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How to deal with a CAPEX-bias: fixed-OPEX-CAPEX-share (FOCS)

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Abstract: In recent years, the OPEX-CAPEX-incentive-bias (short: CAPEX-bias) received renewed attention in regulatory practice. A CAPEX-bias occurs when the OPEX solution is the more efficient approach, but regulation sets distorted incentives to choose the CAPEX solution. This paper presents a promising approach to address the CAPEX-bias: the fixed-OPEX-CAPEX-share (FOCS). With FOCS, all expenses, whether for capital goods (CAPEX) or operational measures (OPEX), are treated as TOTEX. A fixed portion, the capitalisation rate of this TOTEX, is then "capitalised" (quasi-CAPEX) and the remaining portion is directly expensed as quasi-OPEX ("pay-as-you-go"). Because all costs are treated equally, any distortion of behaviour that would arise because of the different treatment of costs, disappears. Similarly, the regulatory effort of scrutinising cost classification is no longer required. The paper also discusses practical implementation issues and first international experience.

Keywords: monopoly regulation, CAPEX-bias, FOCS

JEL-classification: D42, K23, L51

1. Introduction

In order to drive decarbonisation and successfully master the energy transition, grid operators are facing major challenges. Electricity grids have to accommodate more renewable feed-in, while at the same time demand is rising due to advancing electrification. The boom in renewable energies requires modernisation and strengthening of the power grids. Network operators have two ways of doing this. In addition to grid expansion, there are some "smart" solution approaches to address these challenges, for instance using flexibility instead of building an additional line. However, smart grid technologies often have a higher share of operating costs (OPEX) than conventional grid investments (CAPEX) (eg. E-Bridge et al., 2014). This means that they are treated "differently" from a regulatory point of view, which can make the recovery of costs for such smart OPEX-heavy solutions more risky and less worthwhile for grid operators. This is referred to as an OPEX-CAPEX-incentive-bias (CAPEX-bias).

A CAPEX-bias occurs when the OPEX solution is the more efficient approach, but regulation sets distorted incentives to choose the CAPEX solution, or vice versa. A CAPEX-bias is not self-evident and requires a specific cause in regulatory rules, causing a distortion. In an unregulated competitive environment, we would not expect a CAPEX-bias, because firms generally have an incentive to reduce their costs. Typically, CAPEX-bias are caused either by the notion that regulated rate-of-return in capital is higher than the true cost-of-capital, by specific OPEX disadvantages or, importantly, by asymmetries in the regulation.

Another, slightly different viewpoint of the economic intuition could be as follows: On an unregulated competitive market, the costs of a firm have no connection to its revenue. As such, the firm would attempt to reduce costs as much as possible and would be indifferent between CAPEX and OPEX solutions as long as they are cost-efficient. This is different for regulated companies, because under regulation, costs are usually considered in the calculation of regulated revenues. If certain cost categories are treated differently, this can distort the choice between different technical solutions.

The literature on CAPEX-bias started with the seminal work of Averch and Johnson (1962). It has been a long and controversial debate ever since. In practice, the CAPEX-bias has gained renewed attention in recent years (Smith et al., 2019). The main driver behind the renewed interest may well be the ongoing digitalisation, which can push the cost-structure towards OPEX.

In this paper, we study a particularly promising approach to address the CAPEX-bias: the fixed-OPEX-CAPEX-share (FOCS). Under FOCS, all expenditures, whether CAPEX or OPEX are treated exactly the same, as TOTEX. A fixed share, determined by the regulator, is capitalised as quasi-CAPEX and the remaining part is expensed directly as quasi-OPEX. The term FOCS was first coined in Oxera (2019) and then worked out in Brunekreeft & Rammerstorfer (2021) and Meyer (2021). FOCS was suggested in practice by e.g. ACER (2021) and ENTSO-E (2021). FOCS is a variation of TOTEX-regulation, which was implemented exactly to address the CAPEX-bias in water and energy regulation in the UK (Ofwat, 2011; Ofgem, 2017, pp. 14/15; cf. Oxera, 2019).

In the remainder of the paper, section 2 will first give a brief introduction to the problem of the CAPEX-bias. Section 3 will show how FOCS works analytically and how it effectively addresses the CAPEX-bias. Section 4 will then continue with a discussion on practical implementation issues and conclude with real-world UK experience. Section 5 gives concluding remarks.

2. OPEX-CAPEX-incentive-bias (CAPEX-bias) in the literature

In their seminal paper, Averch and Johnson (1962) demonstrated the so-called gold-plating effect: regulation incentivises CAPEX and away from OPEX through a regulated return on capital when the regulated rate of return ("s") is higher than the cost of capital ("r"). The UK water regulator Ofwat (2011, p. 15) echoes this point: "But in some cases, the regulator may – when assessing its duties in the short and long run – 'aim up' on the cost of capital to secure that efficient companies can finance their functions." While the Averch-Johnson effect is well understood, its empirical relevance is unclear (see Borrmann and Finsinger, 1999, p. 353). Law (2014) examines existing literature on overcapitalisation in regulated industries, distinguishing between the different types of regulation and separating theoretical and empirical studies. He concludes that there is little empirical evidence for an Averch-Johnson effect in regulated utilities. Buranabunyut and Peoples (2012, pp. 182-186) present an empirical study on the CAPEX-bias in telecom regulation, which found no bias under price-cap regulation, but did find a bias under rate-of-return regulation. However, since in practice we find hybrid forms of regulation, the conclusion on a CAPEX-bias is ambiguous.

It is important to note that the existence of a CAPEX-bias is not self-evident and requires a specific cause in the rules of the regulation. Therefore, any asserted CAPEX-bias requires a

detailed context-dependent analysis of the incentives set by the regulation. In general, we can distinguish three groups of causes for the CAPEX-bias:

- CAPEX advantage; especially when the regulated return on capital is higher than the actual cost of capital. This is the main cause in Averch and Johnson (1962).
- CAPEX bias: Certain specifications of the regulation can lead to a CAPEX bias, in particular due to an asymmetric regulation of CAPEX and OPEX (cf. AER, 2014) or due to certain features of the existing benchmarking (cf. Smith et.al., 2019).
- OPEX disadvantage: An example is that OPEX risk (compared to CAPEX risk) is not fully captured by regulation (cf. Brunekreeft & Rammerstorfer, 2021).

In practice, the CAPEX-bias has gained renewed attention in recent years (Smith et al., 2019). The UK water regulator Ofwat (2011, pp. 15-18) has discussed the issue at length and provides a long list of possible drivers of CAPEX bias; however, we should note that not all of these drivers are equally compelling. NERA (2016) analysed the problem particularly in the context of smart grids. The European association of electricity distribution system operators EDSO (2017, p. 4) points to a CAPEX-bias for electricity distribution networks. Bade (2016, p. 10) refers to the state regulator in New York, which claims a CAPEX-bias; Makholm (2016), discussing the same developments in New York, mentions a possible CAPEX-bias more critically. The Australian energy regulator AER (2014) emphasizes a balanced and symmetrical treatment of CAPEX and OPEX to avoid CAPEX-bias. Frontier Economics (2018) provides an analysis of TOTEX-regulation for Australian energy regulation triggered by the existing CAPEX bias of the earlier regulatory design. The energy regulator in Germany found that the new incentive regulation, which has been in force since 2019 and treats CAPEX and OPEX asymmetrically, induces a CAPEX-bias (Consentec and Frontier Economics, 2019, p. 105).

3. Fixed-OPEX-CAPEX-share (FOCS)

3.1. Basic idea

The fixed-OPEX-CAPEX-share (FOCS), which we discuss in this paper, is one of the most promising solutions to the CAPEX-bias. FOCS is a variation of TOTEX regulation. TOTEX regulation is well established in the literature, notably by Braeutigam (1981) and Finsinger and Kraft (1984), who refer to this approach as mark-up regulation. The system has been

implemented in the UK for the regulation of water and energy networks (cf. Ofwat, 2011; Oxera, 2014; Ofgem, 2017, pp. 14/15; Smith et al, 2019; and Oxera, 2019).

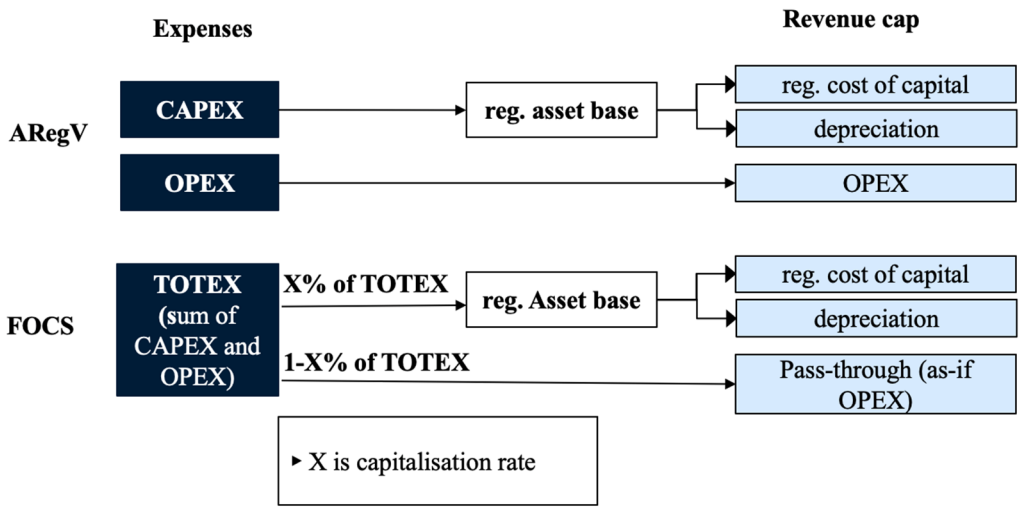

Figure 1: The basic idea of FOCS

Source: Adapted from Oxera (2019)

As illustrated in figure 1, the idea is simple. With FOCS, all expenses, whether for capital goods (CAPEX) or operational measures (OPEX), are treated as TOTEX. A fixed portion, the capitalisation rate of this TOTEX, is then "capitalised" (quasi-CAPEX) and the remaining portion is expensed directly as quasi-OPEX ("pay-as-you-go"). This capitalisation rate is expressed as the fixed-OPEX-CAPEX-share. In regulation, the resulting quasi-CAPEX and quasi-OPEX are treated in exactly the same way as CAPEX and OPEX in the normal regulatory system. The quasi-CAPEX go into the regulatory asset base and generate depreciation and interest. Quasi-OPEX are accounted for within the accounting year. Therefore, the firm is indeed indifferent between CAPEX and OPEX.

3.2. FOCS in a small formal model

It is straightforward to illustrate the FOCS in the formal setting of the seminal Averch-Johnson model (1962) and the exposition of this model in Braeutigam (1981) and in the textbook by Borrmann and Finsinger (1999), which we follow here.

For OPEX we take the cost of labour, wL, where L is the amount of labour and w is the price of labour. Obviously, wL can be replaced by any source of OPEX. For CAPEX we take the cost of capital rK, where K is the amount of capital and r is the price of capital. In our approach, we

take *w* and *r* as given; these are market prices and cannot be influenced by either the company or the regulator. Hence, the variables for OPEX and CAPEX, which are under the control of the firm, are the quantities *L* and *K*. Following Averch-Johnson (1962), the regulatory constraint is the regulated rate-of-return on capital, denoted by *s*.

The revenue (*R*) is a function of the production function *f(L,K)*: *R(f(L,K))*, with derivative R_f. The production function *f(L,K)* itself is twice differentiable:

$$f_L = \frac{\partial f}{\partial L} > 0, \qquad f_K = \frac{\partial f}{\partial K} > 0, \qquad f_{LL} = \frac{\partial^2 f}{\partial L^2} < 0, \qquad f_{KK} = \frac{\partial^2 f}{\partial K^2} < 0.$$

Define the costs of the firm as:

$$C(L,K) = wL + rK \tag{1}$$

The profit (π) is then given by:

$$\pi(L,K) = R(f(L,K)) - C(L,K) \tag{2}$$

and the regulatory constraint:

$$R(f(L,K)) - wL \leq sK \tag{3}$$

Forming the Lagrangian:

$$\mathcal{L}(L,K,\lambda) = R(f(L,K)) - wL - rK - \lambda[R(f(L,K)) - wL - sK] \tag{4}$$

Taking first-order conditions:

$$\begin{aligned} \mathcal{L}_L &= R_f f_L - w - \lambda\left[R_f f_L - w\right] = 0 \\ \mathcal{L}_K &= R_f f_K - r - \lambda\left[R_f f_K - s\right] = 0 \\ \mathcal{L}_\lambda &= R(f(L,K)) - wL - sK = 0 \end{aligned} \tag{5}$$

After rearranging terms, and dividing f_K by f_L, it follows:

$$\frac{f_k}{f_L} = \frac{r - \left(\frac{\lambda}{1-\lambda}\right)(s-r)}{w} \tag{6}$$

This is the standard Averch-Johnson equation, which established the gold-plating effect, if regulation is binding ($\lambda > 0$) and the regulated rate-of-return is larger than the cost of capital ($s > r$). To see this note that the optimal factor equation is:

$$\frac{f_K^*}{f_L^*} = \frac{r}{w} \tag{7}$$

From (6), it can be seen that if $\lambda > 0$ and $s > r$, f_K/f_L must go down to restore the equation (6). A lower f_K means a higher use of capital and a higher f_L means a lower use of labour. Therefore, we find the CAPEX-bias.

The fixed-OPEX-CAPEX-share (FOCS)

Under a FOCS rule, both the cost and the regulatory constraint change.

$$C^F(L,K) = (wL)^F + (rK)^F = (1-\alpha)C(L,K) + \alpha C(L,K) \qquad (8)$$

Where the superscript "F" stands for FOCS.[1] The first derivates of C^F to L and K are:

$$C_L^F = w(1-\propto)\left(\frac{dL}{dL}\right)^F + r \propto \left(\frac{dK}{dL}\right)^F \qquad (9)$$

$$C_K^F = w(1-\alpha)\left(\frac{dL}{dK}\right)^F + r \propto \left(\frac{dK}{dK}\right)^F \qquad (10)$$

Total cost before and after the transformation to FOCS should be the same; FOCS is merely a different composition of OPEX and CAPEX. Therefore, by FOCS-mechanism, we use the following equalities:

$$w = r\left(\frac{dK}{dL}\right)^F \text{ and } r = w\left(\frac{dL}{dK}\right)^F \qquad (11)$$

Note the terms in rounds brackets with the superscript F are effects of applying FOCS; they are not the substitution effects from technology function. After substituting in (9) and (10), it follows, as should be expected:

$$C_L^F = w \;\; and \; C_K^F = r$$

The regulatory constraint sets a mark-up, μ, on quasi-CAPEX; this corresponds to the usual regulated rate-of-return on capital (as "*s*" above), but specified in a slightly different way.

$$R(f(L,K)) \leq (1-\alpha)C^F(L,K) + \mu\alpha C^F(L,K) = (1-\alpha+\mu\alpha)C^F(L,K) \qquad (12)$$

The reader may note that the term $(1-\alpha+\mu\alpha)$ is a construct of constant parameters, set by the regulator, which we denote with σ. It is then immediately obvious that this mechanism boils down to the well-known TOTEX-mark up, as in Braeutigam (1981).

[1] This expression could be slightly refined. Under FOCS, OPEX and CAPEX go into TOTEX; afterwards these are changed into operating costs and capital costs. For capital, expenditure and costs are not the same. We ignore this refinement here.

Forming the Lagrangian:

$$\mathcal{L}(L,K,\lambda) = R\big(f(L,K)\big) - C^F(L,K) - \lambda[R(f(L,K)) - \sigma C^F(L,K)] \qquad (13)$$

Taking first-order conditions:

$$\begin{aligned} \mathcal{L}_L &= R_f f_L - w - \lambda\big[R_f f_L - \sigma w\big] = 0 \\ \mathcal{L}_K &= R_f f_K - r - \lambda\big[R_f f_L - \sigma r\big] = 0 \\ \mathcal{L}_\lambda &= R\big(f(L,K)\big) - \sigma C^F(L,K) = 0 \end{aligned} \qquad (14)$$

Substituting (**14**) and writing out, it follows:

$$\frac{f_K^*}{f_L^*} = \frac{r}{w} \qquad (15)$$

In words, the fixed-OPEX-CAPEX-share avoids the CAPEX-bias.

3.3. FOCS to address risk

As explained above, the primary aim of FOCS is to internalise possible CAPEX biases. As a side-effect, FOCS can have the additional advantage of addressing OPEX risk. We see two routes how FOCS can mitigate risk.

First, as argued in Brunekreeft & Rammerstorfer (2021), FOCS can address OPEX-risk. An example from the regulated network industries may illustrate what is meant by OPEX-risk: replacement or maintenance of old assets. As the network ages, reliability decreases and the likelihood of outages increases. The company has two options. First, it can replace the asset, which requires CAPEX. Alternatively, it can maintain the asset and repair it in the event of a breakdown. This requires OPEX. Since the occurrence of an outage is uncertain, the associated costs are uncertain and, under price- or revenue-cap regulation, the regulated company would likely have to absorb the increased OPEX until the next price-control review. Hence there is an OPEX risk.

OPEX-risk can lead to a CAPEX-bias. The strategic incentive for the regulated entity is to reduce overall risk at the expense of higher costs. By inefficiently using high CAPEX (and inefficiently low OPEX), the company reduces risk while maintaining regulated rate-of-return at the same (externally determined) level. As a result, the capped return-on-capital is higher than the

actual cost-of-capital, creating a margin for excess profits. This risk balancing comes at the cost of higher costs (due to inefficient production), which are passed on in regulated revenue. This results in the CAPEX bias. FOCS can effectively address this bias and thus address the OPEX-risk (Brunekreeft & Rammerstorfer, 2021).

Second, FOCS can reduce OPEX-risk, *because* it is partially treated as CAPEX. A good, albeit somewhat specific example is the discussion on the regulatory treatment of redispatch costs of electricity networks in Germany. The cost of redispatch are only partially under the control of the network companies. An important driver is the weather, as availability of wind and sunshine determine feed-in of renewable energy sources and thus determine the required redispatch. The cost of redispatch is highly volatile. If the cost of redispatch were fully subject to the revenue cap with a five-year time lag, the volatility of the associated costs would be a risk for the network company. For these reasons, the costs of redispatch are largely kept out of the incentive regulation and are treated as cost-pass-through. This, however, means that the network companies have no incentive to improve efficiency of redispatch and this may distort the decision between redispatch (OPEX) and network extension (CAPEX) to address network congestion. For those reasons, it has been suggested to include part of the redispatch costs into the revenue cap or to otherwise incentivise redispatch costs. The strength of the incentives, however, is naturally constrained by the risk the network companies can reasonably cover. Thus we face a trade-off between efficiency incentives and risk-taking (cf. more generally Poudineh et al, 2020).

FOCS can ease the trade-off and allow for stronger efficiency incentives, without exposing the regulated company to an unacceptable amount of risk (cf. Meyer, 2021). There are two ways that reduce the OPEX-risk. First, specifically for the current regulatory system in Germany, redispatch would normally be treated as OPEX under the revenue cap with a five-year time-lag. FOCS could (partially) transfer the OPEX of redispatch into quasi-CAPEX, after which these would be treated as CAPEX under the revenue cap, which has no time-lag. Secondly, and more generally, if the volatile annual expenses of redispatch (OPEX) are transferred in CAPEX, they will be depreciated over a longer period and thus expenses will be smoothed over time and

thus volatility and thus risk decreases. In effect, FOCS would allow a higher efficiency incentive for the same level of risk.[2]

4. Implementation issues and UK experience

For the practical implementation of the fixed-OPEX-CAPEX-share, a number of important details need to be determined (cf. Oxera, 2019). These issues are briefly discussed below.

4.1. Issue 1: Scope of application

In principle, FOCS could be applied to all costs incurred by a network operator. Alternatively, the application could be targeted specifically at a project or a certain field of activities. These are referred to as broad and narrow applications, respectively.

The advantage of a broad scope is that it is easy to implement and control. There are no problems of defining and demarcating the fields of application because all costs are treated using FOCS. Moreover, there is no risk of strategically shifting activities and costs into or out of the FOCS part. FOCS has more generally the character of a broad regulatory solution that should avoid regulatory micromanagement. But this does not mean, that FOCS could not be used for more narrow sets of costs too. The main disadvantage of a broad scope is that the FOCS-system would also be applied to areas where there is no obvious CAPEX-bias or where there are no alternative OPEX-substitutes. Some regulators might also find it easier to implement FOCS for specific activities, rather than overhauling the entire regulatory system.

The advantages and disadvantages of the broad and narrow scope are mirror-opposites. The key advantage of a narrow scope is that it is only applied to justified problem areas where there actually is a CAPEX-bias to be addressed. The disadvantage of a narrow scope is that the regulatory authority must define and demarcate the areas of application. More importantly,

[2] While this example is useful for illustrating the possible usefulness of FOCS, at least three further regulatory questions would have to be answered in the case at hand. First, whether simply putting a share of the redispatch-cost-risk on the regulated company would follow the principle of efficient risk-sharing. This principle would require that only risk that is sufficiently controllable by a party is put on said party. Reducing the exposure to redispatch risk through FOCS, would still mean that a large part of the risk that the company is exposed to, is not controllable by the company. Second, this solution would mean that the regulated company has to finance higher redispatch costs through debt and equity, and wait for payback through the system of the regulatory asset base. Third, it would have to be discussed whether FOCS should be combined with the system of capital-cost-pass-through (Kapitalkostenabgleich) in Germany, or whether a broader redesign of the German system might be a better idea. All of those further considerations are beyond the scope of this paper.

firms might have incentives to shift or rebrand activities from FOCS to non-FOCS areas or vice versa; this would create new distortions and need for regulatory control.

Addressing the strategic incentives for cost-shifting is difficult. However, the problem with strategic cost-shifts is actually well-known in regulatory theory and practice, following the rules of network unbundling. Details may be different, but the general idea is the same. Hence, there is a lot of experience with this type of problem. How could incentives or opportunities for strategic cost shifting be avoided?

- Projects should be specified and demarcated as clearly as possible, so that "third-party costs" stand out as such.
- Regulatory control mechanisms would create additional pressure. As a control, a benchmarking process with comparable projects would be possible. In this case, the strategically acting network operator would come under pressure to justify costs.
- A clear cost allocation, if necessary according to predefined rules with, if possible, unique allocation of cost centres, would make strategic cost shifting difficult.

If the scope is narrow and thus limited to a small class of clearly demarcated and identifiable projects, the question arises as to how the projects could be selected. We see two options for this.

Option 1: Qualifying projects are specified in the regulation as general classes

In the German energy network regulation, section 23 ARegV (investment measures) created a general exemption for which qualifying projects were specified.[3] The background to section 23 was that the investment incentives for some projects under the standard incentive regulation regime (the time-lagged revenue cap) were insufficient. In essence, section 23 removes the time lag until the next regulatory period in the case of an exempted investment. A similar approach of specifying qualifying types of projects in regulation could apply to FOCS.

Option 2: The network operator submits an application

An alternative approach would be an open application procedure initiated by the network operator: the network operator would apply to the regulator for a specific project or activity to be treated under FOCS. In this case, two essential criteria could be applied. First, a minimum

[3] To be accurate, we note that the ordinance has been changed recently. Section 23 still exists formally, but is no longer activated, as it has been replaced by another section arranging an annual CAPEX-true-up.

threshold to ensure that transaction costs (i.e. the cost of the application and the cost of the regulator's check) are not prohibitively high. Second, a requirement would be the justification for the alternative procedure by credibly demonstrating that there is a project-specific regulatory bias in the base regulation.

Comparable criteria have been established in another context. Article 13 of the PCI Regulation 2013 (EC, 2013) aims to improve incentives for higher risk projects of common interest (PCIs), including through priority premiums. A priority premium is a risk-equivalent project-specific increase in the allowed return-on-capital. The priority premium should be requested by the project promoter from the relevant regulator. ACER (2014) has developed a 7-step procedure for these applications, with the burden of proof on the project promoter. A similar procedure could be envisaged for a FOCS application.

4.2. Issue 2: Depreciation

Above, we have pointed out the similarity with the cost-plus approach as in Braeutigam (1981). To internalise the CAPEX-bias, the two mechanisms cost-plus approach and FOCS are indeed very similar. There is an important difference, however. The cost-plus approach sets a mark-up on total costs. Thus, similar to CAPEX, OPEX also receives a mark-up. This causes an asymmetry. CAPEX incurs cost-of-capital, whereas OPEX does not. Therefore, the mark-up on total costs should be adjusted to reflect that the cost base is larger than CAPEX alone and should thus be lower than the rate of cost-of-capital. This asymmetry does not emerge under FOCS. FOCS converts OPEX into quasi-CAPEX. The quasi-CAPEX, which go into the regulatory formula, are then actually depreciated over time. Therefore, transferred into quasi-CAPEX, these OPEX do incur capital costs. It is thus necessary that the quasi-CAPEX are actually remunerated by the regulated return on capital. This implies first that FOCS does not provide excessive profits "by paying a rate of return on OPEX", and second, that the regulated rate-of-return on capital does not need to be adjusted.

Depreciating the quasi-CAPEX is an important part of FOCS. In the regulation, the quasi-CAPEX is added to a synthetic regulatory asset base (RAB). Note that the "normal" CAPEX also go into the synthetic RAB. This raises the obvious question of the length of the depreciation period for the synthetic RAB in a FOCS system. This must be determined by the regulatory authority. Should this depreciation period be longer or shorter, relative to the average depreciation

without FOCS? Should the depreciation period be differentiated for the different application areas?

Preliminary analysis suggests that the precise duration of the synthetic depreciation period is not important for the effectiveness of FOCS, as long as normal CAPEX and quasi-CAPEX are part of the same synthetic RAB und thus subject to the same depreciation duration. However, there are other important aspects to consider.

First, there is an impact of the length of the depreciation period on consumers. The depreciation period of the synthetic RAB determines the structure of costs and hence of the revenue cap. As a result, it determines how consumer prices change over time. It may well happen, that FOCS increases discounted economic efficiency over time, but that consumers are worse off if tariffs first increase and then later decrease. It might happen implicitly that "normal" CAPEX with a relatively long depreciation is transferred into quasi-CAPEX with a shorter depreciation period, raising prices in the short run. The effects on consumers should be examined in more detail.

Additionally, if OPEX is transferred into quasi-CAPEX, it must be pre-financed by the capital market. A longer depreciation period requires a longer period of pre-finance, which has financeability implications for network operators. First UK experience suggests that funding OPEX-based quasi-CAPEX is a potential stumbling block as investors are reluctant to fund quasi-CAPEX not backed by fixed assets. The OPEX-based quasi-CAPEX is indeed not backed by fixed assets, but by the commitment of the regulator that the future revenue cap will cover these costs. Thus, this is problem of regulatory commitment.

A longer depreciation period also has implications for risk. As already pointed out above in section 3.3, FOCS can reduce OPEX-risk, if OPEX is transferred into quasi-CAPEX. The risk reduction will likely be stronger if the depreciation period is longer. However, it should be noted that the risk is not going away, but is shifted to consumers. On the other hand, a longer depreciation period increases the risk of stranded assets; to address such risk regulators actually have considered shortening depreciation duration in some European countries.

In terms of practical experience, Ofgem considers that the rate of depreciation should be set so that different generations of consumers pay tariffs that are broadly proportional to the value of network service they receive. In order to achieve this, it sets the depreciation length as well as calculation method (e.g. straight-line or front-loaded). Ofgem also acknowledges

that depreciation length and profiles can be tools to address cash-flow issues and considerations around stranded assets (Oxera, 2021, p. 19).

4.3. Issue 3: Capitalisation rate

In FOCS, the capitalisation rate, which is between 0 and 1, splits TOTEX into quasi-OPEX and quasi-CAPEX. The exact impact of the capitalisation rate on allowances, profits and tariffs therefore depends on the treatment of OPEX and CAPEX in a given regulatory regime. Some questions on the implementation of the capitalisation rate are:

- Should the capitalisation rate be uniform for the entire FOCS area, or should a differentiation according to cost types or business areas be allowed?
- Should the capitalisation rate be constant over time?
- Should the capitalisation rate be set by the regulator or could be it left to the firm as an ex-ante choice?

In practice, setting the capitalisation rate close to the current CAPEX-OPEX share helps to avoid large changes (e.g. variations in tariffs). Under RIIO-1, Ofgem took into account the CAPEX-OPEX shares estimated by companies, as well as historical rates and the level of technological innovation for the purpose of setting capitalisation rates. In some cases, Ofgem accepted companies' proposals to reduce the capitalisation rates, which has no effect on the overall value of the allowed revenue but improves cash flows. For RIIO-2, capitalisation rates are set ex-ante, based on forecast CAPEX proportions. Different capitalisation rates are used for different types of regulatory expenditure categories (e.g. base revenue vs. re-openers and volume drivers). The decision to set different rates for different expenditure categories was adopted as a compromise between the companies' preference to set ex-ante rates and the need to consider future decisions for re-openers and volume drivers (Oxera, 2021, section 3.2). In the water sector in England and Wales, Ofwat determined the capitalisation rate by considering the OPEX part of allowed TOTEX following its efficiency assessment (Ofwat, 2019).

4.4. UK experience

Notable examples of TOTEX regulation are the schemes introduced by Ofgem in Great Britain, and by Ofwat in England and Wales for the energy and water sector, respectively. Other regulators are considering the adoption of TOTEX-based regulation, for instance Arera (Italy,

Oxera, 2021), AEMC (Australia, Australian Energy Market Commission, 2019)[4] and ERSE (Portugal, ERSE, 2021).

In terms of addressing a potential CAPEX- bias, Ofgem states that "[u]nder the totex approach, when companies spend money on a solution, the same percentage is capitalised irrespective of whether that solution involves opex or capex. This means that the companies are more likely to use the overall cost-effective solution. For example, the totex approach might encourage the companies to use maintenance to avoid replacing an asset, or use demand-side management to avoid installing new capacity" (Ofgem, 2017, p. 14). Ofwat undertook more detailed analysis on the impact of the TOTEX approach. It found that a TOTEX approach has contributed to providing technology-neutral incentives. In its PR14 review, the regulator states that TOTEX regulation "helped increase value for money, as it reduced incentives to opt for less efficient capex-based solutions. There are some good examples of how this changed behaviour during the period. And, overall, the OPEX share increased compared to historic levels, reaching 52% compared to 40%-43% in the previous three reviews, suggesting the capex bias did reduce." (Ofwat, 2021, pp. 5-6). The review also noted that according to some stakeholders, the TOTEX regime led to more openness towards collaboration and partnership-oriented ways of funding. This is because contract payments, which are often classified as OPEX, would be treated the same as in-house CAPEX from a regulatory perspective (Ofwat 2021, pp. 48-49). Both regulators continue to follow a TOTEX-based regime.

5. Concluding remarks

Driven by decarbonisation and digitalisation in recent years, the OPEX-CAPEX-incentive-bias (short: CAPEX-bias) received renewed attention in regulation practice. A CAPEX- bias occurs when the OPEX solution is the more efficient approach, but regulation sets distorted incentives to choose the CAPEX solution, or vice versa. In regulation theory the issue was first set out in the seminal work by Averch and Johnson (1962), who worked on this in the context of rate-of-return regulation. After receiving a lot of attention in the 1980s, the topic lost popularity in 1990s, possibly caused by the emergence of symmetric incentive regulation (RPI-X, price caps, and revenue caps). With the rapid development of digitalisation and the emergence of 'smart' solutions to network congestion, the topic is back on the regulatory

[4] In the end, the AEMC decided not to proceed to a regulatory reform for the time being due to other reform priorities.

agenda. It is important to note that the existence of a CAPEX-bias is not self-evident, but is usually caused by asymmetric regulatory design.

For energy networks (especially electricity), a CAPEX-bias can hinder the efficient development of smart grids. These types of smart solutions tend to rely on OPEX, whereas the alternative would be to expand the network, which is CAPEX-heavy. Thus it is important to design symmetrical regulation that leads to technological neutrality.

In this paper we study a particularly promising approach to address the CAPEX-bias: the fixed-OPEX-CAPEX-share (FOCS). The system has been implemented in the UK for the regulation of water and energy networks (cf. Ofwat, 2011; Oxera, 2014; Ofgem, 2017, pp. 14/15; Smith et al, 2019). The term fixed-OPEX-CAPEX-share was first coined in Oxera (2019). The idea is simple. With FOCS, all expenses, whether for capital expenditure (CAPEX) or operational measures (OPEX), are treated as TOTEX. A fixed portion, the capitalisation rate of this TOTEX, is then "capitalised" (quasi-CAPEX) and the remaining portion is treated as quasi-OPEX ("pay-as-you-go"). The resulting quasi-CAPEX and quasi-OPEX are treated in exactly the same way as CAPEX and OPEX in the normal regulatory system. The quasi-CAPEX are added to the regulatory asset base (RAB) and generate depreciation and return on capital. Quasi-OPEX are recovered within the accounting year. As the capitalisation rate is fixed, only the total expenditure and not the 'true' proportion of OPEX and CAPEX are relevant to determine allowances. Therefore the firm is indeed indifferent between CAPEX and OPEX, so the CAPEX-bias disappears.

At first glance, the mechanism may seem counterintuitive: it seems as if OPEX receives a rate-of-return on capital, which may feel unreasonable. This is a misunderstanding. It is correct that OPEX, which is transferred into quasi-CAPEX, receives a rate-of-return, but as it is quasi-CAPEX it also incurs cost-of capital, because it has to be pre-financed. Therefore, FOCS is not an "OPEX mark-up".

Although the idea is actually quite straightforward, a couple of implementation issues are to be addressed carefully. In this paper, we discussed three implementation issues:

- Scope of application. The scope of application of FOCS can be broad or narrow. Broad means that the application of FOCS would comprise many or even all activities under the same umbrella. Narrow means that FOCS would be targeted to one project or one closely demarcated activity.

- Depreciation. Depreciating the quasi-CAPEX is an important part of FOCS. Under FOCS, the quasi-CAPEX is added to a synthetic RAB. This raises the question of the length of the depreciation period for the synthetic RAB resulting from FOCS. The depreciation length and profile determines relative tariffs for different generations of consumers and affects the financeability of companies.
- Capitalisation rate. The capitalisation rate is the share of TOTEX that is turned into quasi-CAPEX. The capitalisation rate determines the effectiveness of the system and the development of the network charges and thus firm's revenues and consumer payments. Its impact depends on the treatment of OPEX and CAPEX in a specific regulatory system. A practical approach is to set this rate in line with the actual share of CAPEX incurred by companies.

Lastly, we discussed first experiences of a TOTEX regime in the UK. The experience in the UK is promising and both, the electricity and water regulators, continue to use a TOTEX approach in the latest price control periods (which is not the case for many of the other regulatory innovations that were introduced at the same time as TOTEX regulation). Ofwat's review of the first regulatory period in which it introduced a TOTEX approach states that the regime reduced incentives to use less efficient CAPEX-based solutions. The practical experience therefore suggests that a TOTEX (or FOCS) approach helps to reduce a CAPEX-bias and enhances value for money for consumers. In terms of practical considerations, the methodologies used by Ofgem and Ofwat to set parameters such as the capitalisation rate and depreciation length/profile serve as useful regulatory precedent for future implementation in other jurisdictions.

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