since World War II) never shown lower growth rates for several years in a row. But the EU is anything but homogeneous in this respect. The variation in productivity performance across countries is quite substantial – in levels as well as in growth rates. According to O’Mahony and van Arc (2003) about 75% of the total EU slowdown in the second half of the 1990s was due to the German and Italian growth weakness, most notably the German one (even if the German *level* of productivity is similar to that of the US). The aim of this chapter is twofold. On the one hand, the German growth weakness will be analyzed, as it is an essential cause of the European “dragging behind”. On the other hand, the productivity analysis will serve to relate the sector specific productivity growth of the German electricity industry to the total economic performance, which allows the derivation of an important measure of incentive based regulation: the X-factor (see Chapter 5). A major value added of this study is the quality and detail of a new and unique dataset, which is used for the current growth and productivity study.

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<sup>30</sup> This chapter has been presented at the 61st Congress of the International Institute of Public Finance in Jeju (Korea) 2005. I would like to thank participants at this event, in particular Karen Pittel, for helpful comments.

<sup>31</sup> See for example Oliner, Sichel (2000, 2002), Jorgenson (2001), Jorgenson, Stiroh (2000), and Jorgenson, Ho, and Stiroh (2003, 2004)

<sup>32</sup> While Colechia and Schreyer (2002) analyzed nine OECD countries (including the EU countries Finland, France, Germany, Italy, and the UK), Daveri (2000, 2002, and 2004) focused his whole analysis on Europe.

Productivity is not only a fundamental measure of economic performance due to its measure of how effectively an economy transforms inputs into output. Crucial for productivity improvements are continuous changes in the quality of inputs, such as education, technology knowledge, and process and product innovation. The more productive the factors of production become the greater the return to investment (in education or physical capital) and the higher a country's standard of living. Social progress hinges then on productivity growth, because it reflects the accumulation of intangible "social capital," such as human capital, knowledge, and last but not least, access to networks.

The quality of productivity or growth accounting studies depends in particular on the quality of the data, which in turn determines the employed computational method. Existing studies on EU and OECD countries, like O'Mahony, van Arc (2003), Colecchia, Schreyer (2002), and Daveri (2000, 2002, and 2004), also analyze amongst others the German economy, but the data sources they use differ in quality and detail and are in most cases not appropriate for a deeper analysis. While Daveri (2002) refers to a private consortium of several industry associations as its main data source,<sup>33</sup> Colecchia and Schreier use data from the respective national statistical offices. This implies for a number of countries (like Germany, Italy, or the United Kingdom) that the available asset-data are only available at the aggregate level and represent the owner instead of the economic usage structure of capital allocation. The first study to provide insights into sector specific particularities for the whole EU-15 is O'Mahony and van Ark (2003). The richness of this dataset, which is provided by the Groningen Growth and Development Centre (GGDC),<sup>34</sup> comes at the price that growth accounting analyzes can only be pursued via the value-added and not via the gross-output concept (due to the lack of appropriate data on intermediate input). This can be problematic for industry-level productivity analyzes.<sup>35</sup> This dataset reflects, as well as the data in the other studies cited above, a capital allocation according to the owner concept. Furthermore some of the data had to be extrapolated with average values of other European countries. For the calculation of the German aggregate communication-equipment investment GGDC resorts to data of the Ifo Institute. This source, which is the *Ifo Investorenrechnung*, is now used to compute industry-level, asset specific capital stocks and capital services on the basis of the economic-usage concept, building the newly constructed Ifo Productivity Database.

The aim of this paper is to use the richness of the new data source for a documentation of productivity trends over a long time period in order to establish employment trends and to identify driving and retarding factors of productivity growth in Germany. This will serve as a basis for further sector-specific studies, where the total economic development serves as

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<sup>33</sup> The World Information Technology and Services Alliance (WITSA)

<sup>34</sup> See [www.ggdc.net](http://www.ggdc.net).

<sup>35</sup> See Chapter 5 for a discussion of the properties of the respective concepts.

a benchmark.<sup>36</sup> The main advantage of the recently collected and computed capital stocks and capital services data is that they contain the information according to the economic-usage (and owner) concept. The usage-concept is – in contrast to official statistics (where the owner concept is applied) – better suited for productivity research, as it allows a detailed analysis of the industry-level capital allocation. Many investment projects are financed via leasing and other forms of rental arrangements. As a consequence the investments are often used in different sectors than in the one of the owner. The owner concept, in contrast, is better suited for an analysis of the distribution of wealth, which is not relevant for productivity analyses.

Another advantage follows from the bottom-up approach for the calculation of capital services flows for the German economy. The top-down approach computes or takes the capital stocks and capital services flows data from the national statistical agency and allocates the industry-level shares by several assumptions. The bottom-up approach, in contrast, computes first the industry-level capital stocks and capital services flows and aggregates them subsequently in order to derive the total-economy capital stock data. This procedure allows a more accurate calculation of the capital contribution to aggregate growth.

The richness of this dataset allows it to pursue a detailed growth-analysis for the German economy in a similar way as Jorgenson et al. (2003) did for the US. This implies a quantification of the role of information technology (IT), which proves to be still of minor importance in comparison to the US. Beside the analysis of the historical data there is a second main focus of this paper, namely growth and productivity projections for the next decade.

The next section will describe the growth accounting framework that is used here. Subsequently the data sources are presented and described. Section 4 analyzes the historical data from 1970 – 2003, while in section 5 projections for the coming decade are presented. Section 6 concludes.

## 4.2 Growth Accounting Framework

The methodology used here is based on the Divisia index number theory. The concept goes back to Divisia (1925) and was incorporated by the pioneering work of Tinbergen (1942) and Solow (1957). Afterwards Denison, Kendrick, and in particular Jorgenson (in various years with and without co-authors, most prominently with Griliches in 1967) have made extensive use of the Divisia index in their work on the measurement of productivity change. Richter (1966), Hillinger (1970), and Hulten (1977) have made contributions to the logical foundations of the Divisia index.

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<sup>36</sup> The productivity development of the total economy, for instance, is a prerequisite for the determination of a sector specific X-factor, as it is used in sector specific incentive regulation of network industries. See Chapter 5 for an application in the electricity industry.

The resulting growth accounting model provides a “theoretical approach to productivity measurement” and “offers a consistent and well-founded approach that integrates the theory of the firm, index number theory and national accounts” (see OECD, 2001). It is based on the microeconomic theory of production, involves breaking down growth of GDP into the contributions of labor input, capital input and total-factor productivity. Changes in total factor productivity may be interpreted as shifts in an aggregate production function or a technical change, which is not embodied in the respective inputs (Jorgenson, 1966). Changes in real product and real factor input not accompanied by a change in total factor productivity may be identified with movements along a production function (Jorgenson and Griliches, 1967).

The growth rate of total factor productivity is defined as the difference between the growth rate of real output and the growth rate of real factor input. Productivity changes are of a Hicks-neutral type, i.e. they correspond to an outward shift of the production function (captured by the parameter  $A$  in equation 29). The rate of growth of real factor input is defined, in turn, as a weighted average of the rates of growth of individual factors. For every period, income shares are re-calculated and combined with the factor inputs growth rates to obtain an index of combined inputs.

The growth accounting framework rests on a number of assumptions, among which the following are important: the production technology can be represented by a linear homogeneous production function relating total GDP to the primary inputs labor  $L$  and capital services  $K$ ; this function exhibits constant returns to scale; and product and factor markets are characterized by perfect competition. For any desired level of output, the firm minimizes the costs of inputs, subject to the production technology shown above. Factor input markets are competitive, so that the firm takes factor prices as given and adjusts quantities of factor inputs to minimize costs. The output-growth rate equals then a weighted average of the growth-rates of the various inputs plus the total (or multi-) factor productivity growth. The weights attached to each input are income shares of each factor that approximate production elasticities or the effect of a 1% change in individual inputs on output. This approximation is necessary as output elasticities cannot be directly observed. However, under the assumption of constant returns to scale the factor shares of labor and capital can be used as weights.<sup>37</sup>

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<sup>37</sup> The assumption of constant returns to scale is necessary to ensure that the equation of output to total factor income is consistent with equality between factor prices and marginal products. The perfect competition assumption is necessary for getting a value for the social marginal products of labor and capital, which are in this case equal to the rental price of capital and the wage rate. The perfect competition assumption could be dispensed in a growth regression, but this solution has too many other drawbacks and therefore the usual approach to TFP estimation is the non-econometric one. See Section 0 for a discussion of these drawbacks.

The concept captures substitutions among inputs of capital and labor, whereas capital is subdivided in ICT-capital (ICT standing for *information and communication technology*) and non-ICT capital. Jorgenson, Stiroh (2000), and Jorgenson, Ho, and Stiroh (2003) have used this methodology to measure the contributions of information technology to US economic growth and the growth of labor productivity. I will proceed in the same way. Additionally I subdivide the non-IT capital into “construction and buildings” and “other capital”. This seems to be a useful breakdown due to the high relevance of investment in buildings.<sup>38</sup>

Within the growth accounting concept, output can be decomposed into investment and consumption goods, while inputs consist of capital services ( $K$ ) and labor input ( $L$ ). But in the further analysis I will refrain from decomposing output and focus on the decomposition of input factors. Capital services can be decomposed into the capital services flows from information and communication technology<sup>39</sup> – which is computer hardware ( $K_c$ ), software ( $K_s$ ), and communications equipment ( $K_m$ ) – buildings ( $K_b$ ) and other capital services ( $K_o$ ). The input function ( $X$ ) is augmented by *total factor productivity* ( $A$ ). The production possibility frontier can then be represented as:

$$Y = A \cdot X(K_m, K_c, K_s, K_b, K_o, L). \quad (29)$$

Under the standard assumptions of competitive product and factor markets, and constant returns to scale, equation (29) can be transformed into an equation that accounts for the sources of economic growth:

$$\Delta \ln Y = \bar{v}_{K_m} \Delta \ln K_m + \bar{v}_{K_c} \Delta \ln K_c + \bar{v}_{K_s} \Delta \ln K_s + \bar{v}_{K_b} \Delta \ln K_b + \bar{v}_{K_o} \Delta \ln K_o + \bar{v}_L \Delta \ln L + \Delta \ln A \quad (30)$$

where  $\bar{v}$  denotes the average input shares. Under the assumption of constant returns to scale they are equal to value shares and add up to one:  $\bar{v}_{K_m} + \bar{v}_{K_c} + \bar{v}_{K_s} + \bar{v}_{K_b} + \bar{v}_{K_o} + \bar{v}_L = 1$ . I refer to the share-weighted growth rates in equation (30) as the *contributions* of the inputs. Total factor productivity (TFP) –  $\Delta \ln A$  – is then calculated as a residual.

*Average labor productivity* (ALP) is defined according to Jorgenson (2003) as the ratio of output to hours worked, such that  $ALP = y = Y/H$ , where the lower-case variable ( $y$ ) denotes output ( $Y$ ) per hour ( $H$ ). Thus equation (30) can be rewritten in per hour terms as:

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<sup>38</sup> The building's share in the total capital stock is since the 1960s above 75 percent and constantly growing.

<sup>39</sup> The data on ICT technology are limited for the period 1970–1990. The former classification system did only cover asset specific data on office equipment, but not explicitly communications equipment and software. These detailed data are only available since 1991.



$$\Delta \ln y = \bar{v}_{K_{ICT}} \Delta \ln k_{ICT} + \bar{v}_{K_b} \Delta \ln k_b + \bar{v}_{K_o} \Delta \ln k_o + \bar{v}_L (\Delta \ln L - \Delta \ln H) + \Delta \ln A \quad (31)$$

where  $\bar{v}_{K_{IT}} = \bar{v}_{K_c} + \bar{v}_{K_s} + \bar{v}_{K_m}$ . Equation (31) decomposes ALP growth among three components. The first is *capital deepening*, defined as the contribution of capital services per hour and allocated between IT and non-IT components. The interpretation of capital deepening is that increases in capital per worker enhance labor productivity in proportion to the capital share. The second component is *labor quality improvement*, defined as the contribution of increases in labor input per hour worked. This reflects changes in the composition of the work force and raises labor productivity in proportion to the labor share. The third component is *total factor productivity* (TFP) growth, which raises ALP growth point for point.

The above component for labor quality in equation (31) already depicts the variation of labor quality ( $\Delta \ln LQ = \Delta \ln L - \Delta \ln H$ ). In the same way capital quality can be described as  $\Delta \ln KQ = \Delta \ln K - \Delta \ln Z$  with  $Z$  as the capital stock. With these definitions one can decompose the contributions of capital and labor inputs in a way that reflects the contributions capital quality and capital stock, as well as labor quality and hours worked:

$$\Delta \ln Y = \bar{v}_K \Delta \ln Z + \bar{v}_K \Delta \ln KQ + \bar{v}_L \Delta \ln H + \bar{v}_L \Delta \ln LQ + \Delta \ln A \quad (32)$$

This equation will be used for the productivity projections that follow in section 4.5.

#### 4.2.1 The Gross Output and the Value Added Concept

Conceptual problems are related to the definition of “output” as either value added or gross output. Gross output is the value of sales and other operating receipts of an economic unit, while value added subtracts from gross output the value of goods and services purchased from other units and used in the course of production (intermediate inputs).

If industry-level data are analyzed and related to aggregate data (as it is done in chapter 5), the value added concept gives a biased picture of industry-level TFP – in particular when intermediates play an important role. In the real world there is no analogy to value added that is actually produced by a plant. Gross output reflects the common notion that productivity is simply sales per worker or hour worked. Most importantly gross output is not distorted by changes in the mix of primary and intermediate inputs. This entire category of inputs is omitted in value added productivity measurement, which is problematic when industries-specific-TFP-values are compared with each other or related to aggregate TFP. The value-added approach also ignores improvements in the price-efficiency ratio of intermediate inputs and neglects intermediates-input-embodied technological change. This renders the gross output measure a better indicator of all disembodied technological change and the best concept for sectoral studies.

However, for an international comparison of productivity and growth determinants the value added concept (as is used above in equation (30)) is the appropriate method. Value added can be derived with relatively low data requirements and avoids double counts of intermediate products in the aggregation process. Distortions by changes in the mix of primary and intermediate inputs offset each other in the aggregate analysis. Rather than technical change itself, the value-added based measure reflects an industry's capacity to translate technical change into income and into a contribution to final demand.

The focus of the current chapter is a total economy analysis, which makes the value added approach the predominant concept. However, in order to allow TFP comparisons of specific industrial sectors (as in Chapter 5), the aggregate TFP measure is declared according to both concepts<sup>40</sup> In this case the gross-output-based total economy TFP is not computed as a residual, but as a weighted sum of industry-level TFP-values. The respective weights are calculated according to the Domar approach of TFP aggregation (see the Appendix). The Domar weight of an industry is defined as the industry's gross output divided by aggregate value added. In general, these weights sum up to more than one.<sup>41</sup>

## 4.3 Data

### 4.3.1 Capital Stocks

Capital stocks data stem from Ifo Capital Stock and Investment Database (Ifo Investorenrechnung), which provides industry- and asset-specific capital stocks data for 1970 until 1990 for West Germany. From 1991 onwards, industry- and asset-specific capital stocks are calculated according to the perpetual inventory method using investment data from the same data source:

$$S_{i,j,t} = S_{i,j,t-1} (1 - \delta_{i,j}) + I_{i,j,t} \quad (33)$$

$S_{i,j,t}$  is hereby the capital stock in industry  $i$  of the investment asset  $j$  in period  $t$ .  $I_{i,j,t}$  is the corresponding investment in industry  $i$  of investment asset  $j$  in period  $t$  and  $\delta_{i,j}$  is the industry and asset specific depreciation rate. These data can be found in the Ifo Productivity Database.<sup>42</sup>

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<sup>40</sup> The gross output (GO) and the value added (VA) productivity measure are always different but also related to each other: the value-added productivity measure consistently exceeds the gross output TFP-growth estimates by a factor equal to the ratio of gross output to value added. See OECD (2001).

<sup>41</sup> The intuitive reason is that the change in industry-specific factor efficiency creates, in general, extra output, which serves to increase both final demand and intermediate deliveries. The increase in intermediate goods serves further to increase output in those sectors using the intermediate input, and this further increases output, and so on. See Hulten (1978).

<sup>42</sup> For a description of the content, the data sources and the accessibility of this database see the Annex.

### 4.3.2 Capital Services

For the capital services calculations, the Ifo Productivity Database parallels the method in Jorgenson and Stiroh (2001). Capital services  $K_{i,j,t}$  of asset  $j$  in industry  $i$  during period  $t$  are assumed to be proportional to the average capital stock  $S_{i,j,t}$  used in one sector with  $q_{i,j}$  denoting a constant of proportionality. The capital services are therefore proportional to the average capital stock, where the constant of proportionality  $q_i$  is set equal to unity:

$$K_{i,t} = q_i \frac{(S_{i,t} + S_{i,t-1})}{2} \quad (34)$$

The price of capital services (the costs of capital) is computed via a rental price formula, which is based on an arbitrage condition for capital services. It is assumed that an investor is indifferent whether he invests at the capital market and earns a nominal interest  $i_t$  for his investment or whether he invests in an asset of price  $P$  and earns a rental fee  $c_{i,j,t}$  less the depreciation  $\delta_{i,j}$  of the asset.

$$(1 + i_t)P_{i,t-1} = c_{i,j,t} + (1 - \delta_{i,j})P_{i,t} \quad (35)$$

Rearranging the arbitrage condition yields the cost of capital equation:

$$c_{i,j,t} = (i_t - \pi_{i,t})P_{i,t} + \delta_{i,j}P_{i,t} \quad (36)$$

where the industry and asset-specific capital gains  $\pi_{i,j,t}$  in period  $t$  are given by the percentage change of the asset prices in industry  $i$  during period  $t$ :  $\pi_{i,t} = (P_{i,t} - P_{i,t-1})/P_{i,t-1}$

Equation (36) states that the costs of capital equal the difference between the nominal interest rate and the capital gains of the asset weighted by the industry- and asset-specific price deflator plus the asset and industry-specific depreciation of the asset weighted by the same price deflator. The costs of capital therefore consist of deterioration, a required net rate of return, and losses or gains from a change in the market price of capital goods. These costs are the prices for capital services that flow from the productive capital stock. The required data that are computed via industry- and asset-specific price deflators and depreciation rates are more reliable compared to only asset-specific data which are usually taken for growth accounting exercises (as in O'Mahony and van Ark (2003) and Jorgenson, Ho, Stiroh (2003)). The use of this method was only possible due to the availability of the Ifo Investorenrechnung Database, which is according to our knowledge the only database offering such high quality data on the industry-level for Germany.

For a detailed description of the computation methods see Fuchs and Kuhlmann (2005), for more details on the Ifo Investorenrechnung Database see the Appendix.

### 4.3.3 Output, intermediate and labor input, demography

The data on output (Y), intermediate input (M), and the wage sum (WS) originate from the German Statistical Office (GSO) or are derived from GSO data. For the period 1970–1990 Fachserie 18 (FS18) or the DEStatis archive (DEStatis) is used. For 1991–2003 I mainly resort to the Genesis time series database (Gen).<sup>43</sup>

Output (value added and gross output) stems from Gen 81000BJ321 (for 1991–2003), and from GSO FS 18 segment 1496 (for 1970–1990).

*Intermediate input* at the industry-level is calculated for the early period via input-output tables, using industry-level price-deflators (GSO, former time series service TSno.1428, or DEStatis 7849xxx 7846xxx) and subsequently adjusted to the stated value of the main sectors from DEStatis 78490xx, which is also the basis of the aggregate data. For the later period Gen 81000BJ321 is used. Here, for several subsectors, no price index is available. In such cases the respective nominal values of the subsectors are deflated with the price index of the superordinate sector.

For the period 1970–1990 the basic data for the *wage sum* (WS) stem from the GSO FS 18 segment 2279 and are price adjusted with the GDP deflator. These data cover only employed workers and exclude the self-employed. In order to correct for this, the deflated values are multiplied with the yearly, industry-level ratio of all workers to the employees. For the period 1991–2003 Gen 81000BJ323 is used.

*Total hours worked* (H) for the period 1970–1990 are estimated via average weekly working hours per worker (in western Germany) for the years 1995–2002 (DEStatis 4049xxx), prolonged backwards via index time series for average working hours (DEStatis 4043xxx) and adjusted to a yearly basis. For some industries the index time series were fragmentary – in these cases the index of the superordinate category or a weighted sum of similar categories were used. Afterwards these yearly-per-person working-hours were multiplied by the number of employees in order to get total hours worked. Finally these total hours were scaled to the designated total hours of the respective superordinate class (according to GSO FS18, S.21). The data for the period 1991–2003 stem from Gen 81000BJ323. Also in this period the data are not available for every subsector. In these cases the ratio of employees in the specific subsector to employees in the superordinate class is used to estimate hours worked in the subcategory.

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<sup>43</sup> See <http://www.destatis.de/genesis> for the major time series for output and labor input as described above.

For demographic trends in Germany of the years 2002–2050, see Statistisches Bundesamt (2003).

Labor quality data stem from the “Industry Growth Accounting Database – Germany” of the Groningen Growth and Development Center (GGDC).

#### **4.4 Assessment of the historical data**

In this section the historical data from 1970 to 2003 are analyzed to identify drivers and barriers of German economic growth. For this analysis I will focus on the sources of total economic (GDP) growth and on those of average labor productivity growth (GDP per hour worked). This partition basically reflects equations (30) and (31).

##### **4.4.1 Sources of Growth in GDP**

Table 2 as well as Figure 6 report the sources of economic growth following equation 0. For the period 1971–1990, output grew 2.55 percent per year, where capital input contributed 42.4 percent of this growth or 1.08 percentage points. Labor input variation contributed not at all to this growth. The moderate average growth contribution of 0.3 percentage points in the 1980s is totally outweighed by a negative contribution in the 1970s of the same amount. This development is mainly due to significant reductions in total hours worked. The almost permanent negative influence of hours worked on labor input in the period 1970–1990 can only be offset by a constant moderate growth in labor quality. The major part of total growth (for this period) remains unexplained by input growth and is therefore captured by growth in TFP.

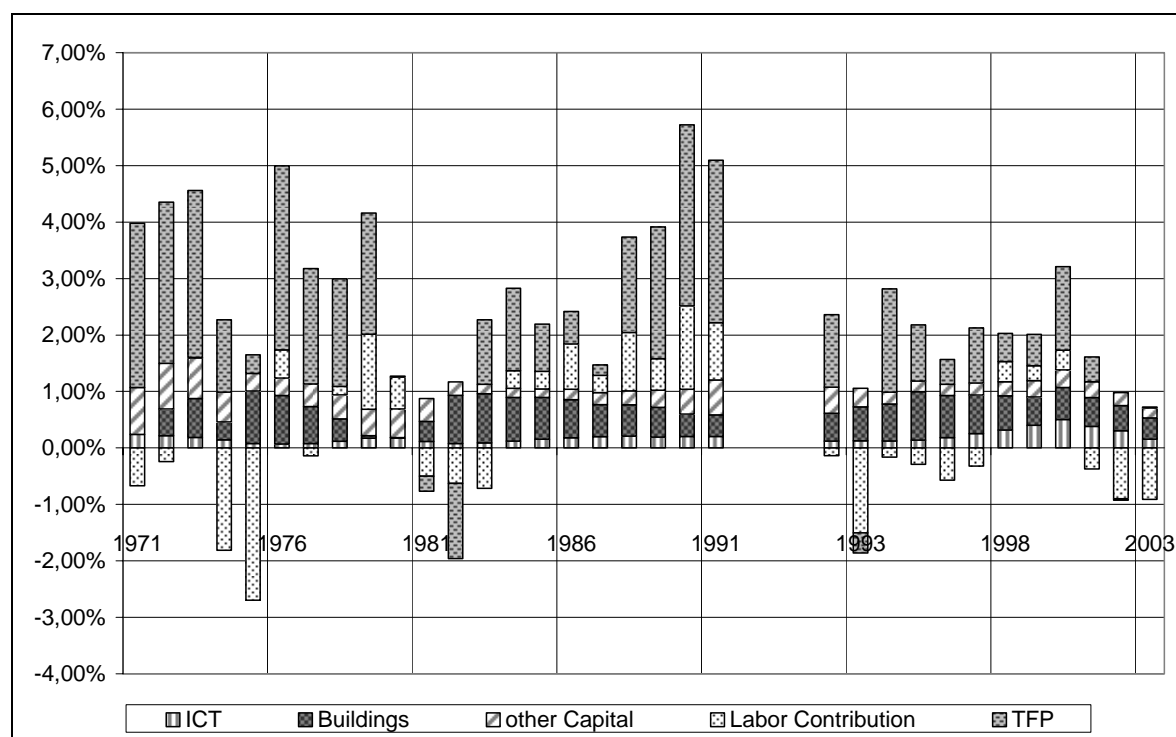
The later period from 1991–2003 comprises the extended geographical region of unified Germany. The burden of German reunification with all the related restructuring measures is certainly one of several reasons for the sluggish German growth performance since the beginning of the 1990s. The growing unemployment problem is visible in the data – in particular in 1993, where the decline in total hours worked explains almost the whole gap between negative economic growth and the positive growth contribution of capital (TFP for this year is close to zero).

Table 2 Growth in GDP and the Sources of Growth – 1971–2003

| Sources of Growth           | 1971-1980 | 1981-1990 | 1971-1990 | 1992-1997 | 1998-2003 | 1992-2003 | 92-03 less 71-90 |
|-----------------------------|-----------|-----------|-----------|-----------|-----------|-----------|------------------|
| Growth in GDP (Y)           | 2.79      | 2.32      | 2.55      | 1.46      | 1.39      | 1.43      | -1.12            |
| Contribution of capital (K) | 1.12      | 1.04      | 1.08      | 1.10      | 1.10      | 1.10      | 0.02             |
| Other                       | 0.83      | 0.26      | 0.40      | 0.27      | 0.26      | 0.26      | -0.14            |
| Total IT contribution       | 0.15      | 0.15      | 0.15      | 0.16      | 0.34      | 0.25      | 0.10             |
| Computer                    | 0.15      | 0.15      | 0.15      | 0.08      | 0.23      | 0.15      | 0.00             |
| Software                    |           |           |           | 0.04      | 0.08      | 0.06      |                  |
| Communications              |           |           |           | 0.04      | 0.04      | 0.04      |                  |
| Buildings (B)               | 0.44      | 0.63      | 0.53      | 0.67      | 0.50      | 0.59      | 0.06             |
| Contribution of Labor (L)   | -0.30     | 0.30      | 0.00      | -0.50     | -0.20     | -0.35     | -0.35            |
| TFP (VA residual)           | 1.97      | 0.98      | 1.48      | 0.86      | 0.49      | 0.68      | -0.80            |
| TFP (GO Domar-weighted)     | 1.29      | 0.85      | 1.07      | 0.50      | 0.65      | 0.58      | -0.49            |

Source: Author's calculations based on GSO, Ifo Productivity Database, and GGDC.

Figure 6 – Sources of Growth in Germany 1971–2003



Source: Author's calculations based on GSO, Ifo Productivity Database, and GGDC.

The contribution of capital to total growth over the whole period (1971–2003) is more or less constant at about 1.1 percentage points. Quite significant is the increase of ICT contribution beginning in the late 1990s.

#### 4.4.1.1 The Role of Information and Communication Technologies

The contribution of ICT to productivity can be traced through three transmission channels, namely through investment in ICT (capital deepening), technological change in ICT producing industries leading to TFP growth, and possible spillovers from the use of ICT. The

last effect enhances the capabilities of labor primarily through more efficient use, which requires investments in organizational change and human capital.<sup>44</sup> Growth accounting distinguishes only the first two channels, whereas further analysis needs to uncover the third. According to van Arc (2006) the regulatory environment needs to provide sufficient incentives to realize indirect gains. Rigid labor and product markets create a bad environment for trial and error processes that are important for letting excellent firms grow and failing firms die. The European markets generally exhibit more rigid framework conditions, and this is certainly one reason for the fact that Europe benefited to a less extent from the “ICT revolution” in the late 1990s compared to the US.

Overall gains from ICT can be classified as direct (through capital deepening) and indirect (through TFP). According to van Arc (2006) Germany fails on indirect gains, but also the direct gains are below expectations. German ICT-investment was quite constant during the 1970s and 1980s, with an average annual contribution of 0.15 percentage points (see Table 2). But, as one might expect, the total ICT contribution became more prominent in the (late) 1990s with an average annual contribution of 0.34 percentage points from 1998–2003. However, the *additional* growth contribution of ICT capital in 1991–2003 compared to the earlier period 1970–1990 is, with an average of 0.1 percentage points in comparison to the US of minor importance.<sup>45</sup> According to Jorgenson, Ho, and Stiroh (2003) the additional US growth contribution of ICT capital in 1995–2000 (the booming time of the so called New Economy) was compared to 1973–1995, about 0.56 percentage points and therefore much higher than in Germany or in Europe as a whole.<sup>46</sup> Investments in ICT technology, which played a substantial role in the US productivity revival, therefore seem to have still a non-negligible potential in Germany.

#### 4.4.2 Sources of Growth in Average Labor Productivity

Table 3 and Figure 7 present estimates of the sources of ALP growth from equation 0. For the period 1971–1990 as a whole, growth in ALP of 3.01 percentage points per year accounted for 118% of output growth, due to capital deepening of 1.22 percentage points per year, improvement of labor quality of 0.31 percentage points, and TFP growth of 1.48 percentage points. The decline of hours worked of 0.46 percentage points per year (reflecting demographic trends and the unions success at that time in cutting working hours without

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<sup>44</sup> ICT use may, for example, enable new organizational models and other innovations in the production process, as well as the production of new goods and services. New ICT investment goods make it possible for firms to innovate and accumulate firm-specific capital, yielding additional output gains, which show up as additional total factor productivity growth in ICT using industries. See van Arc (2006).

<sup>45</sup> The reclassification of the asset types, which has been implemented since 1991, supports this observation. Software and communications equipment were not explicitly enumerated in the early period, and this suggests that total IT contributions were even higher at the time. The actual increase of IT contributions is therefore even lower than the computed value of 0.1 percentage points suggests.

<sup>46</sup> A direct comparison for the same period is not feasible, as German reunification took place within the first time period, which denotes a structural interruption in the data. A comparison of 1998–2003 with 1971–1990 yields an increase in ICT contribution of 0.19 percentage points.

suffering remarkable wage cuts) are the reason that the German economy grew only at an average rate of 2.55 percent in this period.

This decline in total hours worked actually accelerated in the years after German reunification but has slowed down in recent years.

Table 3 Sources of Growth in Average Labor Productivity – 1971–2003

| Sources of Growth in Average Labor Productivity | 1971–1980 | 1981–1990 | 1971–1990 | 1992–1997 | 1998–2003 | 1992–2003 | 92–03 less 71–90 |
|---|-----------|-----------|-----------|-----------|-----------|-----------|------------------|
| Growth in GDP (Y)                               | 2.79      | 2.32      | 2.55      | 1.46      | 1.39      | 1.43      | -1.12            |
| Hours Growth (H)                                | -0.88     | -0.04     | -0.46     | -0.95     | -0.23     | -0.59     | -0.13            |
| ALP Growth                                      | 3.66      | 2.35      | 3.01      | 2.41      | 1.62      | 2.02      | -0.99            |
| Capital deepening                               | 1.38      | 1.06      | 1.22      | 1.48      | 1.19      | 1.34      | 0.12             |
| Other capital deepening                         | 1.22      | 0.91      | 1.07      | 1.29      | 0.84      | 1.07      | 0.00             |
| IT capital deepening                            | 0.16      | 0.15      | 0.15      | 0.19      | 0.35      | 0.27      | 0.12             |
| Labor quality                                   | 0.32      | 0.31      | 0.31      | 0.07      | -0.06     | 0.01      | -0.30            |
| Aggregate TFP                                   | 1.97      | 0.98      | 1.48      | 0.86      | 0.49      | 0.68      | -0.80            |

Source: Author's calculations based on GSO, Ifo Productivity Database, and GGDC.

Figure 7 – Sources of German Labor Productivity Growth



Source: Author's calculations based on GSO, Ifo Productivity Database, and GGDC.

The comparison of the early with the later period reveals that despite an acceleration in capital deepening a strong decrease in TFP and labor quality growth have induced a sharp decline in total economic growth. Measured as a residual TFP could be interpreted as a “measure of economic ignorance” as Abramovitz (1956) has expressed it, in fact it com-



bines a couple of “soft facts” that are hard to quantify. These include motivation and competencies, market characteristics, institutions and regulations, as well as innovation and technological change. Prescott (1998) has shown that differences in physical and intangible capital cannot account for the large international income differences that characterize the world economy today – TFP is the all-important factor. He found industry evidence that TFPs differ across countries and time for reasons other than differences in the publicly available stock of technical knowledge and asks therefore for a theory of TFP, which is still not available.

Also the current analysis confirms the predominant role of TFP-growth in total output growth. However, the productivity slowdown over the whole period is striking. Flaig and Steiner (1993) analyze the surprising nature of the German aggregate productivity slow down until 1985, where, for example, the hypothesis of a structural break in TFP growth following the first oil price shock is rejected. They also state that exogenous shocks to productivity have persistent effects, which means that there is no tendency for productivity to return to the initial growth path after a shock. This persistence result is important in combination with a quite obvious reason for the more recent decline in TFP-growth: German unification. In the course of the transition years the low growth of the eastern part of the country pulled down the German average. Additionally the high demand for public funds in the east increased the public debt enormously, which in turn contributed to international investors’ reluctance to invest in Germany.

The 1990s have also brought other, additional factors causing modified framework conditions and market characteristics, which were particularly harmful for the German economy. At the time Germany had to cope with an intensified globalization with a lot of new low-wage-competition. EU integration had advantages and disadvantages. For Germany it was problematic for at least one reason: it enlarged the market size of small countries entailing additional scale economies (which helped the small countries more than the big ones). Then the Euro was introduced, which lowered the risk premium for investments in all Euro area countries to a level that was formerly “reserved” for Germany. The inherent persistence of exogenous shocks as documented in Flaig and Steiner (1993) has aggravated these multiple, simultaneous shocks.<sup>47</sup>

Another finding of Flaig and Steiner is that industry level TFP growth measures vary substantially both within and between industries. This implies that industry-specific contributions to aggregate TFP are an important component in any aggregate productivity analysis. They will therefore be analyzed below.

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<sup>47</sup> For a more detailed discussion of these simultaneous shocks for the German economy see Sinn (2005).

### 4.4.3 Industry contributions to total TFP-growth and structural change

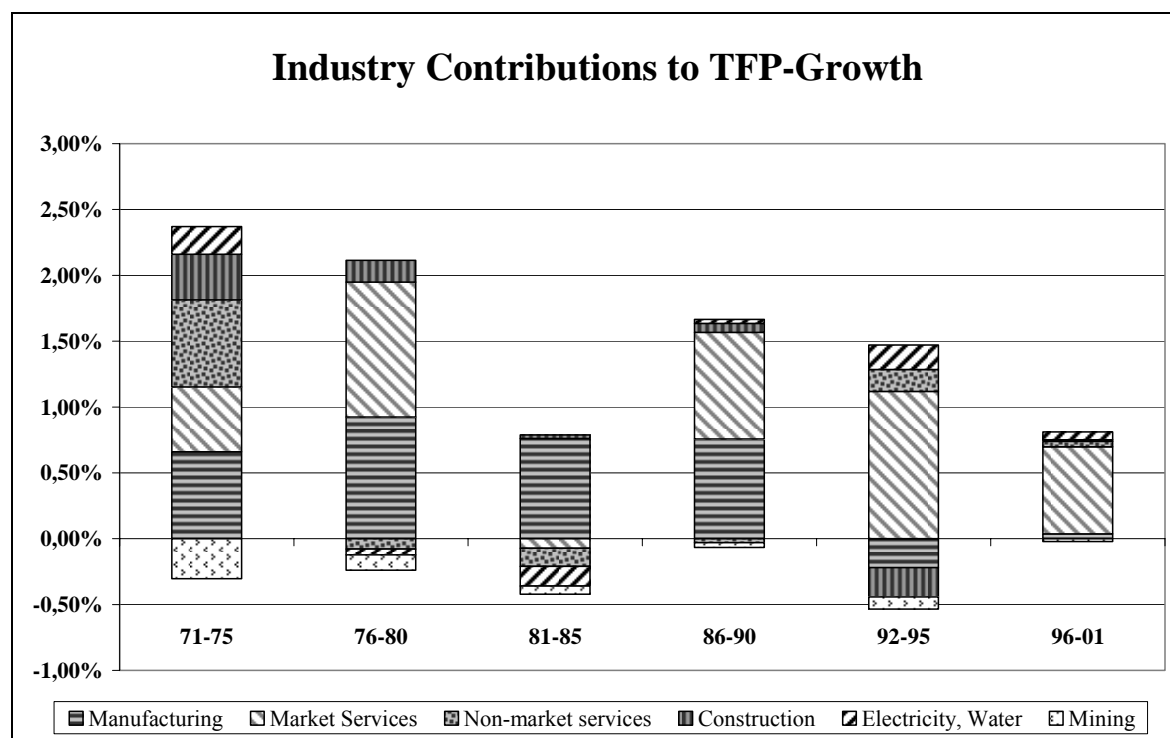
Complementary to the determination of aggregate TFP as a weighted sum of industry-level TFP measures, the Domar approach of aggregation (see the Appendix) allows a determination of the amount that every industry has contributed to aggregate TFP growth. Table 4 and Figure 8 show the resulting industry shares for 5-year averages, scaled to match the above VA-TFP results.

Table 4 Industry contributions to aggregate TFP growth

| Domar TFP           | 71-75  | 76-80  | 81-85  | 86-90  | 92-97  | 98-03 |
|---------------------|--------|--------|--------|--------|--------|-------|
| Agriculture         | 0.20%  | 0.16%  | 0.04%  | 0.13%  | 0.06%  | 0.02% |
| Manufacturing       | 0.95%  | 0.59%  | 0.28%  | 0.46%  | 0.19%  | 0.24% |
| Market Services     | 0.39%  | 0.65%  | 0.06%  | 0.88%  | 0.71%  | 0.14% |
| Non-market services | 0.33%  | 0.38%  | 0.03%  | 0.14%  | 0.13%  | 0.06% |
| Construction        | 0.16%  | 0.13%  | 0.01%  | -0.01% | -0.28% | 0.01% |
| Electricity, Water  | 0.11%  | -0.01% | -0.03% | 0.03%  | 0.04%  | 0.03% |
| Mining              | -0.08% | -0.03% | -0.01% | -0.03% | 0.00%  | 0.00% |
| Aggregate TFP       | 2.07%  | 1.87%  | 0.37%  | 1.60%  | 0.94 % | 0.79% |

Source: Author's calculations based on GSO, Ifo Productivity Database, and GGDC.

Figure 8 – Industry Contributions to aggregate TFP growth

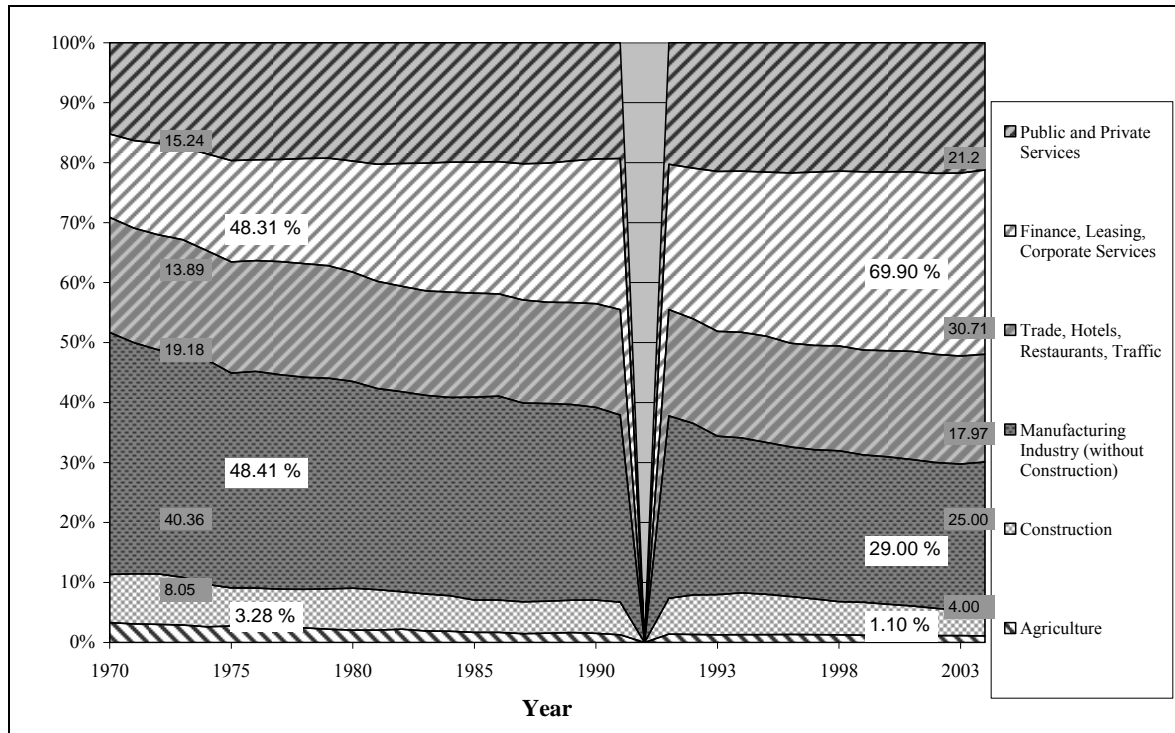


Source: Author's calculations based on GSO, Ifo Productivity Database, and GGDC.

One can see that the decline in the TFP contribution of the manufacturing sector was only partly offset by a higher contribution of market services. A possible explanation of this phenomenon could be seen in the German institutional setting, which might be hindering or at least decelerating the normal process of structural change.

Figure 9 shows the ratio of each sector's gross value added on total economy output and therefore the structural change of the period 1970-2004. The services are partitioned into three subcategories; in the industry sector construction is displayed separately. The shift of economic emphasis from industry to services can be seen clearly.

Figure 9 – Structural change in Germany (1970-2004)



Source: own illustration based on GSO: DEStatis 78440:xx and 76110:xx.

However, this shift is lower than an international comparison would suggest. According to OECD data<sup>48</sup> the sectoral value added of services as a percentage of total GDP for the year 2000 is in Germany (with 68.4 percent) lower than in comparable countries as France (71.7), the UK (71.5), the US (73.7 in 1999), or the whole OECD area (69.8 in 1999). This is at least a slight indicator that Germany has some more difficulties with structural change than comparable countries. According to the IMD World Competitiveness Yearbooks, Germany has lost in its relative competitiveness – in particular in recent years<sup>49</sup>. This is, according to IMD, notably due to a significant loss in the government efficiency (loss of 12 positions in 2001-2005). Irrespective of the actual underlying institutional hindrances, which are not central to the current analysis, this is certainly a relevant component for the explanation of the weak output and productivity development of recent years.

<sup>48</sup> See OECD Statistical Compendium, National Accounts and Historical Statistics (historical ed.), Table 5 Structure or composition of certain economic aggregates.

<sup>49</sup> Between 1998 and 2001 Germany has gained 4 positions (see IMD, 2001), whereas between 2001 and 2005 it has lost 10 positions (see IMD, 2005).

An important application of an analysis of historical data is to use the results for projecting future productivity growth.

#### 4.5 Projecting productivity growth

In this section projections of growth trends for output and labor productivity for the next decade are presented, abstracting from business cycle fluctuations. The key assumptions are that output and the reproducible capital stock will grow at the same rate ( $\Delta \ln Y = \Delta \ln Z_R$ )<sup>50</sup> and that labor hours and the labor force will also grow at the same rate. These are characteristic features of most industrialized economies over periods longer than a typical business cycle.

I begin by decomposing the aggregate capital stock between reproducible capital stock and land, which I assume to be fixed. This implies:

$$\Delta \ln Z = \bar{\mu}_R \Delta \ln Z_R + (1 - \bar{\mu}_R) \Delta \ln LAND = \bar{\mu}_R \Delta \ln Z_R \quad (37)$$

where  $\bar{\mu}_R$  is the value share of reproducible capital stock in total capital stock.

Estimates of trend output and labor productivity growth are constructed, conditional on the projected growth of the remaining sources of economic growth. More formally, if  $\Delta \ln Y = \Delta \ln Z_R$ , then Equations (31), (32), and (37) imply that trend labor productivity and output growth are given by:

$$\Delta \ln y = \frac{\bar{v}_K \Delta \ln KQ - \bar{v}_K (1 - \bar{\mu}_R) \Delta \ln H + \bar{v}_L \Delta \ln LQ + \Delta \ln A}{1 - \bar{v}_K \bar{\mu}_R} \quad (38).$$

For the projection of labor productivity one has to make several assumptions in order to have tangible values for every single component of equation (38).

For complete growth projections based on equation (38), estimates of capital and labor shares, the IT output share, the share of reproducible capital stock, capital quality growth, labor quality growth, and TFP growth are required. Whereas labor quality growth and the various shares are relatively easy to project (the respective time series follow a consistent trend), extrapolations of the other variables are subject to considerable uncertainty. To give consideration to these problems, I present three sets of projections, following Jorgenson et al. (2003): one base-case scenario, a pessimistic scenario, and an optimistic scenario.

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<sup>50</sup> The derivation of the projection equation is adopted from Jorgenson et al. (2003). Assuming that output and the capital stock grow at the same rate refers to a property of the balanced growth equilibrium in the standard neo-classical growth model.

Several parameters are kept constant, while others vary according to the respective scenario. Those that remain constant across the three scenarios are labor quality growth, the capital share, the reproducible capital stock share, and the IT output share. These are referred to as the “common assumptions.” The parameters that vary across these scenarios are IT-related TFP growth, hours growth, the contribution to TFP growth from non-IT sources, and capital quality growth. They are labeled “alternative assumptions.”

#### 4.5.1 Common Assumptions

Comparing the 1980s and 1990s one can see that labor quality growth ( $\Delta \ln LQ$ ) declined significantly in Germany. Ho and Jorgenson (1999) have shown that in the US the dominant trends in labor quality growth are due to rapid improvements in educational attainment and the rise in female participation rates in the 1970s. The improvement in educational attainment of new entrants into the labor force largely ceased in the 1990s, although the average educational level continued to rise as younger and better educated workers entered the labor force and older workers retired. This seems to be in line with the German data, where labor quality growth was on average (from 1991 to 2001) at 0.05 percent, which is used for the projection in all three scenarios.

The capital share ( $\bar{v}_K$ ) features a slight upward trend over the past 30 years, but also stagnation in the last decade. Therefore this share is assumed to be constant at 40.3 percent, the average for 1995–2003.

The fixed reproducible capital share ( $\bar{\mu}_R$ )<sup>51</sup> has shown little change in the last three decades and I assume that it remains constant at 83.7 percent, the average for 1970–2001.

#### 4.5.2 Alternative Assumptions

Differing from Jorgenson et al. (2003) hours growth ( $\Delta \ln H$ ) projections are integrated in the category of alternative assumptions. This is due to the fact that an official and relatively broad dataset is available, containing demographic trend projections by the German Statistical Office.<sup>52</sup> These projections comprise trends for population growth for 10 different scenarios in terms of migration and life expectancy. For our context the focus will be on the group of those aged between 15 and 65. Three out of the ten scenarios are chosen in order to get one base-case, one optimistic and one pessimistic scenario.<sup>53</sup> Even if the group

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<sup>51</sup> In particular the natural resources are not reproducible (excluding renewable primary products).

<sup>52</sup> Statistisches Bundesamt (2003)

<sup>53</sup> The *base case scenario* (version 1) assumes a migration balance of 200,000 migrants per year. Life expectancy at birth is assumed to be 81.1 years for men and 86.6 for women. The *pessimistic scenario* (version 5) assumes a migration balance of 100,000 and a lower life expectancy of 78.9 years for men and 85.7 for women. The *optimistic scenario* (version 9) is calculated with a migration balance of 300,000 and a high life expectancy of 82.6 years for men and 88.1 for women.

of those aged 15-65 is not equal to the active labor force, it is assumed that both groups grow at the same rate.

Total TFP growth for the base-case scenario is equal to the average of 1995–2003, which is 0.60%. The pessimistic scenario assumes that TFP growth is as sluggish as in the late observation period, which is 0.49%. The optimistic value is equal to the higher average of the early 1990s, which is 0.94%.

In Table 5 the three scenarios and the components of the respective projections are presented. The top panel shows the projected growth of output and labor productivity. The subsequent panel reports the four factors that are held constant across the scenarios. These are labor quality growth, the capital share, the IT output share and finally the reproducible capital stock share. The bottom panel includes the components that vary across scenarios – hours growth and capital quality growth.

The base case scenario puts trend labor productivity growth at 1.67 percent per year, and trend output growth at 1.62 percent per year.

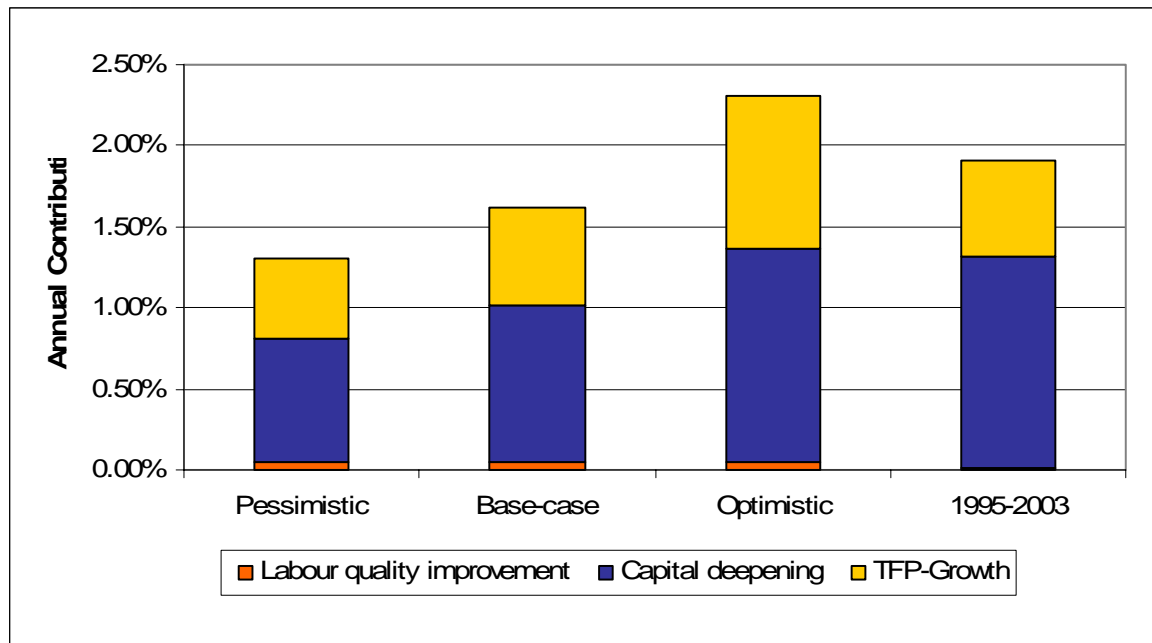
*Table 5 Output and Labor Productivity Projections – Total Economy*

|                                  |                 | <b>Projections</b> |           |                 |
|----------------------------------|-----------------|--------------------|-----------|-----------------|
|                                  |                 | Pessimistic case   | Base case | Optimistic case |
| Output Growth                    | $\Delta \ln Y$  | 1.06%              | 1.56%     | 2.35%           |
| ALP-Growth                       | $\Delta \ln y$  | 1.30%              | 1.62%     | 2.31%           |
| <b>Common assumptions</b>        |                 |                    |           |                 |
| Labor Quality Growth             | $\Delta \ln LQ$ | 0.05%              | 0.05%     | 0.05%           |
| Capital Share                    | $v_K$           | 40.30%             | 40.30%    | 40.30%          |
| Reproducible Capital Stock Share | $\mu_R$         | 83.7%              | 83.7%     | 83.7%           |
| <b>Alternative assumptions</b>   |                 |                    |           |                 |
| Hours Growth                     | $\Delta \ln H$  | -0.241%            | -0.053%   | 0.045%          |
| Capital Quality Growth           | $\Delta \ln KQ$ | 0.80%              | 1.10%     | 1.40%           |
| Total Growth in TFP              | $\Delta \ln A$  | 0.49%              | 0.60%     | 0.94%           |
| Impl. Capital Deepening Contrib. |                 | 0.67%              | 0.89%     | 1.23%           |

Source: own calculations

Figure 10 presents this projection of labor productivity growth and its decomposition in comparison to the period 1995–2003.

Figure 10 – Range of Labor Productivity Projections



Source: own calculations

It is striking that labor quality growth plays, according to this projection, a negligible role for productivity growth, which is highly problematic. In the context of globalization human capital will play a prominent role for western countries that stand in rising competition with the emerging world. Improvements in educational attainment should therefore gain importance at the political agenda.

#### 4.6 Conclusions

The German productivity development is not only interesting from a national point of view. Europe is still lagging far behind the US economy in terms of growth rates and its productivity development. This is to a large extent due to the German productivity slowdown, which makes the Lisbon Agenda<sup>54</sup> and its goals even more unrealistic than with a moderate German growth development.

In this chapter I use a new and extensive database with complete information on industry-level and asset-specific capital services flows, which allows for a detailed productivity analysis of the European “problem child” Germany. It gives a broad overview at the German total-economy and labor-productivity development in the years 1970–2003 and allows projections of productivity trends for the next decade.

The historical records show that the continuous decline in TFP growth and the accompanying decline in labor quality growth was not compensated by moderate capital deepening,

<sup>54</sup> In March 2000, the EU heads of states and governments agreed to make the EU the most competitive and dynamic knowledge-driven economy by 2010.

which resulted in declining labor productivity growth. German investments in IT assets played a growing but still minor role in growth contributions over time. A remarkable “New Economy” effect, which was a major reason for the US productivity revival, cannot be identified for Germany. The country’s economy failed to benefit sufficiently from direct effects through capital deepening (at least in comparison to the US) and it failed to benefit sufficiently from indirect effects, which is at least partly due to market rigidities and other general framework conditions. This reminds on the widely debated Solow (1987) productivity paradox saying that “you can see the computer age everywhere but in the productivity statistics”. One explanation at the time was that there may be a lag in productivity improvements and that the economy would need to adapt before the capital investment in computerized automation would pay off. This has actually been the case in the US and it might be that Germany is still on the way to adapt.

Another interesting result is that a strong decline in total hours worked has come at a high price in terms of annual economic growth. In the 1970s and 1980s this decline was mainly due to a continuous reduction in the weekly hours of work. This trend has been weakened recently by an increase in the weekly working hours for many sectors, but the overall demographic decline has thwarted this development and it is far from having reached its peak. The accompanying stagnation in labor quality in the late 1990s is also a warning signal that should stir politicians into action (irrespective of the frequently observable resistance towards scientific advice).

An analysis of the sector specific contributions to total factor productivity growth shows that the continuous declining contribution of the manufacturing (and construction) sector has not been compensated by a scarcely growing contribution of the service sector. This development can also be seen in the context of structural change or the tertiarization of the economy, where Germany seems to lag behind many other OECD countries. The conjecture has been made that the institutional framework is at least partly responsible for this development, which is affirmed by the IMD competitiveness analyses.

The chapter provides productivity trend projections for the coming decade for Germany. The base-case projection puts trend output growth at 1.56 percent per year with a confidence range of 1.30 percentage points. Average labor productivity will grow at an annual rate of 1.62 percent within a range of 1.01 percentage points. The scenario-based projections rely on a couple of assumptions concerning for example the labor and capital share (based on historical values) or the total hours development (based on official demographic projections). This implies that trend output growth is indeed quite moderate compared to historical growth rates (notably due to the stagnation of a qualified labor force), but compared to the recent background (the average economic growth of 2000-2005 was at 1.13 percent) this is at least an advance. Given that a computer based productivity stimulus might still be expected, as the ICT-analysis and the delayed US growth resurgence suggests, there is still hope for the Germany to reappear at the economic premier league.



## 5 What is the X-Factor in the German Electricity Industry?<sup>55</sup>

### 5.1 Introduction

The European electricity industry, one major guarantor for the efficiency and functioning of most other economic sectors, is under reconstruction. EU regulation has ensured that electricity markets all over the EU, which were monopolistically organized for decades, are about to be liberalized and opened to competition. In Germany, the market for electricity was liberalized 100 percent in 1998, meaning that all (industry and private) customers can choose their individual provider freely. This might suggest that Germany has been leading the way in the liberalization of European electricity markets. However, after it soon proved that the German way of organizing access to the transport and distribution network has not been favorable for competition.<sup>56</sup> In the regime of negotiated third-party access (nTPA), the rules concerning the access to the network were designed by the former monopolists themselves in a so-called association agreement between energy producers and industrial consumers.<sup>57</sup> In these proceedings not a single stakeholder of the potential competitors was involved. It is therefore not surprising that after an enthusiastic kick-off period, most new market entrants left the stage and retail electricity prices have gone up again after an initial decline.<sup>58</sup>

Finally it was Brussels not Berlin that took the decision to end this unfavorable nTPA regime – in June 2003 the European Commission decided that in all member states a national regulator had to be established by July 2004. The corresponding new law came with a nine-month-delay, but it brought several significant modifications to the German electricity market. Beside a legal and operational unbundling of generation and transmission, a regulatory agency was charged with the supervision of the electricity sector. The new duties for the regulatory agency include the supervision of network access charges and the introduction of an incentive based regulatory regime.<sup>59</sup> In such a regime either prices or revenues are capped and are only allowed to grow with the inflation rate minus a factor

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<sup>55</sup> This chapter bases on Kuhlmann (2006) and has been presented at the International Industrial Organization Conference in Boston 2006, and at the 62nd Congress of the International Institute of Public Finance in Paphos (Cyprus) 2006. I would like to thank participants at these events for helpful comments.

<sup>56</sup> The network is still an essential facility with natural monopoly characteristics; every potential energy provider willing to sell electricity needs access to the grid.

<sup>57</sup> Germany was the only country in Europe to choose negotiated third party access instead of a regulated one (rTPA).

<sup>58</sup> This price increase is certainly not only due to a lack in competition – energy taxes and resource prices also play an important role in this context – but it can still serve as an indicator for the effectiveness of all these agreements.

<sup>59</sup> See Chapter 3.4.2.

(X), which accounts for productivity differences between the relevant sector and the rest of the economy. This chapter derives an estimate for the X-factor in the German electricity industry – the crucial variable for any incentive-based regulatory regime.

For this purpose detailed productivity measures on the industry and aggregate level are necessary. Parametric or non-parametric methods, which are most commonly used for a detailed productivity assessment on the firm level, require large datasets covering company-specific data that are not available yet. The German regulatory authority has just begun monitoring the electricity sector and only recently started to collect detailed firm-level data. But a different methodology allows a sector specific productivity measurement without relying on company specific data, namely growth accounting.

The utilized data stem from a newly constructed productivity database for the German economy, which is unique in its coverage. This database contains sector- and asset-specific capital stock and capital services data for the German economy, relies on survey data and provides (in contrast to official data) information on sector-specific asset investments according to the economic-usage concept, which is the relevant concept for industry-level capital analyses. Thereby it is possible to measure sector specific total factor productivity (TFP) values using a growth accounting methodology as developed by Jorgenson and Stiroh (2000).

The chapter is structured as follows. In section 5.2 the general framework of RPI-X regulation is presented as well as the growth accounting methodology, which is used to measure productivity in the relevant sector and in the total economy. Section 5.3 presents the dataset employed, followed by the productivity analysis in section 5.4. Subsequently in section 5.5 four assumptions, which are necessary for the X-factor determination, are discussed, and it turns out that they are all violated in reality. Therefore modifications for the computed X-factor are suggested (following the approach of Bernstein and Sappington, 2000) in order to account for the respective market imperfections and accordingly violated assumptions. These include a limited span of regulatory control, structural changes in the industry, imperfect competition in the rest of the economy, and endogeneity in the economy-wide inflation rate. Section 5.6 concludes.

## **5.2 Framework**

This chapter describes the methodology of an incentive-based RPI-X regulation as well as the growth accounting methodology used for the productivity measurement.

### **5.2.1 The RPI-X Regulation**

The purpose of price-cap or RPI-X regulation, like many forms of regulation, is to replicate the discipline that market forces would impose on the regulated firm if they were present, which limits the firm's ability to extract monopoly profits with the associated allocative

inefficiencies. It provides stronger incentives for cost reduction and technological innovation than rate-of-return regulation does. Price-cap regulation typically specifies a rate at which the prices ( $P$ ) that a regulated firm charges for its services must decline ( $X$ ), on average, after adjusting for inflation ( $RPI$ ), and with an adjustment for exogenous cost changes ( $Z$ ), as depicted in equation (39).

$$P_t = P_{t-1}(1 + RPI_{t-1} - X) + Z \quad (39)$$

A separation of the required rate of price decline from the firm's production costs and earnings has the effect that reduced operating costs result in direct financial benefits for the firm, which justifies the term "incentive-based regulation". This is not the case under a rate of-return regulation plan that consistently links authorized prices to realized costs. The rate at which the firm's inflation-adjusted output prices must decline under price-cap regulation is commonly referred to as the X factor, which is typically the industry-level productivity margin with respect to the total economy.

But why is a relative and not an absolute productivity measure used? If the regulated firm were just like the typical firm in a competitive economy, competition would limit the rate of growth of the firm's prices to the economy-wide rate of price inflation. This requires the regulated industry to realize the same productivity improvements as in other sectors of the economy, to adjust for the input price inflation and to pass the remaining gains on to consumers. As a result, the X-factor should reflect, on the one hand, the extent to which the regulated firm is capable of increasing its productivity more rapidly than are other firms in the economy, and, on the other hand, it should reflect whether the prices of inputs employed by the regulated firm grow less rapidly than the input prices faced by other firms in the economy.<sup>60</sup> This does not necessarily mean that regulated industries always realize higher efficiency gains than competitive industries (whereas in the early years of liberalization there are often high efficiency potentials).<sup>61</sup>

If the regulated industry is able to realize more rapid productivity growth than other industries or if it can realize lower input-price inflation, then the industry should be forced to pass the associated gains to customers in the form of lower prices. This is reflected in a positive X-factor, which is the relative productivity advantage compared to the total economy.

An obvious method to calculate an appropriate X-factor is to compute historical values and to use an average of these values as a proxy for the current X-factor. A major focus of this chapter is therefore the determination of historical TFP growth rates of the German

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<sup>60</sup> See Bernstein and Sappington (2000).

<sup>61</sup> In the water industry for example the system is called RPI + K (instead of RPI – X), reflecting a negative X-factor, where real prices are scheduled to increase. See Armstrong, Cowan, Vickers (1994), Ch.6

electricity industry and to relate them to total economic TFP growth rates, which were determined in chapter 4. However, the sole adoption of the historical productivity differential entails some difficulties, in particular if a new regulatory regime is to be introduced, which increases the incentives for the effort that is put into productivity improvements. It is therefore necessary to be aware of the underlying assumptions of the whole concept. In section 5.5 four underlying assumptions that are violated in practice are discussed. Simultaneously modifications are proposed in order to account for these violations.

### 5.2.2 Productivity Analysis

In principle, several different methods can be used for productivity analyses, the main concepts, with their respective assets and drawbacks, are briefly discussed here. Subsequently the growth accounting concept, which is used for the current analysis, is presented in more detail.

#### *Conceptual Overview*

On the one hand, productivity can be measured with parametric approaches, like simple or corrected OLS regressions or a stochastic frontier analysis (SFA). In a simple OLS regression, an efficiency frontier is estimated reflecting the average performance of the respective industry. The corrected OLS regression (COLS) shifts the same regression line upwards in order to measure optimal instead of average performance. In SFA the regression's residual is split into a normally distributed error term and an inefficiency term. The SFA approach requires that a functional form be specified for the frontier production function. On the other hand, there are non-parametric-approaches, like a data envelopment analysis (DEA), where a production possibility frontier is derived by linear optimization. The DEA approach uses linear programming to construct a piece-wise frontier that envelops the observations of all firms. The frontier shows the best performance observed among the firms and it is considered as the efficient frontier. An advantage of the DEA method is that multiple inputs and outputs can be considered simultaneously, even when they exhibit different units of measurement. Finally, index numbers can be used to measure productivity.

The main *advantage of the parametric approaches* is that they relax the assumption that observable factor prices have to be identical with the factor social marginal products.<sup>62</sup> This assumption is in a non-parametric approach necessary as the social marginal product, which is needed in any standard growth equation (see section 0), is generally not observable. In a regression it can be estimated. Furthermore, the assumption of constant returns to scale is no longer needed. A frontier approach does not incorporate the assumption that all individuals are efficient, as in case of growth accounting where the productivity growth is interpreted as a shift in the production function (technical change). Hence, in the presence

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<sup>62</sup> This would be equivalent to  $F_K = r$  and  $F_L = w$  with  $r$  as the rental price or cost of capital and  $w$  as the wage rate.

of inefficiency, the estimation of technical progress would be biased in a growth accounting model. Another strong point of the parametric SFA-approach is that it takes measurement errors and other noise in the data into account (and does not necessarily incorporate these measurement errors into the TFP-residual as in the growth accounting framework). However, this is only relevant if the errors are non-systematic. A systematic measurement error with a constant upward or downward bias is unproblematic in growth accounting analyses as first differences are used in this framework.

The *disadvantages of growth regressions* are several. First of all the growth rates of labor and capital cannot usually be regarded as exogenous with respect to variations in  $g$ . The factor growth rates would receive credit for correlated variations in unobservable technological change. If the growth rates of labor and capital are measured erroneously, then standard estimates of the coefficients of these variables would deliver inconsistent estimates of the factor shares (denoted  $v_i$  in equation 41 below). Additionally several estimation issues may call into question the robustness of parameter estimates<sup>63</sup>. Furthermore, restricting assumptions like constant returns to scale may be necessary in parametric approaches as well, in order to gain degrees of freedom in small data samples. A further drawback of the econometric approach is the difficulty in replicating and producing productivity estimates on an ongoing basis. This is why the econometric approach is best suited to single, one-off studies (Mawson et al., 2003). Sengupta (1995) even found that non-parametric approaches are “more robust compared to OLS” and that “this robustness is more significant when the errors of observation have significant departures from a normal distribution” and are therefore systematic.

According to Barro (1998) the shortcomings of the econometric approaches outweigh the advantages, which legitimates that a non-econometric approach is the usually preferred method of TFP estimation and will also be used in the current analysis. Albeit these drawbacks, a parametric approach is still seen to be a valid and useful complement in TFP analyses. Also in the current context a parametric approach is used in order to validate the robustness of the non-parametric results.

Another major reason for using a non-parametric-approach is because of the data requirements of the respective method. The German regulatory authority has just recently started to collect detailed firm-level data in the electricity industry. All parametric approaches require a certain number of observations. This requirement cannot be satisfied without reliable data on the firm-level for a couple of years. The non-parametric DEA approach also requires firm-level-data and only the index number approach can provide useful results with aggregate data. Therefore the disposable data are the most important reason for choosing the growth accounting measure of productivity growth, which is in fact an

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<sup>63</sup> E.g.: researchers may be forced to impose a priori restrictions on parameter values in order to avoid implausible estimates such as negative factor income shares.

index number, for deriving an X-factor for the first regulatory period in the German electricity industry.

### *Growth accounting*

Growth accounting involves breaking down growth of gross output into the contributions of labor, capital, and intermediate inputs as well as total-factor productivity. The growth accounting model is based on the microeconomic theory of production and rests on a number of assumptions such as constant returns to scale and perfect competition. The methodology is based on the *production possibility frontier* concept derived from Jorgenson (1966) and Solow (1957) and used by various researchers, among others Jorgenson and Stiroh (2000) who analyze aggregate and industry productivity in a similar way as it is done here.

The growth accounting concept basically rests on a standard neoclassical production function of the form  $Y = F(A, K, M, L)$ . Inputs can be decomposed by capital services ( $K$ ), intermediate inputs ( $M$ ), and labor input ( $L$ ), capturing a substitutability among these inputs. Output is given by  $Y$  and  $A$  serves as parameter for productivity improvements. Deriving this general production function with respect to time and dividing it subsequently by  $Y$  yields the following equation

$$\frac{\dot{Y}}{Y} = \frac{F_A A}{Y} * \frac{\dot{A}}{A} + \frac{F_K K}{Y} * \frac{\dot{K}}{K} + \frac{F_M M}{Y} * \frac{\dot{M}}{M} + \frac{F_L L}{Y} * \frac{\dot{L}}{L}. \quad (40)$$

Growth rates can be represented as differences in logarithms ( $\Delta \ln$ ) and the first term on the right hand side can be interpreted as growth in total factor productivity and rewritten as  $\Delta \ln$  TFP. The assumption of constant returns to scale<sup>64</sup> implies that the sum of the input shares (subsequently termed  $v$ ) equals one. Furthermore it is assumed that product and factor markets are competitive, which allows us to substitute the non-observable factor social marginal products ( $F_K$ ,  $F_M$ , and  $F_L$ ) with observable prices (as the rental price of capital, the wage rate and intermediate input prices). With these assumptions the preceding expression can be transformed into an equation that accounts for the sources of economic growth:

$$\Delta \ln Y = \bar{v}_K \Delta \ln K + \bar{v}_M \Delta \ln M + \bar{v}_L \Delta \ln L + \Delta \ln A. \quad (41)$$

The average input shares  $\bar{v}$  are calculated as the respective value share in capital services ( $K$ ), intermediate inputs ( $M$ ) and the wage sum ( $WS$ ):  $\bar{v}_i = \frac{i}{K + M + WS}$  with  $i = K$ , or  $M$ , or  $WS$ . The share-weighted growth rates in equation (41) represent *contributions* of the

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<sup>64</sup> Up to this point no specific requirements were necessary for the production function. The subsequent constant returns to scale assumption rests on practical reasons in the empirical analysis.

inputs to the industry-level output. The growth in total factor productivity is then calculated as a residual. It represents efficiency gains, technological progress, scale economies, and measurement errors (see Coelli et al., 1998). These efficiency gains allow more measured gross output to be produced from the same set of measured inputs. Labor input is the product of hours worked (H) and labor quality (LQ) as proposed in Jorgenson, Ho, and Stiroh (2003).

Equation (41) displays the output growth decomposition according to the *gross output concept*, which includes intermediate inputs in the analysis and delivers widely unbiased estimates of industry-level TFP growth. Such a decomposition of growth components can also be done according to the *value added concept*, which is most appropriate for productivity comparisons at the aggregate level (as it can be derived with relatively low data requirements and it avoids double counts of intermediate products). However, at the industry level the value added concept can be criticized as providing at best an ambiguous picture of the actual productivity, due to its abstraction from intermediates, and due to the fact that no real world analogy to value added is actually produced by a plant. Since value added is the difference between separately deflated gross output and intermediate inputs, the concept requires an additively separable production function, which imposes strong restrictions on generality and on the role of technological change. For industry specific analyses the gross output concept should therefore be the preferred concept.

In the case of an X-factor determination, both an industry-level and an aggregate TFP value have to be determined and related to each other. In order to avoid a mixture of inconsistent approaches, both TFP values are calculated according to the gross output concept. At the industry level this is the obvious choice. For the total economy analysis, it is also appropriate in the current context. This bottom-up approach, where industry-level data are added up to an aggregate picture, allows us to calculate a *TFP value for the total economy excluding the energy sector* – and this is exactly what is needed for the current analysis. In this case the total economy TFP is not computed as a residual but as a weighted sum of industry-level TFP values. The respective weights are calculated according to the Domar approach of TFP aggregation (see the Appendix).

## 5.3 Data

### 5.3.1 Capital Stocks

Capital stocks data are derived from the Ifo Capital Stock and Investment Database (Ifo Investorenrechnung), which relies on official and on survey data. The data that are used for the current analysis cover the period 1991–2003. Earlier data are valuated to be not comparable to the later period for two major reasons. On the one hand, there have been reclassifi-

cations<sup>65</sup> that make a neat comparison difficult. On the other hand, the geographical coverage is different in both periods due to the German unification in 1990, which further complicates the formation of an average productivity value over the whole historical period.

For the period under consideration (from 1991 onwards) industry- and asset-specific capital stocks for unified Germany are calculated according to the perpetual inventory method using investment data:

$$S_{i,j,t} = S_{i,j,t-1} (1 - \delta_{i,j}) + I_{i,j,t} \quad (42)$$

$S_{i,j,t}$  is the capital stock in industry  $i$  of the investment asset  $j$  in period  $t$ .  $I_{i,j,t}$  is the corresponding investment in industry  $i$  of investment asset  $j$  in period  $t$  and  $\delta_{i,j}$  is the industry and asset specific depreciation rate. These data can be found in the Ifo Productivity Database.<sup>66</sup>

### 5.3.2 Capital Services

For the capital services calculations, the Ifo Productivity Database parallels the method in Jorgenson and Stiroh (2000). Capital services  $K_{i,j,t}$  (which correspond to a rental price of capital) of asset  $j$  in industry  $i$  during period  $t$  are assumed to be proportional to the average capital stock  $S_{i,j,t}$  used in one sector with  $q_{i,j}$  denoting a constant of proportionality. The capital services are therefore proportional to the average capital stock, where the constant of proportionality  $q_i$  is set equal to unity.

$$K_{i,t} = q_i \frac{(S_{i,t} + S_{i,t-1})}{2} \quad (43)$$

The price of capital services (the costs of capital), which is necessary for the value share computation of capital services, is computed via a rental price formula, which is based on an arbitrage condition for capital services. It is assumed that an investor is indifferent as to whether he invests at the capital market and earns a nominal interest  $i_t$  for his investment or whether he invests in an asset of price  $P$  and earns a rental fee  $c_{i,j,t}$  less the depreciation  $\delta_{i,j}$  of the asset:

$$(1 + i_t)P_{i,t-1} = c_{i,j,t} + (1 - \delta_{i,j})P_{i,t} \quad (44)$$

which can easily be solved for the costs of capital:

$$c_{i,t} = (i_t - \pi_{i,t})P_{i,t} + \delta_i P_{i,t+1} \quad (45)$$

<sup>65</sup> A former breakdown into electricity, long-distance heating, and gas has been merged to energy supply.

<sup>66</sup> For a description of the content and the data sources within this database, see the Annex.



where the industry and asset-specific capital gains  $\pi_{i,j,t}$  in period  $t$  are given by the percentage change of the asset prices in industry  $i$  during period  $t$ :  $\pi_{i,t} = (P_{i,t} - P_{i,t-1}) / P_{i,t-1}$

### 5.3.3 Output and Labor

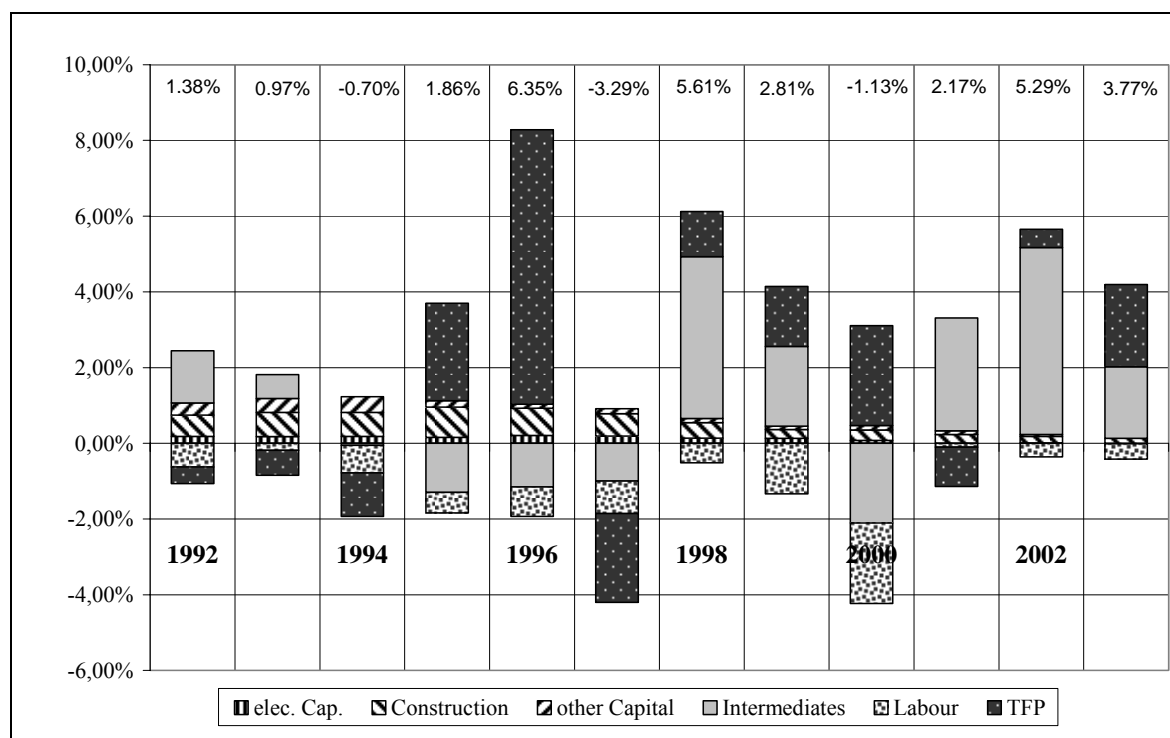
The main data source for the remaining data requirements is the German Statistical Office (GSO) with its time-series database Genesis. The data on output ( $Y$ ) and intermediate input ( $M$ ) originate from Genesis time series 81000BJ321, the wage sum from time series 81000BJ323. Total hours worked ( $H$ ) are virtually in the same data source as the wage sum, but in case of electricity only the superordinate class “energy and water supply” is available. Therefore, the ratio of employees in the electricity sector to employees in the superordinate class is used to estimate hours worked in the subcategory. Labor quality ( $LQ$ ) is taken from the Groningen Growth and Development Center (GGDC) that provides data on growth in labor quality from 1980 to 2001. The missing values for 2002–2003 are estimated as the average of the preceding five years.

As regards the price inflation, I follow the suggestion of Armstrong, Cowan, and Vickers (1994) to use a retail price index for the price cap rather than an industry-specific cost index. This is useful as it cannot be manipulated by the regulated firm, and it gives consumers clear and predictable signals about prices.

## 5.4 Productivity Analysis

The growth accounting analysis of the German electricity sector reveals a relatively high volatility in the industry-level output in the period 1992–2003 that can only partly be explained by changes in capital, intermediates and labor input. Exogenous output shocks are predominantly captured by high TFP changes as Figure 11 demonstrates.

Figure 11 – Sources of Economic Growth in the German Electricity Industry (92-02)



Source: own calculations based on Ifo Productivity Database, German Statistical Office, GGDC

In the early years of liberalization (1998–1999) the noticeable consolidation and corresponding reduction of jobs is associated with positive output growth. This might be an indication of efficiency gains in the early years of liberalization where competition was (at least partially) working. The subsequent decline in output and TFP is induced by economic decline but it might also be the case that the incumbent players were finally able to drive most new entrants out of the market, which meant less competition and less pressure on efficiency improvements.

The output-outlier in 1996 is a statistical artifact without real economic causation. Therefore the TFP (which is measured as a residual) captures the whole effect.<sup>67</sup> The reason for the shock in real output is that an important tax, the “coal penny” (Kohlepfennig), which was used as a subsidy for the coal industry and which was part of the industry-specific price-deflator, was abolished in 1995.<sup>68</sup> The resulting price decline drives the noticeable increase in real output in 1996. Repeated increases in this tax systematically reduced TFP values in the years before 1996. The subsequent abolishment had a one-time effect in the opposite direction. As an isolation of this effect is not possible, these systematic TFP distortions in both directions are assumed to cancel each other out on average and are therefore ignored in the X-factor determination.

<sup>67</sup> Underlying economic reasons for an output shock would be visible in input variations.

<sup>68</sup> In 1995 it averaged 8.5% of the price of electricity, see Storchmann (2005).

### 5.4.1 X- Factor determination

Table 6 lists the annual and average figures on output growth and TFP within the energy sector. The fourth column shows TFP values for the total economy, which have been derived in section 4.4.1. The fifth column lists the difference of TFP in the energy sector to TFP in the total economy or the productivity margin of the energy sector with respect to the total economy. This is nothing else than an ex-post annual X-factor.

Table 6 *Annual X Factors from 1992 to 2002 – Gross Output Concept*

| Year           | Output growth energy sector | TFP growth energy sector | TFP growth total economy | X-factor     |
|----------------|-----------------------------|--------------------------|--------------------------|--------------|
| 1992           | 1.38%                       | -0.44%                   | -0.34%                   | -0.11%       |
| 1993           | 0.97%                       | -0.66%                   | -1.01%                   | -0.35%       |
| 1994           | -0.70%                      | -1.15%                   | 1.35%                    | -2.49%       |
| 1995           | 1.86%                       | 2.57%                    | 0.85%                    | 1.73%        |
| 1996           | 6.35%                       | 7.25%                    | 0.62%                    | 6.63%        |
| 1997           | -3.29%                      | -2.35%                   | 1.38%                    | -3.72%       |
| 1998           | 5.61%                       | 1.19%                    | -0.01%                   | 1.20%        |
| 1999           | 2.81%                       | 1.58%                    | 0.04%                    | 1.55%        |
| 2000           | -1.13%                      | 2.64%                    | 1.92%                    | 0.71%        |
| 2001           | 2.17%                       | -1.04%                   | 0.93%                    | -1.97%       |
| 2002           | 5.29%                       | 0.48%                    | 0.74%                    | -0.27%       |
| 2003           | 3.77%                       | 2.17%                    | 0.08%                    | 2.10%        |
| <b>Ø 92-03</b> | <b>2.09%</b>                | <b>1.02%</b>             | <b>0.55%</b>             | <b>0.48%</b> |

Source: own calculations on Ifo Productivity Database, German Statistical Office, GGDC

Taking the average of this whole period yields an ex-post X-factor of 0.48% for 1992–2003. However, the volatility is apparent in the above set of yearly X-factors, which is mainly due to the high volatility in the electricity-output and an accompanying TFP volatility. In order to validate the results of the chosen approach it seems useful to compare them to results of international analyses and conduct additionally a robustness check.

### 5.4.2 Comparison to international analyses

In order to assess and classify the results of the empirical analysis it seems useful to review international studies concerning industry-specific TFP growth. Table 7 displays the results of two large, cross-national studies that have determined the average annual TFP growth of the energy- and water supply sector (O'Mahoney, van Arc, 2003) or the electricity distribution companies (London Economics, 1999).

Table 7 *Empirical analyses on productivity-growth in the electricity industry*

| Country     | Study                    | Period          | Average annual TFP-growth (%) |
|-------------|--------------------------|-----------------|-------------------------------|
| Germany     | O'Mahony, van Arc (2003) | 1990-95 / 95-00 | 1.21 / 2.76                   |
| France      | O'Mahony, van Arc (2003) | 1990-95 / 95-00 | 2.05 / 2.62                   |
| UK          | O'Mahony, van Arc (2003) | 1990-95 / 95-00 | -1.76 / 4.43                  |
|             | London Economics (1999)  | 1990-97         | 3.5                           |
| Netherlands | O'Mahony, van Arc (2003) | 1990-95 / 95-00 | -0.27 / -0.83                 |
| USA         | O'Mahony, van Arc (2003) | 1990-95 / 95-00 | 0.67 / 0.22                   |
|             | London Economics (1999)  | 1994-96         | 0.7                           |
| Australia   | London Economics (1999)  | 1981-94         | 3.6                           |
| New Zealand | London Economics (1999)  | 1994-97         | 1.4                           |

Source: own illustration

The German TFP-figures of O'Mahoney and van Arc are higher than in this study, which is partly due to the inclusion of the water-industry (in this study it is excluded). However, comparing exactly equal periods (as 1995-2000) yields also quite similar figures (2.15% average annual TFP growth here vs. 2.76%).

A striking result is the strong productivity growth in the British energy and water supply industry when comparing the early to the late 1990s. Despite the rough classification (which comprehends the whole energy sector and not just the network) this productivity surge has to be seen in the context of the liberalization and introduction of an incentive-based regulation that has been pursued in the early 1990s.<sup>69</sup>

Generally TFP-growth of energy and water supply is quite volatile between and within a couple of countries. This result is also in line with Flaig and Steiner (1993) who state that "At the two-digit industry level TFP growth measures vary substantially both within and between industries". A similar result can also be found in Wiegmann (2003).

However, the volatility in the data might, despite the high prevalence of this phenomenon, still challenge the above proposition that data problems like measurement error are unproblematic within the non-parametric growth accounting approach, or, to put it differently, that the chosen method is one reason for the volatile development. Despite the shortcomings of parametric approaches (see the discussion above, in particular the limited number of observations poses some problems here) an OLS regression as well as a stochastic frontier approach are carried out in order to review the above proposition and to cross-check the non-parametric results.

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<sup>69</sup> The effect of introducing an incentive based regime on productivity is briefly discussed in section 5.5.2.

### 5.4.3 Robustness check

When an OLS regression of output with respect to the several inputs is conducted, the residual is the equivalent measure of TFP. The whole setup is similar to growth accounting. The main difference is that the constant returns to scale assumption is suspended in the OLS framework. The regression equation can be described as follows:

$$\Delta \ln Y = \beta_C + \beta_K (v_K \Delta \ln K) + \beta_L (v_L \Delta \ln L) + \beta_M (v_M \Delta \ln M) + \varepsilon \quad (46)$$

where  $\beta v$  corresponds to the estimated social marginal product without assuming constant returns to scale, or, to put it differently, for  $\beta_{i=K,L,M} \approx 1$  the constant returns to scale assumption is indeed satisfied and  $\Sigma v_i \approx 1$ .

In a stochastic frontier framework the residual is split up to a real error term  $v$  (which is normally distributed) and an inefficiency term  $u$  (which is half-normally distributed). In this approach the efficiency measure would be the TFP equivalent. It results from subtracting the inefficiency component  $u$  from potential (frontier) output  $\hat{x}$  divided by potential output:  $\frac{\hat{x} - u}{\hat{x}}$ .

In order to see whether the different approaches provide similar or rather unequal TFP measures, a correlation or covariance matrix is calculated for the respective TFP measures. The matrix is displayed in Table 8.

Table 8 Covariance Matrix of different TFP measures

|                | OLS residual | SFA efficiency | GA TFP |
|----------------|--------------|----------------|--------|
| OLS-Residual   | 1.0000       |                |        |
| SFA-efficiency | 0.9878       | 1.0000         |        |
| GA-TFP         | 0.8754       | 0.8340         | 1.0000 |

The matrix shows that the different productivity measures are to a large extent correlated with each other. The stochastic frontier efficiency measure is correlated with a coefficient of 83.4 percent<sup>70</sup> with respect to the growth accounting TFP value. The OLS residual exhibits an even higher correlation of 87.5 percent.

This robustness check shows that the volatile development of the yearly X values is widely independent of the chosen method of productivity measurement. The above discussion therefore suggests that the X value of 0.48% could, in principle, be used as an X-

<sup>70</sup> Despite the high correlation of the SFA efficiency measure and the growth accounting TFP measure, one should bear in mind that efficiency improvement is just one of three possible reasons for productivity growth. Technical change and the exploitation of scale economies are additional factors.

factor for the first regulatory period of the coming incentive regulation. However, the problem is that such a calculation depends on a couple of assumptions that are typically violated in practice. The following section provides a discussion of the relevance of these assumptions and proposes modifications of the above result. These modifications account for the violations of the respective assumptions.

## 5.5 Modification of the estimated X-factor

The calculated productivity difference is only an appropriate measure for the X-factor if several conditions are satisfied (see Bernstein, Sappington, 2000) It is necessary for the above setup that (1) all services of the regulated firm are subject to price cap regulation, (2) structural changes (as a shift in the regulatory regime) do not occur, (3) the economy-wide inflation rate is not affected by the prices set in the regulated industry, and (4) the economy outside of the regulated industry is competitive. The following subsections will discuss to what extent these assumptions are violated (in the German context) and how the result of the preceding section can be modified in order to account for these violations.

### 5.5.1 Accounting for a limited span of regulatory control

In most regulated industries only a part of the value chain is regulated. This is normally the monopolistic bottleneck. In the electricity industry the distribution and transmission network represent this bottleneck – and in the German case this is indeed the regulated part of the industry. Joint products and common factors of production generally make it impossible to determine TFP growth for specific network services. If a TFP measure for the sector's entire operation has to be used for defining an X factor for the sector's capped services, the general guideline from equation (39) has to be modified. If, for example, prices of uncapped services are rising more rapidly than they would be rising if they reflected only anticipated productivity gains and unavoidable cost increases, then the firm is passing on fewer benefits to customers of uncapped services than price cap regulation of the firm's entire operation would dictate. Therefore the X factor should be decreased in a magnitude corresponding to the fraction of the firm's revenue derived from uncapped services. It is implicitly assumed that competition works in the remaining, unregulated parts of the value chain. Bernstein and Sappington (1999) derive a modified price cap formula in order to account for such a limited span of regulatory control:

$$\Delta \ln P_t = RPI_{t-1} - [x^b + x^l] \quad (47)$$

with a composite x-factor, which is composed of  $x^b$ , the basic x-factor, and  $x^l$ , an additional factor, which is computed in the following way:

$x^1 = -\left[\frac{1-\alpha^c}{\alpha^c}\right] \left[ \text{RPI} - x^b - \Delta \ln P^U \right]$  with  $\alpha^c$  as the fraction of revenue derived from the sale of capped services, which is approximately 0.4 in Germany, and  $P^U$  as the price of uncapped services. Assuming an average growth rate of uncapped services of 2.4 percent<sup>71</sup> and a retail price index of 2.1 percent (which is the average value of 1991-2003) yields an additional X-factor component ( $x^1$ ) of 1.17.

### 5.5.2 Accounting for structural changes in the regulated industry

Absent structural changes in the industry, historic productivity and input price growth rates can serve as reasonable estimates of corresponding future growth rates, which can be used to derive a reasonable value for the basic X factor that is imposed in price-cap regulation plans. A structural change in this context primarily means a shift from rate-of-return regulation to performance-based regulation and a corresponding introduction (or intensification) of competition. Such a regime shift can have two possible implications for the future productivity development, which cannot be derived from historical data. Both effects are working in opposite directions.

When a new regulatory regime becomes effective and competitive pressures increase in the respective market, it can, on the one hand, reasonably be expected that these circumstances motivate the regulated firm to enhance its realized productivity. Therefore historic growth rates typically understate a reasonable X factor, which has to be imposed on the regulated firm. To account for this fact, the basic X factor can be (and often is) augmented by what is called a customer productivity dividend (CPD) or a stretch factor. As stretch factors are designed to reflect the enhanced incentives that a *new* regulatory regime provides, it is appropriate to implement a stretch factor that declines in magnitude over time.<sup>72</sup>

On the other hand, there is also an indirect effect of increased competition. Due to a higher number of competitors, some of the sales are likely to be shifted from an incumbent supplier to new entrants and this reduces the incumbent supplier's scale economies. This is particularly the case in the short run when the presence of fixed inputs limits the incumbent supplier's ability to reduce inputs at the same rate that outputs decline. The reduction of the

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<sup>71</sup> This is a quite conservative estimate. Retail electricity prices for households grew during the liberalization years 1998–2005 with an average rate of 2.35 percent. Considering the years 2000–2005, when market consolidation has already occurred, the average yearly price increase is considerably higher (4.1% for households and 9.6% in industry). Source: Bundesministerium für Wirtschaft und Technologie, Energiedaten, update 07-02-2006

<sup>72</sup> The productivity stretch factor can also be used to tailor the regulatory regime to the circumstances of each particular firm. If the regulated firms differ to a large extent in productivity levels, it might be necessary to use a firm specific stretch factor to account for these level differences. Laggard firms normally have low productivity levels but are potentially capable of high productivity growth rates. In a regulatory context, where a firm is a long way from best practice, a positive stretch factor may be applied to allow for the fact that the firm should be able to make some easy “catch up” gains and exceed the average industry productivity growth rate.

scale economies reduces TFP and thereby the X-factor, which thwarts (to a certain extent) the need for a customer dividend, but in case of network access regulation this indirect effect is negligible. The reason is that in the current German context only network access is subject to incentive regulation and the network is still a natural monopoly. Therefore it is unlikely that new network providers will appear, build up a new infrastructure, and compete with the network of the respective regional incumbent.

Unfortunately there is little conceptual and empirical basis for choosing appropriate customer dividend levels. In the UK, where such a regime shift already happened in 1990, the relevance of a stretch factor has been underestimated (in telecommunications as well as) in electricity.<sup>73</sup> One example of a positive stretch factor is the US Federal Communications Commission, which imposed a customer productivity dividend of 0.5 percent annually in its price-cap plan for AT&T. For the North American gas industry (Canada and the United States) Kaufman (2004) computed a similar average CPD of 0.56 percent for nine gas providers – all within a narrow range.

Due to the lack of a reliable empirical CPD value within the electricity sector (or a clear theoretical approach for the computation of this value), I do assume that the best practice examples from telecommunication and gas are a good proxy for the electricity sector. As a result the computed X-factor should (for the first regulatory period) be increased by 0.5 percent due to structural changes in the industry.

### 5.5.3 Accounting for imperfect competition in the economy

A modification to the basic X-factor is also necessary when some of the industries outside the regulated sector are not competitive – even if output price inflation in these industries is not affected by the prices set in the regulated industry. In such a case, price inflation outside of the regulated sector typically exceeds the rate of price inflation in a competitive environment. In order to account for this market failure, the X-factor has to be increased accordingly.

Here (as well as in the case of a regime shift) there is little conceptual and empirical basis for a clear procedure to address this problem. It is not only conceptually unclear how a measure for the economy-wide deviation from perfect competition should be seized. It is also, from a data perspective, quite unrealistic to obtain a comprehensive, sector-

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<sup>73</sup> In the first regulatory period Ofgem (the UK Office of Gas and Electricity Markets) set negative X-factors for the majority of distribution companies (RECs) and an X-factor of zero for transmission companies (see Armstrong, Cowan, Vickers, 1994, p.177). This step was justified by the need for investment in the sector and ignored the scope for cost-cutting. As a result, pre-tax operating profits for distribution more than doubled in the proximate four years. The X-factor therefore had to be readjusted in 1993 to a (positive) value of 3. In the telecommunication sector the British Office of Telecommunications (“OfTel”, in the meantime “Ofcom”) even had to correct the first X-factor of 3 percent to a magnitude of 7.5 in the second regulatory period due to enormous efficiency improvements and excess profits. Both cases reveal an ex-post correction of at least 3 percentage points.



overlapping measure for this. Therefore it should only be remarked that the overall X-factor tends to be slightly higher than the result of the current analysis would suggest.

#### 5.5.4 Accounting for endogeneity in the economy-wide inflation rate

The logic that underlies the simple X-factor calculation presumes that the economy-wide rate of price inflation is not affected directly by the prices set in the regulated industry. This is in particular the case if the output of the regulated sector is not an intermediate good for the rest of the economy, as firms typically adjust their output prices in response to changes in the input price they face. In practice this assumption is violated for many network industries; for electricity this is all the more the case. Therefore an increase in the economy-wide inflation rate should not authorize a full one-to-one increase in the inflation rate of the regulated industry. The difference between the two inflation rates should generally be greater the larger the regulated sector relative to the economy as a whole and the larger the fraction of regulated revenues derived from the sale of intermediate goods (that are used as inputs for other goods). Hence a central modification is necessary to weaken the link between the realized rate of price inflation in the economy and the authorized rate of price increase in the regulated industry:

Equation (39) can be rearranged to  $\dot{P} = RPI_{t-1} - X$  with  $\dot{P} = \frac{P_t - P_{t-1}}{P_t}$  and Bernstein

and Sappington (1999) show that this expression can (under the assumption that the regulated services are intermediate goods, which is the case for network access charges) be transformed to the following expression:

$$\dot{P} = \beta^{NR} [RPI - X] - [1 - \beta^{NR}] \dot{Q} \quad (48)$$

with  $\beta^{NR}$  as share of revenues (or gross output) of the non-regulated sector on total output and with  $\dot{Q}$  as the growth in output (of the regulated sector). Thus, when regulated services are intermediate goods, a unit increase in the economy-wide inflation rate authorizes less than a unit increase in the growth rate of regulated prices, *ceteris paribus*. Since  $\beta^{NR}$  decreases as the output of the regulated sector increases, the reduction in the sensitivity of  $\dot{P}$  to  $RPI$  is more pronounced the larger the ratio of regulated revenue to total revenue in the economy. For Germany the average  $\beta^{NR}$  of 1991–2003 is 0.98 and the average  $\dot{Q}$  is 2.1 percent. This implies for an X-factor of 0.48 (the basic X-factor) and an average RPI of 2.1 percent an annual approved price increase of 1.55 percent. When the modifications are applied the X-factor is 2.15 (which results from the base X-factor of 0.48 and modifications due to a limited span of regulatory control and the structural change in the industry, which add up an additional markup of 1.67 percentage points), which implies an annual

approved price reduction of 0.09 percent (the adjustment for exogenous cost changes is not included here).

## 5.6 Conclusions

Germany is meant to form the centre of a common European electricity market, but the network usage costs are currently still 70 percent above the EU average and electricity retail prices are among the highest in the whole EU. A new energy law is now intended to perform the balancing act between the retention of a stable and sustainable system and the containment of excessive market power on the part of the incumbent players. Particularly the latter task has not been accomplished by the previous regulatory regime. In the context of rising prices for primary energy carriers and high environmental taxes, the need for competitive pressure on energy prices and the need for productivity improvements within the energy sector is urgent.

The German regulatory authority is expected to come up with a new system of incentive based regulation in the course of 2006. This new regime might indeed achieve both: a non-discriminatory access to the electricity network for new energy providers at lower prices (which is a precondition for functioning competition), and a regulatory framework that favors or rewards firms which achieve above-average productivity improvements.

The aim of this chapter is to compute a reasonable value for the X-factor, which is needed for the introduction of an incentive-based RPI-X regulation. The associated productivity analysis is pursued within the growth accounting framework, resorts to a newly constructed database and provides results on the industry level. The main reason for this approach is that data on the firm level are not available yet. The regulatory authority has started to collect firm specific data only recently, which might rule out any parametric approach within the first years. The analysis reveals that the average productivity margin with respect to the rest of the economy (the X-factor) was 0.48 within the preceding decade. However, several assumptions that are implicitly made in the X-factor determination are violated in practice. In order to account for these violations, some modifications were pursued to account for a limited span of regulatory control, anticipated structural changes in the industry, the endogeneity of the economy-wide inflation rate, and imperfect competition outside the regulated sector. These modifications suggest a modified X-value of 2.15, which seems a reasonable value for the first regulatory period in the new German electricity regime that will arise soon (in particular as exogenous cost changes are not included in the X-factor). When accounting for endogeneity in the economy-wide inflation rate this would imply an average annual decline for network access charges of 0.1 percent, when all other modifications are also applied.

Despite the obvious policy conclusion that can be drawn (in terms of an efficiency goal for the first regulatory period), this result can only be a rough indicator for the real

efficiency differential of the network operators. Even if the data that are used for this analysis exhibit more details than official national accounts data, they are still on the aggregate industry-level. Therefore the findings of this study are indeed useful for an adoption in the first regulatory period where detailed firm-level-data are not available. However, this cannot belie the necessity of a detailed multi-dimensional data collection on the firm level that can be used for future parametric analyses that provide a more accurate and reliable efficiency estimate than aggregate capital data ever can do. Further research will also be necessary to improve the conceptual approach towards the two modifications that are necessary due to a lack of competition in the rest of the economy and due to the regime shift.

Last but not least a short remark should be made that the sole focus on cost-cutting is not unambiguous as it raises legitimate concerns for the quality of service. It therefore seems to be a good option for the German regulator to review the British experience with a new aspect in the price regulation that was introduced in 2003. By measuring the quality of service in terms of the number of interruptions of supply, the duration of these interruptions, and the associated information service provided, failures to perform according to acceptable standards could lead to a reduction of prices of up to 1.75%.<sup>74</sup> Such an extension to standard RPI-X regulation could achieve noticeable efficiency improvements without the risk of infrastructure deterioration, which is the main reproach against incentive-based regulatory regimes.

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<sup>74</sup> See OECD (2005) Annex 1

## 6 Concluding Remarks

In this dissertation several topics that are in direct or indirect connection to network industries have been developed. The first focus is on the *privatization* of network industries, which has been an outstanding phenomenon worldwide since the late 1990s. Chapter 2 provides a theoretical contribution to the question of why a government might want to privatize a state-owned network industry, which entails the loss of control over the firm's investment and employment decisions. It turns out that under the assumptions of price cap regulation, a unionized labor market and wage bargaining, the government's gains from privatization depend on two effects. While the government loses control over the firm's investment and employment decisions, the union's bargaining position can be weakened by privatization. Since price cap regulation tends to increase the wage under privatization, the government's incentives to privatize are low if the union's bargaining power is high. Considering different kinds of investments does not change this result qualitatively.

Once a network industry has been privatized and opened up for competition, the remaining bottleneck part of the industry has to be regulated in order to ensure competition. Chapter 3 gives a brief overview on the natural monopoly characteristics and particularities of a specific network industry that necessitate a sector specific *regulation*. In the case of the German electricity sector, the on-going liberalization process was described. The experiences were compared to the American market, in particular to the devastating events in California beginning in the year 2000. Finally the new German energy law of 2005 was evaluated. One particularity of this new law was the introduction of incentive-based regulation that requires relative productivity measures of the regulated industry with respect to the total economy. Chapters 4 and 5 deal with the related *productivity measurement* of the total economy and of the electricity industry in Germany.

Chapter 4 therefore provides a detailed analysis of German productivity development, which is, on the one hand, used for comparing the sector-specific to the total economic productivity growth. This comparison allows a determination of a so-called X-factor that is needed for the setup of the incentive-based regulation of the German electricity industry. On the other hand, such an analysis is, in addition to the network-specific context, indispensable for understanding why Europe has been lagging behind US growth since the mid-1990s. A new and unique data-base is used to analyze the sources of German productivity growth since 1970. It is shown that investment in information and communication technology (ICT) played a minor role in German productivity development. The results include detailed descriptive statistics and projections for output and labor productivity growth for the coming decade. The base-case projection puts overall trend output growth at 1.56 per-

cent per year over the next decade. Average labor productivity will grow at an annual rate of 1.62 percent.

Chapter 5, finally, uses the results of the previous chapter as a prerequisite to determine an X-factor for the German electricity industry. New legislation requires the implementation of an incentive-based regulation in the coming years. In such a regime either prices or revenues are capped and grow at the inflation rate minus a factor that accounts for productivity differences between the sector and the rest of the economy. Applying the growth accounting methodology, such an X-factor has been derived for the German electricity industry – again by means of the new productivity database of the Ifo Institute. Considering that several underlying assumptions are violated due to market imperfections, modifications are suggested that would increase the calculated X-factor of 0.48 to a modified value of 2.15.

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## **Appendix**

### **The Ifo Productivity Database**

The capital-data that is used for the above productivity analyses is assembled in the new Ifo Productivity database. The Ifo Institute has collected data on prices of investment goods in 52 sectors, which allows to establish an accurate time series of quantity volumes and prices. Hence the industry-specific depreciation rates are unique primary data that are obtained from the Institute's long time series from its investment survey. This section of the Appendix provides information on data sources of input and output, and the systematics and data sources of the underlying investment and capital stock data. For more details see Fuchs and Kuhlmann (2005).

The whole database is currently restricted for internal use but will presumably be accessible for external researchers in 2007. The Ifo Capital Stock and Investment Data are already accessible in the Ifo Data Pool (under specific security precautions).

### **Descriptive Statistics**

Table 9 provides descriptive statistics about the total West German economy from 1970-1990 on output, labor, intermediates, and capital measures.

Table 9 Descriptive Statistics to the Ifo Productivity Database – 1970-1990

| Year | GDP<br>(Mio.€) | Gross<br>Output<br>(Mio.€) | Hours<br>Worked<br>(Mio.h) | Capital<br>Stock<br>(Mio.€) | Emple-<br>yees<br>(1000) | Interme-<br>diates<br>(Mio.€) | Intermed.<br>Value-<br>Share<br>(%) | Labor<br>Value-<br>Share<br>(%) | Capital<br>Value-<br>Share<br>(%) |
|------|----------------|----------------------------|----------------------------|-----------------------------|--------------------------|-------------------------------|-------------------------------------|---------------------------------|-----------------------------------|
| 1970 | 897.0          | 1,458.5                    | 52,073                     | 2,857.0                     | 26,560                   | 558.0                         |                                     |                                 |                                   |
| 1971 | 926.7          | 1,516.2                    | 51,428                     | 3,009.2                     | 26,668                   | 588.1                         | 54.4%                               | 39.4%                           | 6.2%                              |
| 1972 | 964.8          | 1,584.9                    | 51,028                     | 3,168.4                     | 26,774                   | 616.5                         | 53.6%                               | 38.5%                           | 8.0%                              |
| 1973 | 1,008.8        | 1,659.3                    | 50,801                     | 3,327.7                     | 27,066                   | 645.2                         | 53.1%                               | 38.4%                           | 8.5%                              |
| 1974 | 1,013.4        | 1,662.3                    | 49,401                     | 3,472.8                     | 26,738                   | 639.8                         | 50.3%                               | 37.4%                           | 12.3%                             |
| 1975 | 1,002.8        | 1,639.5                    | 47,122                     | 3,598.8                     | 26,020                   | 632.8                         | 50.0%                               | 36.9%                           | 13.2%                             |
| 1976 | 1,052.9        | 1,729.9                    | 47,273                     | 3,720.5                     | 25,882                   | 671.9                         | 51.2%                               | 36.6%                           | 12.1%                             |
| 1977 | 1,084.9        | 1,776.4                    | 46,959                     | 3,846.6                     | 25,919                   | 685.6                         | 52.6%                               | 38.1%                           | 9.3%                              |
| 1978 | 1,117.4        | 1,833.6                    | 46,838                     | 3,977.4                     | 26,130                   | 708.5                         | 55.1%                               | 39.3%                           | 5.5%                              |
| 1979 | 1,163.9        | 1,920.2                    | 47,368                     | 4,115.7                     | 26,568                   | 745.7                         | 55.7%                               | 39.2%                           | 5.1%                              |
| 1980 | 1,178.7        | 1,948.7                    | 47,611                     | 4,260.2                     | 26,980                   | 759.2                         | 52.5%                               | 37.5%                           | 10.0%                             |
| 1981 | 1,180.0        | 1,936.5                    | 47,046                     | 4,399.2                     | 26,951                   | 744.9                         | 46.4%                               | 34.0%                           | 19.6%                             |
| 1982 | 1,170.7        | 1,920.3                    | 46,270                     | 4,523.9                     | 26,630                   | 734.0                         | 45.5%                               | 33.1%                           | 21.4%                             |
| 1983 | 1,188.9        | 1,952.5                    | 45,572                     | 4,643.1                     | 26,251                   | 749.0                         | 46.6%                               | 32.7%                           | 20.7%                             |
| 1984 | 1,222.5        | 2,018.0                    | 45,642                     | 4,763.4                     | 26,293                   | 777.7                         | 46.7%                               | 32.0%                           | 21.3%                             |
| 1985 | 1,249.3        | 2,073.6                    | 45,664                     | 4,880.8                     | 26,489                   | 800.7                         | 47.5%                               | 32.1%                           | 20.4%                             |
| 1986 | 1,279.5        | 2,136.2                    | 46,001                     | 4,999.4                     | 26,856                   | 830.2                         | 49.1%                               | 32.5%                           | 18.4%                             |
| 1987 | 1,298.3        | 2,192.6                    | 45,986                     | 5,122.7                     | 27,050                   | 864.8                         | 49.4%                               | 32.1%                           | 18.6%                             |
| 1988 | 1,346.8        | 2,288.1                    | 46,473                     | 5,251.5                     | 27,261                   | 908.1                         | 50.5%                               | 32.0%                           | 17.6%                             |
| 1989 | 1,399.5        | 2,387.3                    | 46,643                     | 5,389.5                     | 27,658                   | 948.0                         | 52.4%                               | 32.5%                           | 15.1%                             |
| 1990 | 1,479.6        | 2,525.6                    | 47,411                     | 5,542.2                     | 28,479                   | 1,004.7                       | 52.2%                               | 31.9%                           | 15.8%                             |

Source: Ifo Productivity Database (GDP, Gross Output, Capital Stock)

Table 10 covers the later period for unified Germany with the same descriptive statistics as presented in Table 9.

Table 10 Descriptive Statistics to the Ifo Productivity Database – 1991-2003

| Year | GDP<br>(Mio.€) | Gross<br>Output<br>(Mio.€) | Hours<br>Worked<br>(Mio.h) | Capital<br>Stock<br>(Mio.€) | Emple-<br>yees<br>(1000) | Interme-<br>diates<br>(Mio.€) | Intermed.<br>Value-<br>Share<br>(%) | Labor<br>Value-<br>Share<br>(%) | Capital<br>Value-<br>Share<br>(%) |
|------|----------------|----------------------------|----------------------------|-----------------------------|--------------------------|-------------------------------|-------------------------------------|---------------------------------|-----------------------------------|
| 1991 | 1,760.6        | 3,029.1                    | 59,666                     | 7,852.3                     | 38,621                   | 1,384.11                      | 50.11%                              | 35.10%                          | 14.79%                            |
| 1992 | 1,799.7        | 3,073.2                    | 59,475                     | 8,068.4                     | 38,059                   | 1,429.30                      | 48.32%                              | 33.85%                          | 17.84%                            |
| 1993 | 1,785.3        | 3,038.6                    | 58,071                     | 8,282.9                     | 37,555                   | 1,414.02                      | 47.15%                              | 32.96%                          | 19.89%                            |
| 1994 | 1,832.7        | 3,115.7                    | 57,902                     | 8,493.2                     | 37,516                   | 1,453.87                      | 47.14%                              | 32.09%                          | 20.76%                            |
| 1995 | 1,867.4        | 3,205.1                    | 57,503                     | 8,707.9                     | 37,601                   | 1,515.32                      | 44.95%                              | 29.90%                          | 25.14%                            |
| 1996 | 1,886.0        | 3,252.0                    | 56,734                     | 8,917.2                     | 37,498                   | 1,542.18                      | 46.24%                              | 30.37%                          | 23.40%                            |
| 1997 | 1,920.0        | 3,319.7                    | 56,326                     | 9,124.2                     | 37,463                   | 1,577.37                      | 47.18%                              | 30.34%                          | 22.48%                            |
| 1998 | 1,959.0        | 3,409.2                    | 56,783                     | 9,337.1                     | 37,911                   | 1,646.83                      | 48.87%                              | 30.57%                          | 20.55%                            |
| 1999 | 1,998.4        | 3,534.6                    | 57,106                     | 9,561.8                     | 38,424                   | 1,741.18                      | 51.46%                              | 31.14%                          | 17.40%                            |
| 2000 | 2,062.5        | 3,680.6                    | 57,459                     | 9,796.0                     | 39,144                   | 1,824.40                      | 49.83%                              | 30.09%                          | 20.08%                            |
| 2001 | 2,088.1        | 3,725.2                    | 57,142                     | 10,022.0                    | 39,316                   | 1,841.48                      | 50.34%                              | 30.32%                          | 19.34%                            |
| 2002 | 2,089.3        | 3,681.4                    | 56,322                     | 10,219.3                    | 39,096                   | 1,789.93                      | 49.50%                              | 30.44%                          | 20.06%                            |
| 2003 | 2,085.4        | 3,712.5                    | 55,539                     | 10,390.4                    | 38,722                   | 1,824.02                      | 51.23%                              | 30.65%                          | 18.13%                            |

Source: Ifo Productivity Database

### Data Sources concerning Labor and Capital

In our estimates of aggregate labor input (L) we resort to data of GGDC.<sup>75</sup> According to Jorgenson (2000) we derive changes in labor input by:  $\Delta \ln L = \Delta \ln LQ + \Delta \ln H$ , where  $\Delta \ln LQ$  equals labor quality and H is hours worked. Given that the series of labor quality covers only the period 1980-2000, we extrapolate earlier and later values by using those of the 1980ies or the late 1990s respectively, due to the relatively constant or non-volatile growth of this variable. All further sources in the context of labor inputs are depicted in Table 11.

Table 11 Data sources of labor inputs

| Variable                            | Industry-level/<br>Aggregate | Period    | Source   |
|-------------------------------------|------------------------------|-----------|--|
| Gross wage sum                      | I                            | 1991-2003 | GSO, Genesis 81000BJ323  |
|                                     | A                            |           | GSO, Genesis 81000BJ323  |
| Employees and Self-employed workers | I                            | 1991-2003 | GSO, Genesis 81000BJ323  |
|                                     | A                            |           | GSO, Genesis 81000BJ323  |
| Employees                           | I                            | 1991-2003 | GSO, Genesis 81000BJ323  |
|                                     | A                            |           | GSO, Genesis 81000BJ323  |
| Hours worked                        | I                            | 1991-2003 | GSO, Genesis 81000BJ323, own calculations based on Genesis 62221BJ005-008 and DESTATIS 4061xxx   |
|                                     | A                            |           | GSO, Genesis 81000BJ323  |
| Labor quality                       | I                            | 1980-2000 | GGDC, <a href="http://www.ggdc.net">www.ggdc.net</a> , based on unpublished data received from German Statistical Office, originally from the German Employment Statistics and Wage and Salary Statistics. |
| Gross wage sum                      | I                            | 1970-1990 | GSO, Fachserie 18, 2279XXX   |
|                                     | A                            |           | GSO, DESTATIS 7861085  |
| Employees and Self-employed workers | I                            | 1970-1990 | GSO, Fachserie 18, 917XXX  |
|                                     | A                            |           | GSO, DESTATIS 7862085  |
| Employees                           | I                            | 1970-1990 | GSO, Fachserie 18, 917XXX  |
|                                     | A                            |           | GSO, DESTATIS 7863085  |
| Hours worked                        | I                            | 1970-1990 | GSO, time-series service, 4037XXX  |
|                                     | A                            |           | GSO, Fachserie 18, S.21  |

The input and output measures that are used at the industry and aggregate level are displayed in Table 12

<sup>75</sup> Groningen Growth and Development Centre, [www.ggdc.net](http://www.ggdc.net), Industry Growth Accounting Database: Labor quality



Table 12 Data sources of input and output

| Variable                                     | Industry-level/<br>Aggregate | Period    | Source  |
|--|------------------------------|-----------|---|
| Gross Output, in 1991 prices                 | I                            | 1970-1990 | GSO, DESTATIS 7849XXX, own calculations using Input-Output tables, various issues   |
| Gross Output, in current prices              | I                            | 1970-1990 | GSO, DESTATIS 7848XXX   |
| GDP, in current prices                       | A                            | 1970-1990 | GSO, DESTATIS 7841005   |
| GDP, in 1995 prices                          | A                            | 1970-1990 | GSO, DESTATIS 7841024   |
| GDP deflator                                 | A                            | 1970-1990 | Ratio of nominal to real GDP  |
| Intermediate Inputs, in 1991 prices          | I                            | 1970-1990 | GSO, DESTATIS 7749XXX, own calculations using Input-Output tables, various issues   |
| Intermediate Inputs, in current prices       | I                            | 1970-1990 | GSO, DESTATIS 7746XXX   |
| Value-Added, in 1991 prices                  | I                            | 1970-1990 | GSO, Fachserie 18, 1496XXX  |
| Value-Added, in current prices               | I                            | 1970-1990 | GSO, Fachserie 18, 1495XXX  |
| Price deflators for intermediate goods       | I                            | 1970-1990 | Own calculations using the gross output deflator at lowest available level for periods prior to 1976 or service industries, or data of intermediate goods, GSO, DESTATIS 7849XXX, 7846XXX for 1976 and later. |
| Gross Output, in const. prices (chain index) | I                            | 1991-2003 | GSO, Genesis 81000BJ321   |
| Gross Output, in current prices              | I                            | 1991-2003 | GSO, Genesis 81000BJ321   |
| GDP, , in const. prices (chain index)        | A                            | 1991-2003 | GSO, Genesis 81000BJ007   |
| GDP, in current prices                       | A                            | 1991-2003 | GSO, Genesis 81000BJ007   |
| GDP deflator                                 | A                            | 1991-2003 | Ratio of nominal to real GDP  |
| Intermediate Inputs, in 1991 prices          | I                            | 1991-2003 | GSO, DESTATIS 7716XXX   |
| Intermediate Inputs, in current prices       | I                            | 1991-2003 | GSO, DESTATIS 7715XXX   |
| Value-Added, in const. prices (chain index)  | I                            | 1991-2003 | GSO, Genesis 81000BJ321   |
| Value-Added, in current prices               | I                            | 1991-2003 | GSO, Genesis 81000BJ321   |
| Price deflators for intermediate goods       | I                            | 1991-2000 | Own calculations using the gross output deflator at lowest available level for service industries, or data of intermediate goods, GSO, time-series service 1428XXX  |

## The Ifo Investorenrechnung Database

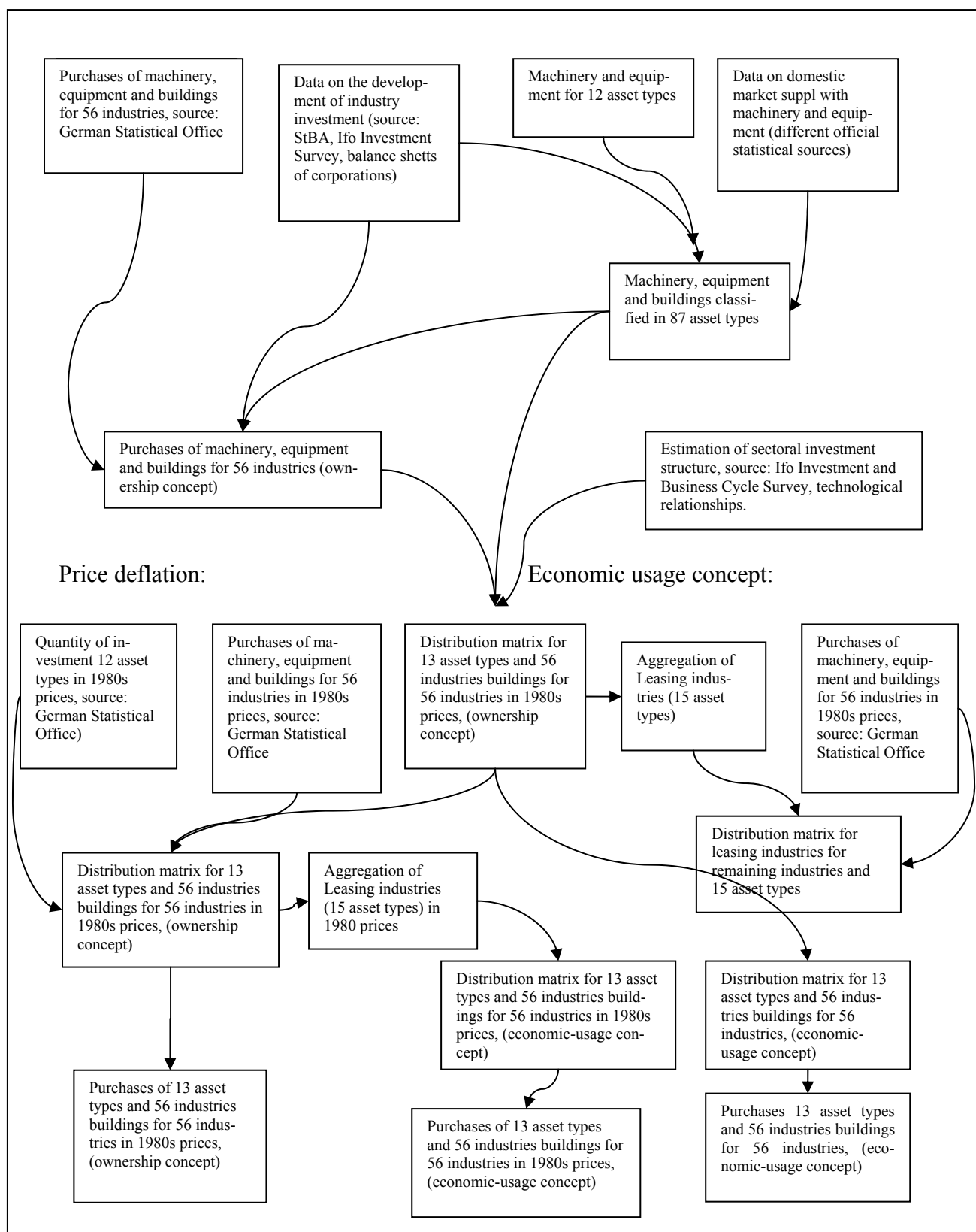
The capital data which is used for the growth accounting exercise in the Ifo Productivity Database is taken from the Ifo Investorenrechnung Database whose Investment series consists of two parts: the investment series section and the capital stocks series section.

### *The Ifo Investorenrechnung Investment Series*

The systematic, calculations and data sources of the Ifo Investorenrechnung Investment Series section is depicted in Figure 12. The starting point for the investment series calculations is statistical data which is taken from the German statistical office and contains the formation of investment in 55 industries and data on the development of industry investment which are obtained by different data sources containing some official statistical sources but also information of the Ifo Investment survey with about 2000 reporting corporations. Additionally to the rich information on industry investment, the Ifo Investorenrechnung Investment Series uses data of the German Statistical Office on 12 asset types and data of other statistical sources (such as industry employer associations) on the market supply structure of different asset types, which leads finally to a more detailed classification of investment assets in 87 categories. The information of the investment assets and on industry investment is in the next step combined with estimates of the sectoral investment structure in order to obtain a distribution matrix for 13 asset types and 56 industries and also industry- and asset-specific price deflators. The obtained distribution matrix and price deflators are then scaled to deliver results that are consistent with the official data of the German Statistical Office and converted to 1980 prices additionally to current prices.

Using information provided by the Ifo Investment Survey on the leasing industries, the obtained data are modified by allocating the investment assets of the leasing industries to those industries which use them for production purposes. This procedure leads finally to the *economic-usage concept* and provides an investment matrix for industry- and asset-specific investments and prices. This price information is used for the Ifo Productivity Database and serves as input for the capital services flows and costs of capital calculations. More detailed information on the investment series can be found in Gerstenberger et al. (1989)

Figure 12 – The Ifo Investorenrechnung Investment Series Database: Systematics



Source: Fuchs, Kuhlmann (2005)

### *The Ifo Investorenrechnung Capital Stocks Series*

The second part of the Ifo Investorenrechnung Database, which is used for the Ifo Productivity Database, is the capital stocks series section. The systematics, calculations and data sources of the Ifo Investorenrechnung Capital Stock Series section is depicted in Figure 13. The starting point for this calculation builds data of the Ifo Investorenrechnung Investment Series Database which contains information on 13 asset types and 56 industries in 1960. For the calculation of capital stocks from 1960 onwards, it is necessary to have information on the investment in machinery and equipment from 1924 onwards and on investment in buildings from 1850 onwards. The investment data for this period have been provided by the German Statistical Office and the DIW, Berlin. Using the investment data, information on the economic usage periods of an asset and a hazard rate function for different asset types and industries, it was possible to estimate industry- and asset-specific capital stocks for 56 industries and 13 asset types. Data on the duration of usage of an asset in an industry was obtained by the AfA-tables<sup>76</sup> of the German Statistical Office. Due to the high disaggregation of the AfA-tables a weighting scheme was employed in order to obtain the sector- and industry-specific usage duration, which was in the next step combined with Ifo survey data on the industry-level in order to obtain economic-usage durations. In accordance to the method of the German Statistical Office, it is assumed that the economic usage duration of assets decreases by 25% from 1950 until 1986.

These procedures, which specify in fact an annual inflow of new and an outflow of used assets, allow to obtain industry- and asset specific capital stocks. These can be deflated by the industry- and asset-specific price deflators to obtain the capital stocks in 1980s prices and current prices for 13 asset types and 56 industries using the investment price deflators (following Jorgenson and Stiroh 2000). More detailed information on the capital stocks can also be found in Gerstenberger et al. (1989).

The *depreciation rates* of the Ifo Productivity Database stem from the Ifo Investorenrechnung Database and based on the economic usage duration. From 1986 onwards the economic usage duration of assets is assumed to be constant.

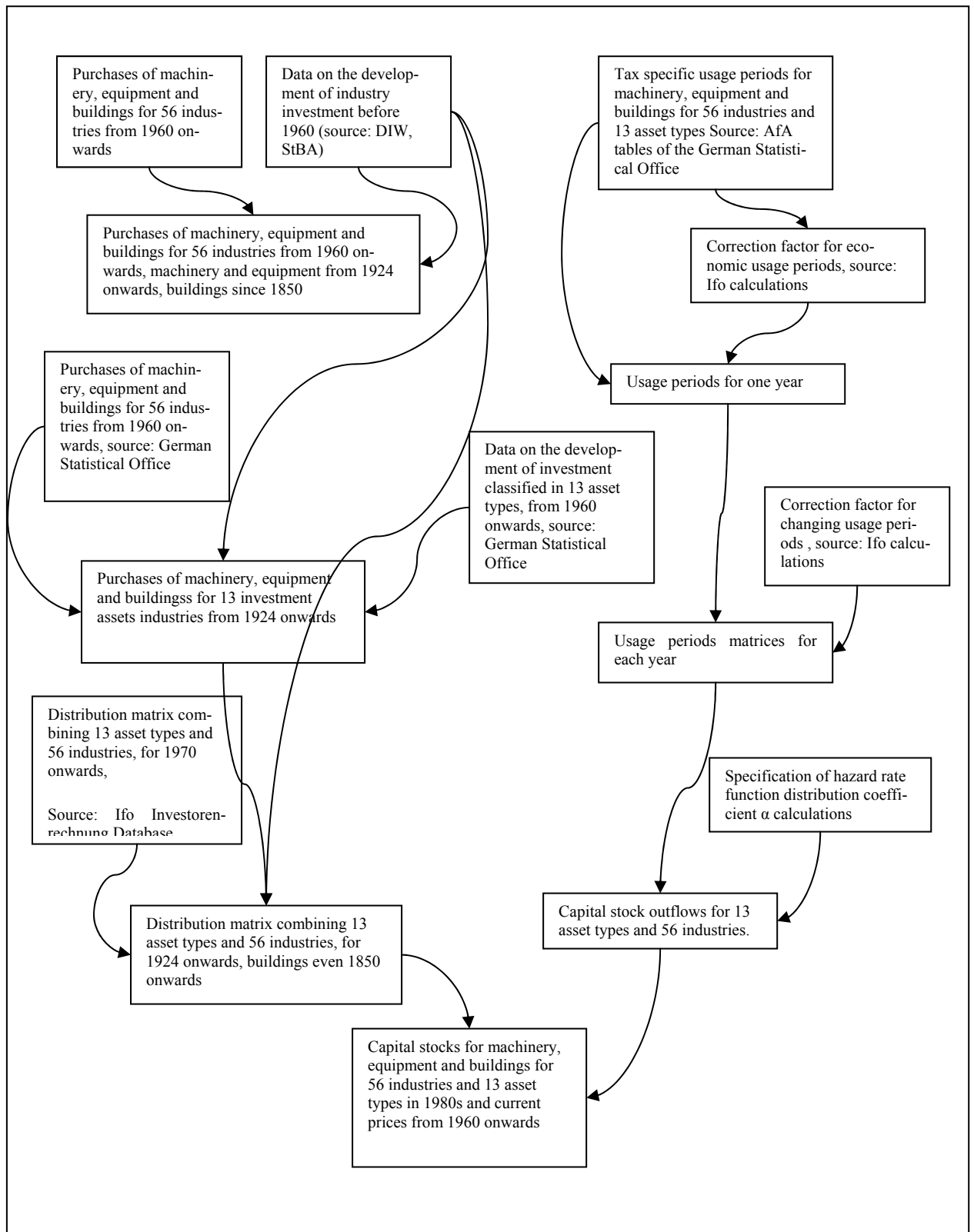
The *price deflators* of the Ifo Productivity database stem from the Ifo Investorenrechnung database for 1960 until 2000.

*Nominal interest rates* stem from the OECD Economic Outlook (Interest Rate, Long-Term – Germany: DEUIRL) for the period 1960 to 2006.

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<sup>76</sup> “AfA“ abbreviates “Abschreibung für Abnutzung“, which means depreciation.

Figure 13 – The Ifo Investorenrechnung Database: Calculation of capital stocks



Source: Fuchs, Kuhlmann (2005)

### Domar TFP-Aggregation

The Domar (1961) weighting scheme is used to derive total economic productivity growth on the basis of industry-specific (gross-output-based) TFP-values. The concept considers the importance of the output of an industry  $i$  as an intermediate input in the production of other industries, accounting more accurately for inter-industry relationships in the economy-wide production process. The basic weighting formula of an industry  $i$  for the calculation of its contribution to aggregate TFP growth is:

$$w_{it} = \left( \frac{Y_{it-1}}{\sum_i VA_{t-1}} + \frac{Y_{it}}{\sum_i VA_t} \right) * 0.5$$

with  $w_{it}$  as the Domar weight of industry  $i$  in period  $t$  which is a two year average of the current and the prior year ratio of gross output of industry  $i$  over aggregate value-added. This procedure allows calculating the industry contribution to aggregate TFP by considering the importance of an industry as input-supplier of other industries.

**Curriculum Vitae**

|             |  |
|-------------|--|
| 1976-07-14  | Born in Munich, Germany  |
| 1996        | Abitur at the Albertus-Magnus-Gymnasium Bensberg   |
| 1996 – 1997 | Alternative national service, Alten- und Familienhilfe, Bergisch Gladbach                                    |
| 1997 – 2000 | Economic studies at the University of Munich (LMU)   |
| 2000 – 2001 | Economic studies at the Université Libre de Bruxelles, Erasmus exchange                                      |
| 2002        | Master degree (Diplom Volkswirt) at the University of Munich (LMU)   |
| 2002 – 2006 | Ph.D. student at the University of Munich and research assistant at the Ifo Institute for Economic Research. |