Cost disease in defense and public administration: Baumol and politics

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Abstract William Baumol's model predicts a steady increase in relative public sector prices (or costs) because of the combination of slow productivity growth and wage growth similar to sectors wherein productivity is growing more quickly. In this paper, we extend the Baumol model with political variables and analyze price growth in defense and public administration using Norwegian data. We find strong support for the mechanism of the Baumol model since manufacturing productivity is the most important determinant of relative public-sector prices. Greater political fragmentation has also contributed to the price growth, but its quantitative effect is smaller than that of manufacturing productivity. An analysis of a labor-intensive private service (restaurants and cafes) supports the broader relevance of the Baumol mechanism and the validity of the estimated effect of political fragmentation on the two sectors considered herein.

Keywords Baumol mechanism · Public sector prices · Political fragmentation · Error correction model

JEL Classification H11 · H40 · H56

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1 Introduction

The rising costs of providing public services has received much attention since the seminal contribution of Baumol and Bowen (1966). Using the performing arts as an example, they argued that the scope for productivity growth in labor-intensive services is limited. Services provided by the public sector, like education and health-care, are labor-intensive and the scope for productivity growth is certainly less than in some sectors of the private economy, such as manufacturing.[1] Over time, private sector wages tend to increase in line with productivity growth in that sector. Moreover, in order to attract workers, the public sector cannot experience a wage growth substantially slower than in the private sector. The combination of slower productivity growth and wage growth rates similar to the private sector means that the relative price of public services tends to increase over time. That observation often is labelled "Baumol's cost disease".

In a recent paper on reform of public services by Sørensen (2015), the cost disease is considered to represent a fundamental threat to the welfare state. The main point is that unbalanced productivity growth has disagreeable implications. If public spending is to be held constant as share of GDP, the growth of public services will be substantially slower than the (real) growth in private consumption. Balanced growth in public services and private consumption would, on the other hand, mean a steadily increasing tax level. Since limits on the growth of tax levels exist, the cost disease implies that the growth of public services in the long run will be slower than the growth of private consumption.[2]

The cost disease is a common explanation for public sector growth (see Gemmel 1993 for a collection of theoretical approaches and experiences from several sectors and countries). That literature often, explicitly or implicitly, assumes that the cost disease is driven by an exogenous productivity gap between the private and the public sectors. Such an assumption differs sharply from studies of public-sector efficiency. The approach typically taken in the efficiency studies is first to calculate variations in efficiency across governmental units using frontier techniques, and, then, to ask whether economic and political factors can account for the observed variation in public-sector efficiency. Existing examples include De Borger et al. (1994), Balaguer-Coll et al. (2007), Borge et al. (2008) and Geys et al. (2010). In that literature, measured public-sector productivity is not considered to be exogenous, but rather an outcome of a political process.

The main contribution of this paper is to bridge the analyses of Baumol's cost disease and the efficiency variation across governmental units. We start out in Section 2 by presenting an extended Baumol model wherein public-sector productivity is affected by political variables. As in the original formulation, we distinguish between progressive and non-progressive sectors, which in the empirical analysis is operationalized as, respectively, the manufacturing sector and the public sector (defense and public administration). After documenting the existence of a cost disease in Section 3 and discussing our econometric model and data in Section 4, the estimation results for defense and public administration are presented in Section 5. The estimation results yield strong support for the mechanism of the Baumol model because manufacturing productivity is found to be the most important determinant of relative public-sector prices. In addition, our results suggest that greater

[1] Many private service industries may also have limited scope for productivity growth. See the analysis of restaurant and cafes in Section 6.
[2] The view that the cost disease is a threat to the welfare state is challenged in theoretical contributions by Andersen (2016) and Andersen and Kreiner (2017).

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political fragmentation has contributed to relative price growth in the public sector. In Section 6, we analyze a labor-intensive private service (restaurants and cafes). That analysis confirms the broader relevance of the Baumol mechanism and the validity of the estimated effect of political fragmentation on cost increases in defense and public administration. Finally, Section 7 offers some concluding remarks.

2 An extended Baumol model

Baumol's (1967) original contribution distinguishes between "progressive" and "non-progressive" sectors. Progressive sectors are characterized by steady increases in productivity owing to capital accumulation, innovation and economies of scale. In the non-progressive sector, productivity increases only sporadically. Manufacturing is an example of a progressive sector, while the performing arts, teaching and health-care are examples of non-progressive sectors.

In order to capture the main ideas, we follow Baumol (1967) and formulate production functions with labor as the only (variable) input:

$$Y_{Pt} = A_t L_{Pt} \tag{1}$$

$$Y_{Nt} = B_t L_{Nt} \tag{2}$$

In equations (1) and (2), Y_{Pt} and Y_{Nt} are outputs in the progressive and non-progressive sectors at time *t*, L_{Pt} and L_{Nt} are labor inputs at time *t*, and A_t and B_t are (constant) productivity parameters at time *t*. The assumption of steady productivity growth in the progressive sector and slower productivity growth in the non-progressive sector implies that the ratio A_t / B_t rises over time.[3]

Wages in the progressive sector (W_{Pt}) are assumed to follow productivity, i.e.

$$W_{Pt} = A_t W_{P0}, \tag{3}$$

where W_{P0} is a constant. In order to attract workers, wages in the non-productive sector (W_{Nt}) must (over time) grow at the same rate as wages in the progressive sector. That assumption can be operationalized as:[4]

$$W_{Nt} = W_{Pt} \tag{4}$$

It follows from equations (1)-(4) that unit labor costs in the two sectors are given by:

$$C_{Pt} = \frac{W_{Pt} L_{Pt}}{Y_{Pt}} = \frac{A_t W_{P0} L_{Pt}}{A_t L_{Pt}} = W_{P0} \tag{5}$$

[3] Our formulation of the production function is a bit more general than the formulation used by Baumol (1967) because we also allow for productivity growth in the non-progressive sector. A similar formulation is used by Colombier (2012).

[4] Equation (4) implies that the wage level is the same in the two sectors. None of the following results would be affected if we instead made the weaker assumption of proportionality.

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$$C_{Nt} = \frac{W_{Nt} L_{Nt}}{Y_{Nt}} = \frac{A_t W_{P0} L_{Nt}}{B_t L_{Nt}} = \frac{A_t}{B_t} W_{P0} \tag{6}$$

A key implication of the Baumol model is that the cost per unit of output in the progressive sector will remain constant, while the cost per unit of output in the non-progressive sector will increase over time. The source of the growth of unit costs in the non-progressive sector is that wages increase in tandem with productivity in the progressive sector, while productivity growth is less than in the progressive sector. An important implication is that the increase in the unit cost in the non-progressive sector will be faster the higher is the productivity growth in the progressive sector.

Different empirical approaches are used to test the Baumol model and its implications. One line of research is to investigate whether rising relative prices (or costs) can explain the observed growth in expenditures on non-progressive goods and services relative to GDP. A usual indicator of relative prices is the ratio of a deflator (price index) for the non-progressive service under consideration and the GDP deflator. Several studies of the public sector tend to find that rising relative prices contributes to more public spending as share of GDP: among these are Borcherding (1985), analyzing general public spending in the United States, and Getzner (2002), analyzing public cultural expenditures in Austria. The larger share of public spending in GDP is driven by rising relative prices in combination with demands for public services that are price-inelastic. The latter is an important test of a key implication of the Baumol model, which also had been emphasized by Baumol (1993). The demand for public services generally is found to be price-inelastic (see, e.g., Oates 1996), which means that the Baumol effect may contribute to greater public spending. However, in a study of Norway during the 1880-1990 period (Borge and Rattsø 2002), that is not the case. Although evidence of a cost disease exists in the sense that the price of public services has grown over time relative to the private sector, the demand response to the former has been sufficiently strong to neutralize the effect on public spending.

Another approach is to link the growth of non-progressive spending to the underlying mechanisms of the Baumol model. Hartwig (2008) points out that, in the Baumol model, rising relative prices for non-progressive services are related to economy-wide wage growth in excess of productivity growth. He proposes to test the Baumol model by using the differences between wage growth and productivity growth as explanatory variable in place of the relative prices of non-progressive services. He documents empirically that health-care expenditures in OECD countries grow more rapidly in periods when the difference between economy-wide wage growth and productivity growth is large. Similar results are found by Colombier (2012) and Bates and Santerre (2013).

Rising labor costs of non-progressive services may also affect the ways in which the services are produced, as one can expect a shift towards less labor-intensive production methods in response. Baumol and Baumol (1985) discuss the case of performing arts and argue that one strategy may be to "debase the product" by cutting rehearsals, performing in larger capacity playhouses or using simpler stage sets. Werck and Heyndels (2007) and Werck et al. (2008) provide empirical evidence for product debasing in analyses of Flemish theatres.

In this paper, we follow the early contribution by Berry and Lowery (1984) and analyze relative prices rather than expenditures. We think that this approach has two major advantages. First, we are able to identify more directly the relevance of the mechanisms driving rising relative prices in the Baumol model. In particular, we will investigate whether rising relative prices of non-progressive services can

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be explained by productivity growth in the progressive sector. Second, as in the literature on efficiency in the public sector, we can include political factors that may affect productivity in the public sector.

The empirical model is derived by, first, taking the log of relative unit labor costs in equations (5) and (6) and then hypothesizing that productivity in the public sector is determined by a set of political variables ($B_t = f(POL_t)$):

$$\log P_{Nt} = \log(\frac{C_{Nt}}{C_{Pt}}) = \log A_t - \log B_t = \log A_t - \log f(POL_t) \tag{7}$$

In equation (7), P_{Nt} is the relative price (or cost) of the non-progressive sector relative to the progressive sector. The two predictions from (7) are that (i) rising productivity in the progressive sector increases the relative price of the non-progressive sector and (ii) a change in one of the elements in POL_t which increases productivity in the public sector, will have the opposite effect. The productivity variable is a test of the Baumol mechanism (spillover of private sector wages to the public sector), while the political variables account for factors that may have a direct effect on the public sector's productivity.

Public sector inefficiency usually is modelled as a principal-agent problem (see the original contributions by Niskanen 1971 and Migué and Bélanger 1974). In that setting, service production is delegated to an agency (bureau) that is better informed about costs than the politicians (sponsor) who oversee the agency. Moreover, a conflict of interest exists because the agency has preferences for budgetary slack. Budgetary slack encompasses a variety of non-productive activities and is conceptually the same as low productivity. Later theoretical contributions have investigated how politicians can increase productivity in the public sector by playing a more active role in the budgetary process, either by imposing a hard budget constraint (Chan and Mestelman 1988) or by adopting incentive schemes (Dixit 2002). We hypothesize that a strong political leadership is likely to increase productivity for two reasons. First, to build a reputation for hard budget constraints it is necessary to accept periods with low service production. Strong political leaders may find it easier to resist pressures to increase spending in response. Second, as incentive schemes and other public sector reforms tend to be unpopular among government employees, strong political leaders may be necessary to implement productivity enhancing reforms.

The choice and definitions of variables capturing the Baumol mechanism and the strength of the political leadership are discussed further in Section 4, along with other variables that may affect the relative price of public services. We first determine whether the data are supportive of a cost disease in the sense that the relative prices of defense and public administration are increasing over time.

3 Time series properties of relative prices: Is there evidence of a cost disease in the data?

Norwegian national accounts provide information on the evolution of prices for each sector we consider. In order to investigate the cost disease, we study price indices for defense and public administration relative to the price index for the private sector. Here, the private sector is defined as mainland-Norway exclusive of the public sector (defense and public administration) and includes both manufacturing and services. Mainland-Norway excludes petroleum extraction and ocean shipping. By

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excluding petroleum extraction, the price index for the private sector is not directly affected by oil price changes and the test of the cost disease will be cleaner. Public administration includes all non-defense services provided by Norway's central and local government.

Public-sector production is measured on the input side as the sum of compensation of employees, consumption of fixed capital (depreciation) and intermediate inputs. Production in current prices is then split into price and volume components. The price component, which is of interest in this study, is constructed from information on wages and market prices of fixed capital and intermediate inputs. The price indices for fixed capital and intermediate inputs are industry independent and common for defense and public administration. However, because input compositions vary, the impact of changes in the price indices will differ for defense and public administration. Price data for defense were based previously on annual cost surveys reported by the Ministry of Defence. The survey information was broken down into approximately 200 national account products for intermediate consumption and 60 products for fixed capital formation (Fløttum 1996). Currently, such detailed reporting no longer is available (Statistics Norway 2012). Instead, input composition is calibrated against changes in the rest of the national accounts. For public administration, Statistics Norway uses a variety of methods to estimate price growth.

The separation between defense and public administration is of interest because the defense sector differs from the rest of the public sector in important respects. First, defense is less labor-intensive than public administration, and in consequence, evidence of the cost disease should be weaker in defense. Second, non-labor inputs also differ. In the defense sector, such inputs are technologically advanced, the scale of production is relatively small, and state-of-the-art equipment is required even if it represents only a marginal improvement over the previous generation (Kirkpatrick 1995; Hove and Lillekvelland 2016). Those considerations imply that the cost disease should be stronger in defense than in public administration.

Figure 1 about here

Fig. 1 illustrates the development of price indices for defense, public administration and the private sector over the 1970-2012 period. The evolution of prices is consistent with a cost disease since the price growth is substantially higher in the two public sectors considered than in the private sector. The average annual growth rates in public administration and defense are 5.9 % and 5.6 %, respectively, compared to 4.6 % for the private sector price deflator. The differences in price growth were relatively small until the late 1980s. Moreover, the variations in price growth across sectors are positively correlated with labor-intensity measured by the wage share. In 2010, the wage shares for the three sectors were 62 % (public administration), 40 % (defense) and 29 % (private sector).

The cost disease is also evident from Fig. 2, which shows the development of relative prices. The figure confirms the pattern of higher price growth in defense and public administration than in the private sector, and with a growing difference from the late 1980s. The reduction in the relative prices between defense and public administration indicates that the cost disease is less severe in defense than in public administration.

Figure 2 about here

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A formal test of whether a cost disease can be found in the data is conducted by investigating the time series properties of the relative prices. A cost disease is consistent with relative prices being non-stationary. The time series properties are tested by DF tests (Dickey and Fuller 1979; Elliott et al. 1996) and KPSS tests (Kwiatkowski et al. 1992). The two tests complement each other. While the DF-test tests the null hypothesis of non-stationarity against the alternative of stationarity, the KPSS-test tests the null hypothesis of stationarity against the alternative of non-stationarity.

The DF and KPSS tests are performed on the logs of relative prices and for both levels and first differences (growth rates). Appropriate lag lengths for DF tests are guided by the Schwarz criterion (Schwarz 1978), the Ng-Perron sequential t (Ng and Perron 1995) and by the Ng-Perron modified Akaike information criterion (MAIC) developed by Ng and Perron (2001). We decided to use one lag for the DF tests because at least one of the criteria always suggested using one lag. For the KPSS test, the maximum number of lags was determined by the rule provided by Schwert (1989). This criterion suggested three lags in all cases.[5]

The two upper rows in Table 1 report DF and KPSS tests for the relative prices of the two public sectors (public administration and defense) and the private sector. A first observation is that the results are the same for both public administration and defense. Applying the DF test, we cannot reject the null hypothesis that the two relative prices are non-stationary, while the hypothesis of non-stationarity is clearly rejected for the first differences. The conclusion from the DF test is thus that the growth rates (first differences) of relative prices are I(0) and that the levels are non-stationary I(1). The KPSS test yields the same conclusion. The null hypothesis of stationarity clearly is rejected for the levels of relative prices, but cannot be rejected for the first differences. Taken together, the DF and KPSS tests provide strong evidence of a cost disease in the data, i.e., prices in public administration and defense grow faster than prices in the private sector.

Table 1 about here

Figs. 1 and 2 indicate that the cost disease is stronger in public administration than in defense. Whether the difference is statistically significant can be investigated by performing DF and KPSS-tests on the relative prices of the two public sectors. These results are reported in the bottom row of Table 1. According to the DF test, the null hypothesis of non-stationarity cannot be rejected for the levels of the relative prices, but at the 10 % level the same hypothesis can be rejected for the first difference. The KPSS test points in the same direction. Stationarity can be rejected for the relative price levels, but not for the first differences. As a result, both tests provide evidence that the cost disease is more severe in public administration than in defense. The interpretation of this finding is that the effect of defense being less labor intensive dominates the effect of faster price growth for non-labor inputs.

4 The error correction model and potential drivers of the cost disease

The previous section documented the existence of a cost disease in both defense and public administration. In this section, we formulate an error correction model that facilitates an analysis of

[5] We do not allow for a time trend in any of the tests since that would make the interpretation of the test less clear. Trend-stationarity would, for instance, be consistent with a cost disease if the time trend is found to be a significant explanatory variable.

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the determinants of the cost disease. We focus on the Baumol mechanism captured by productivity in the progressive sector and political variables that may have direct effects on productivity in the public sectors.

The prices of defense and public administration (both relative to the private sector), which will serve as dependent variables, were found to be non-stationary or I(1). Given that a dependent variable and the possible explanatory variables are I(1) and are cointegrated, the dynamics can be represented by an error correction model that allows for separating short- and long-run effects.

The point of departure is the following model

$$\log P_{Nt} = \alpha + \beta \log A_t + \lambda POL_t + \phi Z_t + u_t , \tag{8}$$

which is a linearization of equation (7). In addition to productivity in the progressive sector (A_t) and political variables (POL_t), we enter a vector of controls (Z_t). When the variables in (8) are I(1) and cointegrated, implying that the error term u_t is stationary I(0), Engle and Granger (1987) showed that the dynamics can be represented by the following error correction model:

$$\begin{aligned} \Delta \log P_{Nt} &= \beta_0 \Delta \log A_t + \lambda_0 \Delta POL_t + \phi_0 \Delta Z_t - \gamma [\log P_{Nt-1} - \alpha - \beta \log A_{t-1} - \lambda POL_{t-1} - \phi Z_{t-1}] + \varepsilon_t \\ &= -\alpha\gamma + \beta_0 \Delta \log A_t + \lambda_0 \Delta POL_t + \phi_0 \Delta Z_t - \gamma [\log P_{Nt-1} - \beta \log A_{t-1} - \lambda POL_{t-1} - \phi Z_{t-1}] + \varepsilon_t \end{aligned} \tag{9}$$

In the econometric analysis P_{Nt} is either the relative price of defense ($N = D$) or the relative price of public administration ($N = S$).

Productivity in the progressive sector captures the Baumol mechanism. It is measured by productivity in the manufacturing sector, more precisely production per man-hour from the national accounts. During the period under study, productivity in the manufacturing sector has increased steadily. The average annual growth rate is 3.4 % and the variable clearly is I(1). The solution of the theoretical model, equation (7), implies that $\beta = 1$. The conclusion follows from the assumption that labor is the only input and that the relative price in equation (7) is relative unit labor costs. In the econometric analysis, the price indices are more comprehensive and capture intermediate inputs and fixed capital (see Section 3). Moreover, the private sector price index (used to calculate the relative prices) includes services in addition to manufacturing goods. We thus expect $\beta < 1$.

We expect that strong political leadership is likely to increase productivity in the public sector. Earlier studies, among them Kalseth and Rattsø (1998) and Borge and Rattsø (1997, 2002), have found that strong political leadership restrains public spending in Norway. However, studies of wages and efficiency are of particular relevance for our analysis. First, in a study of public sector wage formation, Johansen and Strøm (2001) found that wage growth in the local public sector was negatively related to the strength of the central government, but they found no impact on central government wages. Second, Borge et al. (2008) analyze so-called global efficiency at the local government level. They find strong support for the hypothesis that strong political leadership contributes to high productive efficiency.

In the econometric analysis, we use a Herfindahl-Hirschman index (*HHI*) of the party composition of the parliament as indicator of political strength. The index is calculated as

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$$HHI = \sum_{i=1}^{N} SH_i^2 \ , \tag{10}$$

where *N* is the number of parties in the parliament and SH_i is the share of seats held by party *i*. The index is inversely related to party fragmentation and takes the maximum value of 1 when all seats are held by a single party. Its minimum value (1/*N*) is attained when all seats are divided equally among the *N* parties. The degree of fragmentation is greater the larger is the number of parties and the more equally divided the seats are among the parties. The degree of party fragmentation has risen during the period under study, indicating that parliamentary political leadership has become weaker. The Herfindahl-Hirschman index was reduced from 0.31 in 1970 to 0.25 in 2012. After the 2001 election, fragmentation was at its highest with an Herfindahl-Hirschman index as low as 0.19.

As a second political variable, we include ideology. Political ideology may affect public sector price growth through wage growth. A general expectation is that conservative parties are less tolerant of growth in public sector wages. Strøm (1995), who finds that a larger share of socialists in the local government council increases the wages for low-skilled local public employees, provides empirical support for that expectation. Another argument for including ideological orientation is the strong correlation between the measure of political strength and ideology. The strong correlation reflects that the Labour Party is the dominant party on the left, while the parties on the right are more fragmented. If ideology is important for public sector prices, the estimated effect of political strength will be biased if ideology is left out. We capture ideology by the share of representatives in the parliament from the Labour Party and parties to its left *(Left*).[6]

The Cold War came to an end during the period under study and the organization of the Norwegian defense has undergone important changes. One important change is conscription. Formally, Norwegian men faced conscription for the entire period we study, but in practice the share of men serving in the military forces declined gradually from the late 1980s. The conscripts are paid only a small amount of money each day. Lesser reliance on conscripts is therefore likely to increase unit wage costs and the price of defense. We include the share of conscripts (*Conscript*) of total employment in total defense employment to test this. Other changes materialized from the end of the cold war to the present, with the largest rearrangement of the sector taking place in the 2002–2005 period (Ministry of Defence 2001). Those reconfiguration of the defense sector were a delayed response to changes in the security climate following the end of the Cold War. Although the mechanisms are entirely clear, those changes likely affected the price of defense. A problem is that the changes took place gradually over a long period of time and it is not obvious what we should use as a structural break in our time series. Moreover, it is not clear whether a potential break would affect the growth rate directly (level effect) or change the marginal effects of other regressors (interaction effect). Our solution is to test for unknown structural breaks in the time series, which should detect both forms of impact on the price series caused by the defense sector's structural changes.

In addition to productivity, political variables and the share of conscripts, we include a set of controls to capture the business cycle, the price of oil and the exchange rate. The business cycle is captured by the annual percentage growth in GDP per capita (*GDP-growth*). The price of crude oil is measured in US dollars (*Oil*) and the exchange rate as the price of US dollars in Norwegian kroner (*USD*). It is not

[6] The coefficient of correlation between *HHI* and *Left* is 0.61.

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obvious how these controls will affect the dependent variables since they may affect public sector prices and private sector prices in the same direction. A booming economy will increase wage growth in both the public and private sectors, depreciation of the currency will increase the price of imported goods, affecting both public and private sector prices, and a higher oil price will increase costs in both the public and private sectors. The price of crude oil also controls for the large and growing influence of the petroleum sector on the Norwegian economy in the period under study.

Tests for the time series properties of the explanatory variables discussed above indicate that all except *USD* and *GDP-growth* are I(1).[7] The test is less conclusive for the share of conscripts. We rely on the cointegration tests (discussed in Section 5) to detect whether its time series properties differ from the other variables.

5 Empirical results

This section presents the estimation results for the model discussed in Section 4. We use the VAR approach suggested by Johansen (1988) to investigate the cointegration properties of the model. The explanatory variables described above are treated as exogenous. Moreover, the lag length is restricted to one, meaning that we have a conditional VAR model. In the search for a more parsimonious model, we started out by testing for cointegration. Based on those results, we eliminated the variables that were statistically insignificant (at the 10 % level) in this first step, and the dynamic model (9) was estimated conditional on the cointegration relation found in the first step. Variables with no statistically significant long-run impacts also were included in the dynamic model to allow for short-run effects. Similarly, variables found to be I(0) were also included in first-differenced form in the second step. As a formal test for cointegration we use the error correction test presented by Ericsson and MacKinnon (2002). They show that with a balanced model and a statistically significant error correction term the model is cointegrated. Below it is shown that these criteria are fulfilled for all models.

5.1 Defense

The results of the Johansen procedure are presented below. The long-run model is

$$\log P_{Dt} = 0.183(0.029)\log A_t - 0.592(0.200)HHI_t - 0.387(0.118)Conscript_t \ , \qquad (11)$$

where the standard errors are in parentheses.

The resulting dynamic model is:

$$\Delta \log P_{Dt} = -0.189(0.030) + 0.006(0.002)USD_t + 0.221(0.074)\Delta HHI_t - 0.307(0.029)CI_{Dt-1} \qquad (12)$$

The cointegrating error correction term (CI_{Dt-1}) is:

[7] The test results are reported in Table A3 in the Appendix.

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$$CI_{Dt-1} = \log P_{Dt-1} - 0.183\log A_{t-1} + 0.592HHI_{t-1} + 0.387Conscript_{t-1} \tag{13}$$

The diagnostics are as follows:

$$R^2 = 0.57, \quad AR1-2: F(2,35) = 0.018, \quad ARCH1-1: F(1,49) = 2.312, \quad Reset\,F(2,35) = 0.111$$

The diagnostics indicate that the model is well behaved. The AR 1-2 test is a standard test of autocorrelation up to degree 2, where the null hypothesis is that autocorrelation is absent. The test reveals that there is no sign of autocorrelation in the residuals. Furthermore, we report the ARCH for autoregressive conditional heteroscedasticity. The null hypothesis is that the variance of the error term is constant over time, and, again, the test result does not indicate problems of misspecification. The last reported diagnostics show the results of the reset test, which normally is interpreted as a general misspecification test (see, e.g., Bårdsen and Nymoen 2011). The test statistic clearly is not statistically significant and supports the conclusion of a well-specified model. Moreover, the coefficient of the error correction term has a t-value of 10.59 with a corresponding p-value approximately equal to zero, which shows that the variables in the long-run model are cointegrated.

It follows from the long-run model that the observed growth in the relative price of defense is driven by rising productivity in the manufacturing sector, party fragmentation and the share of conscripts. Neither ideology, oil price nor the exchange rate have any long-run impact on relative price growth. The positive and significant coefficient for manufacturing productivity yields strong support to the mechanisms of the Baumol model. The negative and significant effect of the Herfindahl-Hirschman index supports the hypothesis that a strong political leadership is able to limit the growth of the relative price of defense. That result also is consistent with studies analyzing efficiency variations across government units. Finally, and as expected, a large share of conscripts reduces the relative price of defense, in budgetary terms if not in terms of opportunity cost.

Most of the growth of the relative price of defense during the period under study can be explained by the Baumol mechanism. Based on the long-run model, nearly 70 % of the price growth is explained by productivity growth in manufacturing. Greater party fragmentation explains 11 % and a smaller share of conscripts explains 5 % of the growth.

The dynamic model in (13) presents the determinants of the short-run effects on the price growth. It follows that currency depreciation increases price growth, while a more fragmented parliament has the opposite effect. The effect of the exchange rate means that the price of defense goods fluctuates more with the US exchange rate than do private sector prices, probably because of the higher costs of defense materials. It is a bit surprising that the short-run effect of party fragmentation is opposite to the long-run effect. That result may be explained by the possibility that a more expansionary fiscal policy following greater party fragmentation has a short-run effect on prices and wages in the private sector, while it takes some time before the prices in the defense sector start to rise.

Table 2 about here

To investigate whether structural breaks exist in the time series, for instance because of the reconfiguration of the defense sector (e.g., reduced conscription and the end of the Cold War), we have tested for parameter stability. The test procedure involves sequential application of breakpoint

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tests as described by Bai (1997). The point of departure is a test of parameter stability based on the full sample with unknown breaks. If the null of parameter stability is rejected, the break date is determined and new stability tests are performed on the subsamples. This procedure goes on until stability is not rejected for any subsample or the maximum number of (pre-specified) breaks is reached. The main advantage of this procedure over a standard Chow-test is that we do not need to specify the dates for regime changes a priori.

We have tested for joint stability of all determinants and separate tests for stability of the constant term and the error correction term. To avoid estimates being based on very few observations, the test is set up with a minimum segment length of 9 observations. The critical values (at the 5 % level) are calculated by Bai and Perron (2003). Table 2 reports the results, and it follows that the null hypothesis of stable parameters cannot be rejected either for joint parameter stability or for any subgroup of parameters.

5.2 Public administration

Below we report the results for the model with the relative price of public administration as the dependent variable. The search for the final model included the same explanatory variables as the analyses of the relative price of defense.

The estimated long-run and dynamic models are presented in (14) and (15) respectively:

$$\log P_{St} = 0.257(0.028)\log A_t - 0.427(0.221)HHI_t - 0.712(0.121)Conscript_t \tag{14}$$

$$\Delta\log P_{St} = -0.176(0.039) - 0.218(0.095)Left_t - 0.033(0.006)\Delta Oil_t - 0.246(0.050)CI_{St-1} \tag{15}$$

Here, the error correction term (CI_{St-1}) is:

$$CI_{St-1} = \log P_{St-1} - 0.257\log A_{t-1} + 0.427HHI_{t-1} + 0.712Conscript_{t-1} \tag{16}$$

The diagnostics are as follows:

$$R^2 = 0.61, \quad AR1-2: F(2,35) = 0.855, \quad ARCH1-1: F(1,40) = 0.059, \quad Reset\,F(2,35) = 0.333$$

The diagnostics indicate a well-behaved model. In addition, the error correction term has a t-value of 4.92 and a corresponding p-value approximately equal to zero, showing that the variables in the long-run model are cointegrated.

Manufacturing sector productivity, party fragmentation and the share of conscripts in the Norwegian armed forces drive the long-run growth in the relative price of public administration. Ideology, the oil price and exchange rate have no significant long-term impact. As for defense, a positive and significant elasticity for manufacturing productivity supports the mechanisms of the Baumol model. Although the estimated elasticity is larger for public administration than for defense, the difference is not statistically significant in terms of non-overlapping confidence intervals. The negative and significant coefficient for the Herfindahl-Hirschman index supports the hypothesis that weak political leadership

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is detrimental to productivity growth in the public sector. This finding also is consistent with other analyses of government efficiency.

It is a bit surprising that the share of conscripts reveals a significant long-term effect on public administration. As for defense, the estimate indicates that a smaller share of conscripts increases the sector's relative price. A possible interpretation is that the reduction in the share of conscripts since the late 1980s also captures the end of the Cold War and budgetary cutbacks for defense. Budgetary cutbacks for defense may supply budgetary room for larger expenditures in other public sectors that may, in turn, lead to lower productivity.

As in the case of defense, most of the growth of the relative price of public administration during the period under study can be explained by the Baumol mechanism. According to the long-run model, 70 % of the relative price growth is explained by productivity growth in manufacturing. Greater party fragmentation explains 6 % and a smaller share of conscripts 7 %.

In the dynamic model (15), ideology and the price of crude oil show a short-term effect on the relative price of public administration. An increase in the price of crude oil reduces public administration's relative price growth. Our interpretation of this result is that wages and prices in the private sector respond more rapidly to oil price increases than wages and costs in public administration. The short-run effect of ideology is that stronger influences for parties on the left reduce price growth in the short run, although no long-run effect is evident.

Table 3 about here

Table 3 displays the results for the tests of parameter stability. The test procedure is the same as for defense. For the subgroups of variables, parameter stability is far from being rejected. Moreover, joint parameter stability cannot be rejected at the 5 % level of significance. Based on these tests we conclude that no problem related to instability of the parameters is found.

6 The broader relevance of the Baumol mechanism and the validity of party fragmentation

The analyses of defense and public administration show that productivity in the manufacturing sector and party fragmentation are important determinants of relative price growth. Theoretically, the Baumol mechanism captured by manufacturing productivity should be of relevance in both public and private sectors, while party fragmentation should be of importance only in the public sector. In order to investigate the broader relevance of the Baumol mechanism and the validity of the estimated effect of political fragmentation in defense and public administration, we analyze a labor-intensive private service. More precisely, we estimate the model for the relative prices of restaurants and cafes (denoted P_R). The price index for restaurant and cafes constitutes a part of the consumer price index (*CPI*), and as for defense and public administration, the price is measured relative to the private sector price deflator.

DF-tests and KPSS-tests revealed that the relative prices of restaurants and cafes are non-stationary, but that the first difference is stationary. Restaurants and cafes can therefore be modelled in the same way as our two public sectors. The starting point for the analysis is a model with the same determinants

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as for defense and public administration. The results of the Johansen procedure are displayed in (17) and (18):

$$\log P_{Rt} = 0.190(0.048)\log A_t \tag{17}$$

$$\Delta\log P_{Rt} = -0.056(0.016) - 0.063(0.012)\Delta Oil_t - 0.506(0.182)\Delta Left_t - 0.128(0.027)CI_{Rt-1} \tag{18}$$

The error-correction term (CI_{Rt-1}) is:

$$CI_{Rt-1} = \log P_{Rt-1} - 0.190\log A_{t-1} \tag{19}$$

The diagnostics are as follows:

$$R^2 = 0.60, \quad AR1-2: F(2,36) = 2.219, \quad ARCH1-1: F(1,40) = 1.972, \quad Reset\, F(2,36) = 1.662$$

The diagnostics do not reveal any misspecification problems. Manufacturing productivity turns out to be the only significant long-term determinant of the relative price of restaurants and cafes. For our purpose, this finding has two important implications. First, it confirms that the Baumol mechanism is relevant, not only for public services, but also for a labor-intensive private service. Second, the insignificance of party fragmentation for restaurants and cafes increases the validity of the estimated effects of party fragmentation in defense and public administration. However, parliamentary ideology appears to have an immediate effect. A possible interpretation of this finding is that parties on the left run a more expansionary fiscal policy that has a short-term effect on private sector prices.

7 Concluding remarks

The Baumol model predicts a steady increase in relative public sector prices (or costs) because of slow productivity growth and wage growth similar to sectors with higher productivity growth. A main contribution of this paper is to bridge analyses of the Baumol mechanism and the literature that considers public sector productivity as the outcome of a political process. Using data from the Norwegian national accounts, we analyze the prices of defense and public administration (both relative to the prices of the private sector) during the 1970-2012 period. We find strong support for the Baumol mechanism because manufacturing productivity is found to be the most important driver of relative price growth in the public sector. Both in defense and public administration around 70 % of the relative price growth can be explained by productivity growth in the manufacturing sector. Greater party fragmentation also is important empirically, but its role is minor compared to manufacturing productivity. An analysis of a labor-intensive private service (restaurants and cafes) confirms the broader relevance of the Baumol mechanism and the validity of the estimated effect of political fragmentation on both defense and public administration.

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Appendix: Variable definitions, descriptive statistics and tests of time series properties

Table A1 about here

Table A2 about here

Table A3 about here

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Table 1 DF and KPSS-tests

	DF		KPSS		Conclusion	
Relative price	Level	First diff.	Level	First diff.	Level	First diff.
Public administration – private	1.647	-2.909***	1.14***	0.221	Non-stat.	Stat.
Defense – private	0.646	-4.037***	1.08***	0.144	Non-stat.	Stat.
Defense - public administration	-0.519	-2.198*	0.886**	0.065	Non-stat.	Stat.

The tests are performed on the logs of the variables. Asterisks indicate significance levels: ***= 1 %, ** = 5 %, * = 10 %.

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Table 2 Tests of parameter stability, defense

	Scaled F-statistics	Critical value (5%)
All determinants	8.84	16.19
Short-run determinants	9.29	11.47
Error correction term	5.25	8.58
Constant	5.53	8.58

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Table 3 Tests of parameter stability, public administration

	Scaled F-statistics	Critical value (5%)
All determinants	12.48	16.19
Short-run determinants	4.69	11.47
Error correction term	2.21	8.58
Constant	2.34	8.58

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Table A1 Variable definitions and sources

Name	Definition	Source
P_D	Price of defense relative to the private sector	Statistics Norway
P_S	Price of public administration (excluding defense) relative to the private sector	Statistics Norway
P_R	Price of restaurant and cafes relative to the private sector	Statistics Norway
A	Production per man-hour in the manufacturing sector	Statistics Norway
HHI	The Herfindahl-Hirschman index of party fragmentation of the parliament	Norwegian Social Science Data Services (NSD)
Left	The share of representatives from centre-left and left-wing parties	NSD
Conscript	The number of persons liable for military service as share of employment in defense	Norwegian Armed Forces
Oil	Oil price in USD	BP
USD	NOK/USD exchange rate	Central Bank of Norway
GDP-growth	Annual growth rate of GDP per capita (%)	Statistics Norway

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Table A2 Descriptive statistics

Variable	# obs	Mean	Std. dev.	Min	Max
P_D, 1970=100	43	120.03	14.76	100	145.23
P_S, 1970=100	43	129.54	19.02	100	167.64
P_R, 1970=100	43	157.43	28.24	100	191.91
A	43	244.20	155.03	100	410.07
HHI	43	0.26	0.05	0.19	0.33
Left	43	0.47	0.03	0.40	0.50
Conscript	43	0.36	0.06	0.23	0.48
Oil	43	31.27	27.50	1.80	111.67
USD	43	6.58	1.00	4.94	8.99
GDP-growth	42	2.44	1.56	-2.90	5.59

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Table A3 Time series properties tests

Variable	Dickey Fuller		KPSS	
	Level	FD	Level	FD
P_R	0.192	-4.511***	1.130***	0.215
A	0.699	-3.085***	1.518***	0.243
Herf	-1.603	-4.330***	0.739**	0.066
Left	-1.581	-4.407***	0.720**	0.051
Conscript	-0.569	-2.103*	0.343	0.783***
Oil	-0.147	-4.426***	0.750***	0.196
USD	-2.689***	-4.147***	0.188	0.073
GDP-growth	-3.652***	-5.918***	0.212	0.042

Asterisks indicate significance levels: ***= 1 %, ** = 5 %, * = 10 %.

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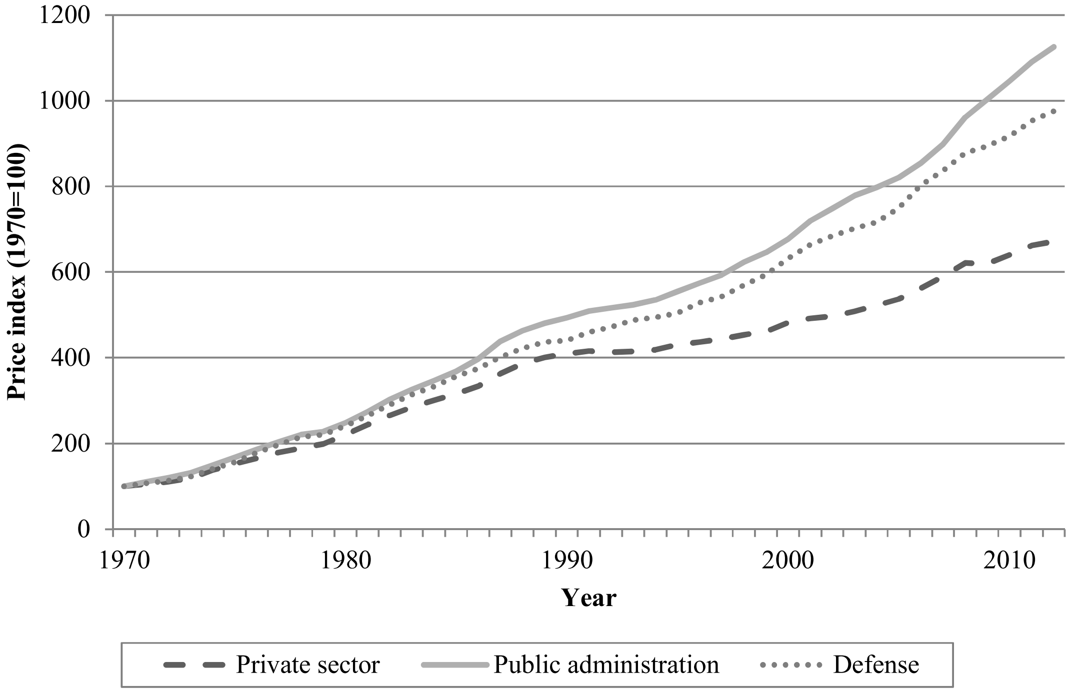

Fig. 1 Price indices for public administration, defense and the private sector, 1970-2012

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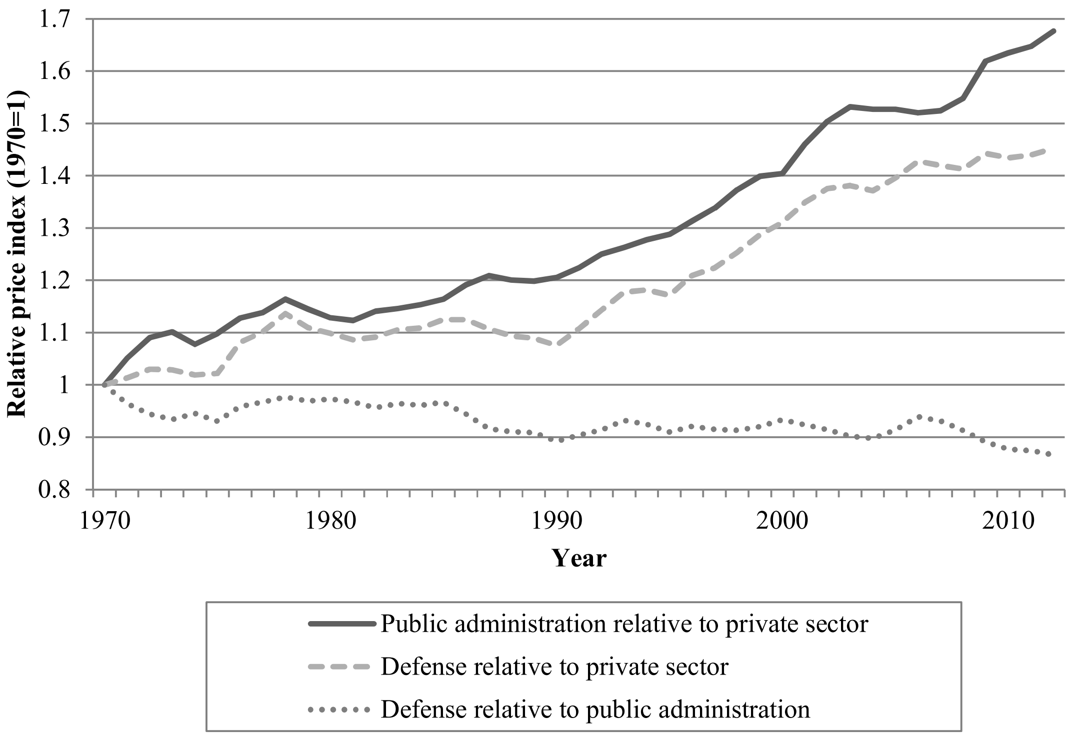

Fig. 2 Relative prices, 1970-2012

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