The Baumol effect in defence and public administration

Lars-Erik Borge[1] · Kjetil Hove[2] · Tobias Lillekvelland[2] · Per Tovmo[1]

March 2017

Abstract

The Baumol hypothesis predicts a steady increase in relative public sector prices (or costs) because of slow productivity growth. In this paper we analyse price growth in the public sector with particular attention to defence, using Norwegian data. There is strong evidence for a Baumol effect in the sense that relative public sector prices are non-stationary and growing over time. The Baumol effect is weaker in defence than in public administration (the rest of the public sector). Moreover, we investigate the determinants of the Baumol effect. It is evident that the Baumol effect is driven by economic growth and political fragmentation, both in defence and public administration. A placebo test for a labour intensive private service supports the validity of the estimated effects of political fragmentation.

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

JEL Classification H11 · H40 · H56

Corresponding author: Lars-Erik Borge, lars.erik.borge@ntnu.no

[1] Department of Economics, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway

[2] Norwegian Defence Research Establishment (FFI), P.O. Box 25, NO-2027, Kjeller, Norway

1 Introduction

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

In a recent paper on reform of public services by Sørensen (2015), the Baumol effect is considered a fundamental threat to the welfare state. The main point is that unbalanced productivity growth has unpleasant implications. If public spending is to be held constant as share of GDP, the growth of public services will be substantially lower than the growth of private consumption. A balanced growth of public services and private consumption would mean a steadily increasing tax level. Since there are limits to the growth of the tax level, the Baumol effect implies that the growth of public services in the long run will be lower than the growth of private consumption.

The Baumol effect has motivated two types of empirical research. First, there is a large body of literature providing empirical evidence for a relative cost increase of labour intensive services. Nordhaus (2008) conducts a comprehensive study of a complete set of industry account data for the US, where he provides evidence of relatively slow productivity growth for labour intensive services. Second, the cost disease is considered to be a potential driver of public sector growth. Borcherding (1985) made an early contribution from the US, while Gemmel (1993) provides a collection of experiences from several countries. Whether the cost disease contributes to increased public spending depends on the price elasticity of demand for public services. If demand is inelastic, the cost disease contributes to a higher level of public spending, while the opposite is the case when demand is price elastic. Demand for public services is generally found to be price inelastic (see e.g. Oates 1996), which indicates that the Baumol effect may lead to increased public spending. However, in a study of Norway of the period 1880-1990 (Borge and Rattsø 2002), this is not the case. Although there is evidence of a cost disease in the sense that the relative price of public services has increased over time, the demand response has been sufficiently strong to neutralize the effect on public spending.

The works referred to above have in common that a Baumol effect is driven by an exogenous productivity gap between the private and the public sectors. This assumption differs sharply from recent studies of efficiency in the public sector. The typical approach taken in the efficiency studies is to first calculate variation in efficiency across government units using frontier techniques, and then analyse whether economic and political determinants can account for the observed variation in efficiency. Examples include De Borger et al. (1994), Balaguer-Coll et al. (2007), Borge et al. (2008) and

[1] Many private service industries may also have limited scope for productivity growth. See the analysis of restaurant and cafes in Section 5.

Geys et al. (2010). In this literature public sector productivity is not considered as exogenous, but rather as an outcome of a political process.

A first contribution of this paper is to bridge the analyses of the Baumol effect and the analyses of efficiency variation across government units. As in the literature on the Baumol effect and public sector growth we use country level data, more precisely Norwegian data from the national accounts during 1970-2012. In a first step we investigate whether a Baumol effect is present in the sense that the relative price of public services has increased over time. In a second step we analyse the determinants of the Baumol effects to find to which extent the Baumol effect is explained by economic and political factors.

The second contribution of the paper is to conduct separate analyses of two subsectors of the public sector. In the empirical analysis, the public sector is split into defence and the rest (denoted public administration in the following). This separation is of interest because the defence sector differs from public administration in important respects. First, defence is a less labour intensive than public administration, and as a consequence the Baumol effect should be weaker in defence. Second, non-labour inputs are different. In the defence sector these inputs are technologically advanced, the scale of production is relatively low, and there is a need for state of the art equipment even if it only represents a marginal improvement compared to the previous generation (Kirkpatrick 1995). This means that the Baumol effect should be stronger in defence than in public administration.

The rest of the paper is organized as follows. Section 2 discusses data and time series properties of prices of defence and public administration. The Baumol effect is present in both sectors, but it is weaker in defence. Sections 3 and 4 are devoted to the determinants of the Baumol effect. Section 3 discusses the error correction specification, while Section 4 presents the estimation results. Economic growth and political fragmentation come out as the most important determinants of the Baumol effect, both in defence and in public administration. The estimated effects of economic growth indicate that GDP may affect the size of the public sector through both a Wagner (demand) channel and a Baumol (cost) channel. In Section 5 we perform a placebo test of restaurant and cafes, a labour intensive private service, to investigate the validity of the estimated effect of political fragmentation in the public sector. Finally, Section 6 offers some concluding remarks.

2 Data and time series properties: Is there a Baumol effect in the data?

The national accounts provide information on the development of prices for each industry. In order to investigate the Baumol effect, we study the price indices for defence and public administration relative to the GDP price index for Mainland-Norway. Mainland-Norway is the Norwegian economy excluding petroleum extraction and ocean shipping, and is for simplification denoted the private sector in the following.[2] By excluding petroleum extraction, the price index of the private sector will not be directly affected by oil price changes and the test of the Baumol effect will be cleaner. Public administration includes all non-defence services provided by central and local government.

[2] This is not totally correct since the public sector is included in Mainland-Norway. However, the price for the public sector relative to Mainland-Norway and relative to the private sector will always move in the same direction.

In the public sector production is measured from 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 defence and public administration. However, because the input composition varies, the impact of changes in the price indices will be different for defence and public administration. Input composition is calculated from survey data.

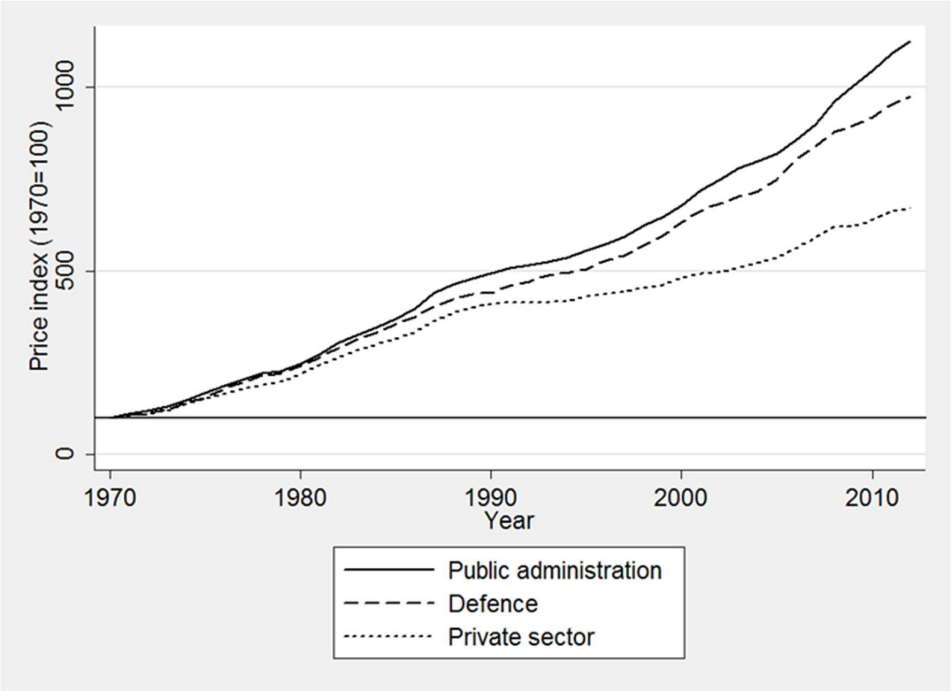

Fig. 1 Price indices for public administration, defence and the private sector, 1970-2012

Fig. 1 illustrates the development of price indices for defence, public administration and the private sector in the period 1970-2012. The development is consistent with a Baumol effect in the sense that the price growth is substantially higher in the two public sectors than in the private sector. The average annual growth in public administration and defence are 5.9 and 5.6 percent respectively, compared to 4.6 percent in the private sector. The difference in price growth between the public and the private sector was relatively small until the late 1980s. As expected, the price growth is positively related to labour intensity measured by the wage share. In 2010 the wage shares for the three sectors were 62 percent (public administration), 40 percent (defence), and 29 percent (private).

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

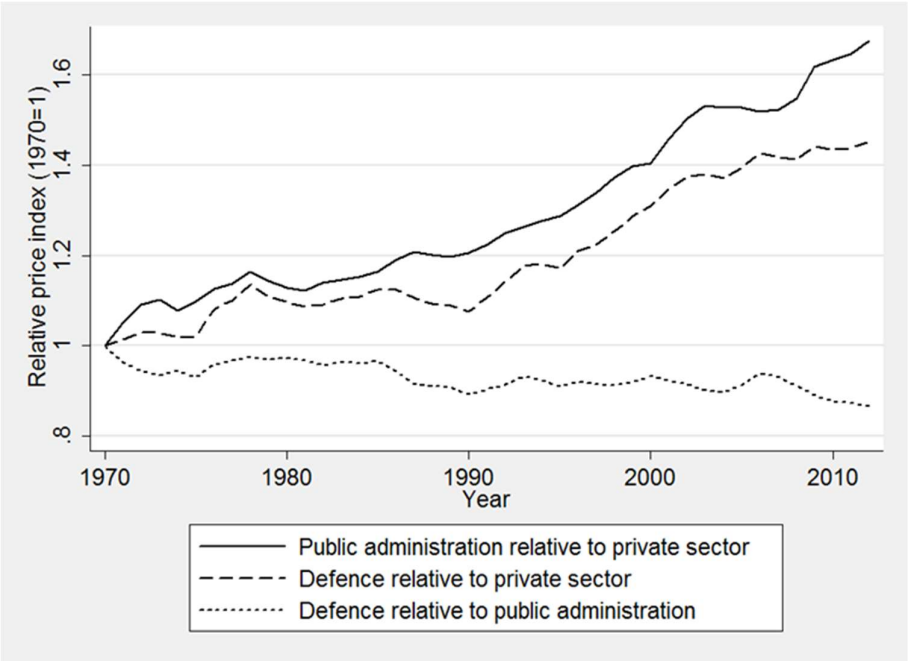

Fig. 2 Relative prices, 1970-2012

A formal test of whether there is a Baumol effect in the data can be conducted by investigating the time series properties of the relative prices. A Baumol effect is consistent with relative prices being non-stationary. The time series properties are tested by DF tests (Dickey and Fuller 1979) 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 log 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 as 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.[3]

The two upper rows in Table 1 report DF and KPSS tests for the relative prices between the public sectors (public administration and defence) and the private sector. A first observation is that the results are the same for both public administration and defence. Using 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. Accordingly, the conclusion from the DF test is 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 is clearly rejected for the levels of relative prices, but cannot be rejected for the first differences. Taken together the DF and KPSS tests

[3] 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 Baumol effect if the time trend comes out as significant.

provide strong evidence of a Baumol effect in the data, i.e. prices in public administration and defence have a higher growth rate than prices in the private sector.

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.
Defence - private	0.646	-4.037***	1.08***	0.144	Non-stat.	Stat.
Defence - public administration	-0.519	-2.198*	0.886**	0.065	Non-stat.	Stat.

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

Figs. 1 and 2 indicate that the Baumol effect is stronger in public administration than in defence. Whether the difference is statistically significant can be investigated by performing DF and KPSS-tests on the relative price between 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 level of the relative price, but at the 10 percent 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 level of the relative price, but not for the first difference. As a consequence, both tests provide evidence that the Baumol effect is more severe in public administration than in defence. The interpretation of this finding is that the effect of defence being less labour intensive dominates the effect of a higher price growth for non-labour inputs.

3 The error correction model and potential drivers of the Baumol effect

The previous section documented the existence of a Baumol effect in both defence and public administration. In this section, we formulate an error correction model that facilitates an analysis of the determinants of the Baumol effect and develop hypothesis regarding potential determinants.

The relative prices of the public sectors, 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 which allows for a separation between short and long run effects.

The point of departure is the following model

$$Y_t = \alpha + \beta X_t + u_t, \tag{1}$$

where Y_t and X_t both are I(1) and are cointegrated, implying that the error term u_t is stationary I(0). Engle and Granger (1987) showed that in this case the dynamics can be represented by the following error correction model:

$$\Delta Y_t = \beta_0 \Delta X_t - \gamma[Y_{t-1} - \alpha - \beta X_{t-1}] + \varepsilon_t \tag{2}$$

Our corresponding empirical model is

$$\Delta P_{jt} = \gamma_j P_{jt-1} + \alpha_{j0}\Delta X_t + \alpha_{j1}X_{t-1} + \beta_{j0}\Delta Pol_t + \beta_{j1}Pol_{t-1} + \varepsilon_{jt}, \quad j= D, S \tag{3}$$

where P_j is the (log of) the price of defence (D) and public administration (S) relative to the private sector. X is a vector of economic determinants and the vector Pol comprises characteristics of the political leadership. All variables in the empirical analyses are in logs except the variables that are measured as shares. Definitions, sources and descriptive statistics are in the Appendix.

To capture the impact of economic growth and business cycles we include real GDP per capita (*GDP*) in the X vector. Economic growth as a result of increased productivity in the private sector is expected to increase the relative price of production in the public sector in line with Baumol's theory. To capture a potential impact of fiscal stress in the public sector we have included a variable (*Fiscal press*) which is measured as the share of the population in age groups expected to be high demanders of public services.[4] The idea is that increased fiscal stress will force the public sector to hold down wage growth. Consequently, we expect the variable to have a negative impact on prices in both defence and public administration. Other variables are the exchange rate for Norwegian kroner versus US dollars (*USD*) and the price of crude oil (*Oil*). The exchange rate affects the cost of imported goods. It is not obvious how this will affect the dependent variables since they are measured as ratios to private sector prices. However, if we make the reasonable assumption that imported goods make up a larger share of production costs in the private sector, the exchange rate will have a negative impact on the relative prices of the public sectors. Moreover, the exchange rate is likely to be less important for the price of defence where the share of imported goods is more similar to that of private services. The price of crude oil is included as a control variable to capture the large and increasing influence of the petroleum sector on the Norwegian economy in the period under study.

There have been important changes in the organization of defence during the period of study. One important change is conscription. Formally, Norwegian men still face the conscription, but in practice the share of men serving in the military forces has declined gradually since the late 1980s. The conscripts are paid only a small amount of money each day. Fewer conscripts is therefore likely to increase unit wage costs and the price of defence. We include the share of conscripts (*Conscript*) of total employment in the defence to test this. There have also been other changes from the end of the cold war to this date with the largest rearrangement of the sector taking place in the period 2002–2005 (Ministry of Defence 2000–2001). These changes came about as a delayed consequence of changes in the security climate following the end of the cold war. Although not clear how, these changes might affect the price of defence. 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 break date. Moreover, it is not clear whether a potential break would affect the growth rate directly (level effect) or change the impact 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 caused by structural changes of the sector.

The vector of political variables includes variables capturing strength and ideology of the political leadership. The measure of strength is a Herfindahl-index (*Herf*) of the party fragmentation of the parliament. The index is calculated as

[4] More precisely, *Fiscal press* includes inhabitants below 19 years of age and above 67 years of age.

$Herf = \sum_{p=1}^{P} SH_p^2,$

where P is the number of parties in the parliament and SH_p is the share of seats held by party p. The index is inversely related to fragmentation and it takes the maximum value of 1 when all seats are held by a single party. The minimum value is $1/P$, which will be the case if the seats are equally divided among the P parties.

Numerous studies, among them Kalseth and Rattsø (1998) and Borge and Rattsø (2002), have found that political strength restrains local public spending in Norway. 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 strength of the central government, but they found no impact on central government wages. If political strength holds down wage growth, we expect a negative impact on the prices of defence and public administration of the Herfindahl-index.

Ideology of the government could affect the price growth through the wage growth and a general expectation is that conservative parties are less tolerant of growth of public sector wages. Empirical support for this is found in Strøm (1995), where a positive correlation between the share of socialists in the local government council and the wage level for low skilled local public employees is documented. Another argument for including ideological orientation is a positive correlation between the measure of political strength and ideology. 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 centre-left and left wing parties *(Left)*.[5]

Tests for the time series properties of the variables presented above indicate that most of them are clearly I(1)[6]. The tests are less conclusive for the share of conscripts and the measure of fiscal stress, but we rely on the cointegration tests to detect whether their time series properties differ from the other variables.

4 Empirical results

This section presents the estimation results for the model presented in Section 3. 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 the results we eliminated the variables that were statistically insignificant (at the 10 percent level) in this first step and the dynamic model (3) was estimated conditional on the cointegration relation found in the first step. Variables with no statistically significant long run impact 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.

[5] The coefficient of correlation between *Herf* and *Left* is 0.61.
[6] The test results are reported in Table A3 in the Appendix.

4.1 Defence

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

$$P_{Dt} = 0.148\ (0.031)GDP_t - 1.635\ (0.360)Herf_t\ , \tag{4}$$

where the standard errors are in parentheses.

The resulting dynamic model is:

$$\Delta P_{Dt} = -0.105\ (0.007)\Delta Oil_t + 0.008\ (0.003)\Delta USD_t - 0.020\ (0.006) - 0.153\ (0.029)CI_{t-1} \tag{5}$$

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

$$CI_{t-1} = P_{Dt-1} - 0.148\ GDP_{t-1} + 1.635Herf_{t-1} \tag{6}$$

The diagnostics are as follows:

$$R^2 = 0.54,\quad F(3,38) = 14.7,\ \ AR\ 1-2: F(2,36) = 0.538,\ \ Normality\ \chi^2(2) = 0.595,$$
$$Reset\ F(2,36) = 0.137, ARCH\ 1-1: F(1,40) = 0.784$$

The diagnostics indicate that the model is well determined. The AR 1-2 test is a standard test of autocorrelation up to degree 2 and it shows that there is no sign of autocorrelation in the residuals. The normality test shows that normality is not rejected and consequently, it is correct inference to use the t-distribution to test the significance of the estimated parameters. The ARCH and the Reset F tests, both interpreted as general misspecification tests, do not indicate problems of misspecification.

It follows from the long run model that the observed growth of relative price in defence is driven by *GDP* and political fragmentation. The decline in the number of conscripts, increased need for public services and ideology of the political leadership have no long run impact on the price growth. The elasticity of the relative price with respect to *GDP* is 0.15. With a tripling of GDP per capita over the sample period, this is a significant contributor to the observed price growth. A positive relationship between the relative price of defence and *GDP* is consistent with the original explanation of the Baumol cost disease as a result of lower productivity growth in defence than in the private sector. An above average increase in cost of purchased goods will have the same impact, given that if the defence uses more labour intensive intermediate goods than the private sector.

The negative impact of the Herfindahl-index is consistent with earlier Norwegian studies (e.g. Kalseth and Rattsø 1998 and Borge and Rattsø 2002) documenting that a low degree of party fragmentation reduces public spending. The estimated effect may be reflect lower wage growth as found by Johansen and Strøm (2001). To sum up, economic growth and reduced political strength over the sample period can explain the observed Baumol effect in defence during the period of study.

The dynamic model in (5) presents the determinants with an immediate effect on the price growth. The price of crude oil reduces relative price growth in defence, indicating that private sector production is more dependent on oil price fluctuations than defence production. On the other hand,

the price of defence production fluctuates more with the US exchange rate than the private sector price. A reasonable interpretation is that it is a consequence of imported high cost defence materials. The error correction term has the expected negative impact, but the numerical effect is rather small, indicating that return to equilibrium after deviations is slow.

Table 2 Parameter stability tests, defence

	Scaled F-statistics	Critical value (5%)
All determinants	10.54	15.67
Short run determinants	3.16	10.98
Error correction term	6.75	17.76
Constant	9.71	8.22

To investigate whether there are structural breaks, for instance because of the rearrangement of the defence (e.g. reduced conscription and the end of the cold war), we have tested for parameter constancy. The test procedure involves sequential application of breakpoint tests as described by Bai (1997). The point of departure is a test of parameter constancy based on the full sample with unknown breaks. It the null of parameter constancy is rejected the break date is determined and new stability tests are performed on the subsamples. This procedure goes on until constancy is not rejected for any subsample or the maximum number of (pre specified) breaks is reached. The main advantage compared to 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 for all determinants and separate tests for stability of the constant term and the error correction term. To avoid the estimates to be based on very few observations the test is set up with a minimum segment length of 9 observations. The critical values (at 5 per cent level) are calculated by Bai and Perron (2003), and they show that the null of stable parameters cannot be rejected. However, when testing for stability in the constant term , there seems to be a break, i.e. a permanent shift in the growth rate. We have reestimated the model with a break in the constant term and the results reported above are robust to this modification of the model. However, in the modified case *GDP* comes out with a significant short term effect on the relative price of defence.

4.2 Public administration

Below we report the results for the model with the price of production in the public sector exclusive of defence as dependent variable. The search of the final model was based on a model including the same covariates as the analyses of the relative price of defence services.

The estimated long run and the dynamic models are presented in (7) and (8) respectively:

$$P_{St} = 0.328\ (0.065)GDP_t - 0.707\ (0.321)Herf - 0.945\ (0.195)Conscript_t \tag{7}$$

$$\Delta P_{St} = -0.166\ (0.098)\Delta Left_t - 0.033\ (0.006)\Delta Oil_t - 0.176(0.043) - 0.166\ (0.037)CI_{t-1} \tag{8}$$

Where the error-correction term (CI_{t-1}) is:

$$CI_{t-1} = P_{St-1} - 0.32\ GDP_{t-1} + 0.707Herf_{t-1} + 0.945Conscript_{t-1} \tag{9}$$

Diagnostics:

$$R^2 = 0.57, \quad F(3,38) = 16.77, \quad AR\ 1-2: F(2,36) = 1.575, \quad Normality\ \chi^2(2) = 0.624,$$
$$Reset\ F(2,36) = 0.454, ARCH\ 1-1: F(1,40) = 1.574$$

The diagnostics indicate a well specified model. The long run growth in the relative price of public administration is driven by *GDP*, political strength and the reduction in the share of conscripts, while the ideology of government and fiscal pressure have no significant long term impact.

The estimated elasticity of *GDP* is twice as high for public administration as for defence. This is consistent with the plot of the two prices (in Figs. 1 and 2), which indicated that the Baumol effect was strongest in public administration. For political strength the difference goes in the opposite direction, and the estimated coefficient is less than half of that for defence. It is a somewhat puzzling result that increased share of conscripts increases the price of public administration, while it had no impact on the price of defence. The result may reflect the impact of underlying fiscal conditions that influences both the number of conscripts and public finances in general.

The dynamic model presented in (8) indicates, as for the relative price of defence, which increased fluctuations in the price of crude oil influences public administration price growth. As for defence, the effect probably works through the denominator of our price measure in the sense that an increase in the oil price affects private sector prices more than public sector prices. The estimated coefficient is larger than for defence, implying that the cost of defence is more dependent on the price of oil than the cost of public administration, but still less dependent than private sector. Finally, centre-left and left wing parties' influence in the parliament reduces price growth in the short run, although there was no long run effect. The impact of the error term indicates in the same way as for defence a rather slow adjustment after deviations from equilibrium.

Table 3 Parameter stability tests, public administration

	Scaled F-statistics	Critical value (5%)
All determinants	17.48	16.19
Short run determinants	5.40	11.47
Error correction term	3.64	8.58
Constant	3.79	8.58

Table 3 displays the results for parameter constancy test. The test procedure is the same as described above. When testing joint stability there are some indications of breaks in the data. However, when testing sub groups of variables, parameter constancy is far from being rejected. Based on these tests we conclude that there is no serious problem related to instability of the parameters.

5 Testing the validity of political fragmentation

The analyses of defence and public administration show that *GDP* and political fragmentation are the main determinants of the Baumol effect in the long run. While economic growth may be of importance for the Baumol effect in both public and private sectors, political fragmentation should of importance only in the public sector. In order to investigate the validity of the estimated effect of political fragmentation, we perform a placebo test by analysing a labour intensive private service. More

precisely, we estimate the model for the relative price of restaurants and cafes (denoted P_R). The price index for restaurant and cafes is taken from the consumer price index (CPI), and as for defence and public administration, the price is measured relative to Mainland-Norway.

DF-tests and KPSS-tests revealed that the relative price for restaurants and cafes are non-stationary, but that the first difference is stationary. Restaurant and cafes can therefore be modelled in the same way as defence and public administration, and the results of the Johansen procedure are displayed below. The long run and dynamic models are presented in (10) and (11)

$$P_{Rt} = 0.214\ (0.053) GDP_t \tag{10}$$

$$\Delta P_{Rt} = -0.063\ (0.012)\Delta Oil_t - 0.488\ (0.182)\Delta Left_t - 0.156\ (0.037) - 0.141\ (0.030) CI_{t-1} \tag{11}$$

where the error-correction term is

$$CI_{t-1} = P_{Rt-1} - 0.214\ GDP_{t-1} \tag{12}$$

Diagnostics:

$$R^2 = 0.60, \quad F(3,38) = 19.1, \quad AR\ 1-2: F(2,36) = 2.406, \quad Normality\ \chi^2(2) = 0.268,$$
$$Reset\ F(2,36) = 0.152, ARCH\ 1-1: F(1,40) = 1.162$$

The diagnostics do not indicate any grave misspecification problems, although there are some signs of remaining auto correlation. The starting point of the analysis is a model with the same determinants as for defence and public administration. The only significant long term determinant is *GDP*, consistent with the Baumol hypothesis of slower productivity growth for labour intensive services. For our purpose, it is particularly interesting to notice that the strength of the political leadership does not come out with a significant effect on the relative price for restaurant and cafes. The insignificance of political strength for the private service increases the validity of the estimated effects in defence and public administration. However, ideology of the leadership appears to have an immediate effect. As possible interpretation of this finding is that centre-left governments run a more expansionary fiscal policy that increases private sector prices.

6 Concluding remarks

The Baumol hypothesis predicts a steady increase in public sector prices relative to the private sector because of relatively slow productivity growth. In this paper we have analysed relative price growth in the public sector in Norway with particular attention to defence and public administration. There is strong support for the Baumol hypothesis in the sense that relative public sector costs are non-stationary and growing over time. This poses a significant challenge to defence and public administration. The Baumol effect is weaker in defence than in the rest of the public sector, probably reflecting a higher share of purchased inputs in defence. We have also investigated the determinants of the Baumol effect. It is evident that the Baumol effect is driven by *GDP* and political fragmentation, both in defence and in the rest of the public sector.

The estimated effect of political fragmentation for defence and public administration is consistent with findings in studies of efficiency in the public sector using microdata. We have analysed a private service

(restaurants and cafes) as a placebo test. The fact that we find no effect of political fragmentation for restaurants and cafes strengthens the validity of the estimates for defence and public administration.

The effect of economic growth on public sector costs points towards an interesting interplay between the Baumol effects and Wagner's law. Wagner's law predicts that public sector increases as share of *GDP* when *GDP* increases, reflecting a pure income effect on demand for public services. Our results indicate that *GDP* has an additional effect on the size of the public sector as a determinant of the Baumol effect.

Acknowledgements We appreciate comments from participants at LAGV (Aix-en-Provence), IIPF (Lugano) and EPCS (Groningen), and in particular Anna Laura Mancini, Shintaro Nakagawa and Atin Basuchoudhary. We are grateful to Gunnar Bårdsen for advice on specification and estimation, and to Steinar Todsen at Statistics Norway for supplying the data.

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

Table A1: Variable definitions and sources

Name	Definition	Source
P_D	Price of defence relative to Mainland-Norway	Statistics Norway
P_S	Price of public administration (excluding defence) relative to Mainland-Norway	Statistics Norway
P_R	Price of restaurant and cafes relative to Mainland-Norway	Statistics Norway
GDP	Real GDP per capita, measured in 10 000 NOK	Statistics Norway
Fiscal press	Share of inhabitants below 19 years and above 67 years of age	Statistics Norway
Conscript	The number of persons liable for military service as share of employment in defence	Norwegian Armed Forces
Oil	Oil price in USD	BP
USD	NOK/USD exchange rate	Bank of Norway
Herf	The Herfindahl-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

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
GDP	43	308.77	91.19	156.00	439.45
Fiscal press	43	39.47	1.59	36.86	41.80
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
Herf	43	0.26	0.05	0.19	0.33
Left	43	0.47	0.03	0.40	0.50

Table A3: Time series properties tests

Variable	Dickey Fuller		KPSS	
	Level	FD	Level	FD
P_R	0.192	-4.511***	1.130***	0.215
GDP	0.231	-3.652***	1.160***	0.212
Fiscal press	-0.768	1.519	1.150***	0.156
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
Herf	-1.603	-4.330***	0.739**	0.066
Left	-1.581	-4.407***	0.720**	0.051

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

References

Bai, J. (1997). Estimating multiple breaks one at a time. *Econometric Theory, 13(3)*, 315-352.

Bai, J. and Perron, P. (1998). Estimating and testing linear models with multiple structural changes. *Econometrica, 66(1)*, 47-78.

Bai, J. & Perron, P. (2003). Critical values for multiple structural change tests. *Econometrics Journal, 6(1)*, 72-78.

Baumol, W. J. (1967). Macroeconomics of unbalanced growth: The anatomy of urban crisis. *The American Economic Review, 57(3)*, 415–426.

Baumol, W. J. (2012). *The Cost Disease*. Yale University Press.

Baumol, W. J. & Bowen, W. G. (1966). *Performing Arts: The Economic Dilemma*. New York: The Twentieth Century Fund.

Balaguer-Coll, M. T., Prior, D., & Tortosa-Ausina, E. (2007). On the determinants of local government performance: A two-stage nonparametric approach. *European Economic Review, 51(2)*, 425–451.

Borcherding, T. (1985). The cause of government expenditure growth: A survey of the US evidence. *Journal of Public Economics, 28(3)*, 359-382.

Borge, L.-E. & Rattsø, J. (2002). Spending growth with vertical fiscal imbalance: Norway 1880-1990. *Economics and Politics, 14(3)*, 351-373.

Borge, L.-E., Falch, T., & Tovmo, P. (2008). Public sector efficiency: the roles of political and budgetary institutions, fiscal capacity and democratic participation. *Public Choice, 136(3-4)*, 475–495.

Chalmers, M. (2009). Defence inflation: Reality or myth?, *RUSI Defence Systems, 12(1)*, 12-16.

De Borger, B., Kerstens, K., Moesen, W., & Vanneste, J. (1994). Explaining differences in productive efficiency: An application to Belgian municipalities. *Public Choice, 80(3)*, 339–358.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association, 74(366)*, 427–431.

Elliott, G., Rothenberg, T. J. & Stock, J. H. (1996). Efficient tests for an autoregressive unit root. *Econometrica, 64(4)*, 813–836.

Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica, 55(2)*, 251–276.

Gemmel, N. (1993). *The growth of the public sector*. Aldershot: Edward Elgar.

Geys, B., Heinemann, F., & Kalb, A. (2010). Voter involvement, fiscal autonomy and public sector efficiency: Evidence from German municipalities. *European Journal of Political Economy, 26(2)*, 265-278.

Granger, C. W., & Newbold, P. (1974). Spurious regressions in econometrics. *Journal of Econometrics, 2(2)*, 111–120.

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control, 12(2-3)*, 231-254.

Johansen, K., & Strøm, B (2001). Wages and politics: Evidence from the Norwegian public sector. *Oxford Bulletin of Economics and Statistics, 63(3)*, 311-331.

Jones, D. L., & Woodhill, N. J. (2010). *Estimating defence inflation*. Defence Statistics Bulletin No. 10. Bristol: Defence Analytical Services and Advice.

Kalseth, J., & Rattsø, J. (1998). Political control of administrative spending: The case of local governments in Norway. *Economics and Politics, 10(1)*, 63-83.

Kirkpatrick, D. L. I. (1995). The rising unit cost of defence equipment – the reasons and the results. *Defence and Peace Economics, 6(4)*, 263–288.

Kirkpatrick, D. L. I. (2004). Trends in the costs of weapon systems and the consequences. *Defence and Peace Economics, 15(3)*, 259–273.

Kirkpatrick, D. L. I. (2008). Is defence inflation really as high as claimed? *RUSI Defence Systems, 11(2)*, 66-71.

Kwiatkowski, D., Phillips, P. C., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root? *Journal of Econometrics, 54(1-3)*, 159–178.

Ng, S., & Perron, P. (1995). Unit root tests in ARMA models with data-dependent methods for the selection of the truncation lag. *Journal of the American Statistical Association, 90(429)*, 268–281.

Ng, S., & Perron, P. (2001). Lag length selection and the construction of unit root tests with good size and power. *Econometrica, 69(6)*, 1519–1554.

Nordhaus, W. D. (2008). Baumol's diseases: A macroeconomic perspective. *B.E. Journal of Macroeconomics, 8(1)*, Article 10.

Oates, W. E. (1996). Estimating the demand for public goods: The collective choice and contingent valuation approaches. In Bjornstad, D.J., & Kahn, J.R. (Eds.), *The contingent valuation of environmental resources: Methodological issues and research needs*. Cheltenham: Edward Elgar.

Phillips, P. C. (1986). Understanding spurious regressions in econometrics. *Journal of Econometrics, 33(3)*, 311–340.

Schwarz, G. (1978). Estimating the dimension of a model. *The Annals of Statistics, 6(2)*, 461–464.

Schwert, G. W. (1989). Tests for unit roots – a Monte Carlo investigation. *Journal of Business & Economic Statistics, 7(2)*, 147–159.

Solomon, B. (2003). Defence specific inflation: A Canadian perspective. *Defence and Peace Economics, 14(1)*, 19–36.

Ministry of Defence. (2000-2001). Omleggingen av Forsvaret i perioden 2002-2005 (the alteration of the Norwegian defence in the period 2002-2005) (St.prp. nr. 45).

Strøm, B. (1995). Envy, fairness and political influence in local government wage determination: Evidence from Norway. *Economica, 62(247)*, 389-409

Sørensen, P. B. (2015). Reforming public service provision. What have we learned? *EPRU Working Paper Series 2015-01*.