Economies of scope in Danish primary care practices

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Title: Economies of scope in Danish primary care practices

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Abstract

Aim:
We analyze total operating costs and activities in Danish General Practice units to assess whether there are unexploited economies of scope in the production of primary care services.

Methods:
We apply stochastic frontier analysis to derive cost functions and associated cost complementarities between GP services and overall economies of scope.

Data:
Cross-section data for a sample of 331 primary care practices with 1-8 GPs from the year 2006. This is a unique combined dataset consisting of survey and register data.

Results:
We find a trend towards cost complementarities between the production of standard consultations and email/phone consultations. In contrast, we obtain insignificant anti-cost complementarities between standard consultations and home visits as well as an insignificant trend towards anti-complementarities between email/phone consultations and home visits. Overall we find positive economies of scope in the production of GP services.

Conclusions:
Our preliminary results show that there were overall economies of scope associated with the joint production of a) standard consultations, b) email/phone consultations and c) home visits. Cost complementarities between standard consultations and email/phone consultations outbalance anti-cost complementarities between standard consultations versus home visits and email/phone consultations versus home visits.
**Introduction**

Recently a number of Danish GP units have decided to consolidate into larger units. For instance, one of the largest Danish GP Practices consists of 22 GPs plus other staff. This indicates that there is an opportunity for GP units to consolidate within local geographical regions. This development is appreciated by the Danish Regions, see [1].

So far, the structure of GP practice units has been dominated by solo practices or small practices with few GPs per practice unit. The Association of Danish Regions believes that unexploited gains from joint production may allow for cost savings and possibly improved quality of care. Furthermore, GP units are private organizations which usually attempts to minimize costs as part of profit maximization. Hence, cost considerations are fundamental.

Whether or not increasing consolidation of GP units is an economic advantage depends on whether there are economies of scale and scope and whether larger GP units lead to improved clinical outcomes. One existing study indicates that the Danish GP sector is subject to economies of scale [2]. Therefore, this study is focusing on cost complementarities and economies of scope. Cost complementarities exist between two outputs if the marginal cost schedule of one output is decreasing in the other output. Cost complementarities express the extent to which the cost of a specific output is changing as a function of the output of another output [3]. Within the GP practice context, outputs could be seen as different types of GP services (outputs) such as the number of different types of GP consultations. Economies of scope are often examined through cost complementarities. Scope economies exist where it is less costly to produce two or more outputs applying common shared inputs than to produce them separately [4]. This means that economies of scope express production characteristics by joint production of several unique outputs. In the GP sector, economies of scope may, for example, be obtained though the sharing or joint utilization of inputs such as practice premises, common treatment guidelines and sharing of personnel.

According to industry structure theory the present configuration of GP units may not be considered sustainable (cost efficient) in the long run if there exist opportunities for restructuring which would allow provision of similar amounts and quality of GP services at lower cost [3].
The purpose of this paper is to apply econometric cost functions to assess whether there are unexploited cost complementarities and economies of scope in the production of GP services in Denmark. The ongoing development indicates that some stakeholders believed that the optimal GP unit configuration is subject to economies of scale and/or scope.

**Method**

A classical cost function is used to make inference about cost complementarities and economies of scope. This implies several decisions such as definition of unit of analysis, choice of GP production and cost function models, functional form, specification of cost and output variables and estimation technique.

There is no evidence that GP units operate in their long-run equilibrium, in the sense that GP practice units adjust all their inputs to their cost-minimizing level. The Danish GP sector is regulated and competition is imperfect. Therefore, it is appropriate to estimate short-run cost functions [5]. The justification is that the short-run approach permits GPs to apply non-optimal levels of the fixed inputs such as expenses for practices premises, IT, heating, electricity and depreciation on operational assets. Accordingly, GPs are only assumed to use cost minimizing quantities of easily adjustable variable inputs, such as wages for employed physicians and other wages for clinical personnel (e.g. nurses and administrative staff). In addition, this study applies stochastic frontier analysis to allow for non-cost minimizing behaviour among GPs and their staff.

To estimate a short run cost function the quadratic functional form has been applied [6]. This function belongs to the family of flexible functional forms, which do not pre-judge the existence or cost complementarities and degree of economies of scope [3,7,8]. Furthermore, the quadratic functional form is preferred to the standard translog cost function. This is due to potential transformation problems with the translog model, which may create biased cost estimates as well as biased estimates of ´optimal´ GP size [9,10]. The translog function is also not well suited for an output vector including zero observations which is required for estimation of stand alone cost. We estimate a model of the form:

$$C_i(Q_{i1}, Q_{i2}, Q_{i3}, K) = \beta_0 + \beta_1 Q_{i1} + \beta_2 Q_{i2} + \beta_3 Q_{i3} + \beta_4 FC + \frac{1}{2} \beta_5 Q_{i1}^2 + \frac{1}{2} \beta_6 Q_{i2}^2 + \frac{1}{2} \beta_7 Q_{i3}^2 + \frac{1}{2} \beta_8 FC^2 + \beta_9 Q_{i1}Q_{i2} + \beta_{10} Q_{i1}Q_{i3} + \beta_{11} Q_{i2}Q_{i3} + \beta_{12} Q_{i1}FC + \beta_{13} Q_{i2}FC + \beta_{14} Q_{i3}FC + \text{adjusters} + v_i + u_i \quad i = 1, \ldots, N \quad (1)$$
Where $C_i$ is the total cost per GP unit per year including all variable and fixed costs ($i = 1, \ldots, N$) in 2006. To attempt to capture central elements of casemix and severity we use the revenue of services as proxies for the outputs of GP units. GP revenue is believed to be the best available index-measures of GP practice output. The GP tariff for each of the GPs individual service is interpreted as a proxy weight reflecting casemix [11]. $Q_1$ is the production value of normal GP consultations, $Q_2$ is the production value of GP email & phone consultations and $Q_3$ is the production value of GP Home visits. $FC_i$ is a monetary measure of the fixed costs, *adjusters* are cost shifters such as patient and GP characteristics and $\beta_0$ is a constant and $\beta_j (j=1,\ldots,5)$ is a coefficient for the absolute increase in costs due to changes in the covariate from the linear, squared and interaction terms, respectively. The term $v_i$ is a random disturbance term representing random events not under control of the firm such as random events and error in identifying or measuring covariates. The term $u_i$ is a non-negative error term accounting for the cost of inefficiency in production. This implies that the model allows for inefficient use of inputs in some GP units which increases the costs of these units compared to the most cost efficient units.

We use the estimated short-run cost function (1) and the envelope condition to estimate the long-run cost function [5,12]. The envelope condition implies that the first order condition of (1) set equal to zero defines the short-run ‘optimal’ amount of capital in terms of fixed costs. Substituting the ‘optimal’ number of fixed costs into the short-run cost function yields the long-run cost function.

Cost complementarities and economies of scope
The ultimate and demanding way to assess the existence of economies of scope is to test for subadditivity (natural monopoly). In practice, subadditivity tests require cost extrapolation outside the range of the present dataset. The argument is that not all possible output levels (corresponding to the range of potential configurations) exist in the Danish GP sector. For instance, ‘extreme’ output vectors equal to the entire GP output and stand alone cost such as $C(y_1,0,0)$ $C(0,y_2,0)$ $C(0,0,y_3)$. In this study, therefore, we attempt to measure central aspects of efficiency in joint production in two less demanding and feasible ways: a) cost complementarities and b) economies of scope. The sign and the magnitude of the interaction

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1 To assess the effect of the index approach we have estimated an alternative model where $Q_1$ is the number of normal GP consultations, $Q_2$ is the number of phone & email consultation and $Q_3$ is the number of home visits.
terms in (1) should be interpreted as cost-complementarities measures between two outputs. Hence, a negative sign imply cost complementarity between the involved outputs and a positive sign indicates anti-cost complementarities. Economies of scope are said to exist if joint production of multiple outputs in one GP unit is less expensive than separate production in more specialized GPs. A sufficient condition for economies of scope is cost complementarities between all output combinations less than the individual output vector. However, it is difficult to apply this demanding sufficient condition to test for economies of scope. The existence of cost complementarities in a subgroup of all output combinations may also result in economies of scope (necessary condition). Cost complementarities between some outputs may dominate anti-cost complementarities among other outputs. Therefore, in this paper we supplement the investigation of joint production by the overall estimate of economies of scope in the following way:

\[
SCP = \frac{\Delta C_1 + \Delta C_2 + \Delta C_3 - \Delta C_{1,2,3}}{\Delta C_{1,2,3}}
\]

(3)

where

\[
\Delta C_1 = C(Q_1^m + \Delta Q_1, Q_2^m, Q_3^m) - C(Q_1^m, Q_2^m, Q_3^m)
\]
\[
\Delta C_2 = C(Q_1^m, Q_2^m + \Delta Q_2, Q_3^m) - C(Q_1^m, Q_2^m, Q_3^m)
\]
\[
\Delta C_3 = C(Q_1^m, Q_2^m, Q_3^m + \Delta Q_3) - C(Q_1^m, Q_2^m, Q_3^m)
\]
\[
\Delta C_{1,2,3} = C(Q_1^m + \Delta Q_1, Q_2^m + \Delta Q_2, Q_3^m + \Delta Q_3) - C(Q_1^m, Q_2^m, Q_3^m)
\]

The index m in (3) shows the minimum output for each output. In the short run, to estimate the amount of fixed costs for the prediction of \(\Delta C_1, \Delta C_2, \Delta C_3\) and \(\Delta C_{1,2,3}\) we conduct an auxiliary regression of the form \(K = \alpha + \beta_1 Q_1 + \beta_2 Q_2 + \beta_3 Q_3\). Different sizes of GP units will have different endowments of fixed cost in the short run. In the long run we use a derived expression for the optimal amount of fixed capital (envelope condition). This permits fixed cost to be variable in the long run. (3) was estimated for four different size groups. The size groups were defined by the number of GPs in each practice unit. The smallest size group consists of solo practices, while the three other size groups consist of GP units with more GPs based on the number of GPs per practice. The standard deviation obtained from bootstrapping, with 1000 replications is used to conduct a test of the significance of SCP-estimates.
Data

We use a combined cross-section dataset consisting of survey and register data from the annual Danish GP survey and the National Health Service from the year 2006. The sample includes 331 GP units, which have been grouped into four size groups (1 GP, 2-3 GPs, 4-6 GPs, and 7-8 GPs). The cost and output variables used to estimate the cost function and their sample means for each of the size groups are shown in table 1.

<table>
<thead>
<tr>
<th>Size GPs per unit</th>
<th>N</th>
<th>Costs (000)</th>
<th>Consultations (revenue in €)</th>
<th>Consultations (#)</th>
<th>FC (000)</th>
<th>[0-100]</th>
<th>Operational (€)</th>
<th>Normal (Q1)</th>
<th>Email &amp; phone (Q2)</th>
<th>Home visits (Q3)</th>
<th>Normal (Q1)</th>
<th>Email &amp; phone (Q2)</th>
<th>Home visits (Q3)</th>
<th>FC (€)</th>
<th>Socio-economic index</th>
</tr>
</thead>
<tbody>
<tr>
<td>All GPs</td>
<td>331</td>
<td>287,437</td>
<td>242,709</td>
<td>9,308</td>
<td>14,987</td>
<td>11,377</td>
<td>364</td>
<td>73,933</td>
<td>30.6</td>
<td>204,110</td>
<td>23.4</td>
<td>121,259</td>
<td>29.8</td>
<td>72,088</td>
<td>29.8</td>
</tr>
<tr>
<td>7-8 GPs</td>
<td>5</td>
<td>807,404</td>
<td>694,878</td>
<td>101,256</td>
<td>42,674</td>
<td>32,972</td>
<td>1091</td>
<td>204,110</td>
<td>23.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-6 GPs</td>
<td>71</td>
<td>503,235</td>
<td>436,621</td>
<td>64,670</td>
<td>26,940</td>
<td>19,698</td>
<td>650</td>
<td>121,259</td>
<td>29.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-3 GPs</td>
<td>147</td>
<td>279,764</td>
<td>240,615</td>
<td>37,065</td>
<td>14,870</td>
<td>11,287</td>
<td>336</td>
<td>72,088</td>
<td>29.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 GP</td>
<td>108</td>
<td>131,909</td>
<td>97,147</td>
<td>16,659</td>
<td>6,005</td>
<td>5,029</td>
<td>180</td>
<td>38,653</td>
<td>32.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The socio-economic patient casemix index has values in the range [12-63.5]
Total operational cost were measured as the annual total accounting cost of each GP “production unit” based on the profit and loss account reported in an extension of the annual GP survey, 2006. The total cost per GP unit was operationalized as the total accounting cost reported in the GP survey. According to expression 1) we apply 3 GP outputs and cost controllers as potential cost drivers. GP input prices are assumed to be constant.

Moreover, we use two alternative set of outputs from GP production units, 1 proxy for fixed cost in the short run and 2 control variables (a socioeconomic index and a dummy for practice type). The alternative set of covariates is introduced to test the robustness of results to alternative output measure. The first set of output variables (model 1) included 3 proxies for subgroups of the value of GP services: 1) Value of normal GP, 2) value of email & 3) home visits and value of home visits. In this set of outputs the output values were calculated as the activity level per physician multiplied by the National Health Service tariff of each service. The other alternative set of outputs (model 2) was the number of consultations in subgroups of GP services: 1) number of normal consultations, 2) number of email & phone consultations.

Fixed costs per practice unit have been operationalized as fixed cost for practice premises. This means that we did not include any of the so called semi-fixed cost as a part of fixed cost. A socioeconomic index and dummy for practice type have been included to control for differences in patient characteristics and practice characteristics.
### Results

Table 2 shows the results for the short-run cost model in the two versions of the quadratic model specification.

<table>
<thead>
<tr>
<th>Q1 (Standard consultations – revenue / #)</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q2 (Telephone &amp; email consultations – revenue / #)</td>
<td>1050162.0**</td>
<td>1440789.2***</td>
</tr>
<tr>
<td>Q3 (Home visit consultations – revenue / #)</td>
<td>(2.95)</td>
<td>(3.99)</td>
</tr>
<tr>
<td>FC (Expenses for practice premises*)</td>
<td>412433.3</td>
<td>83421.0</td>
</tr>
<tr>
<td>Q1*Q1</td>
<td>(1.62)</td>
<td>(0.31)</td>
</tr>
<tr>
<td>Q2*Q2</td>
<td>233335.6**</td>
<td>200925.8</td>
</tr>
<tr>
<td>Q3*Q3</td>
<td>(2.15)</td>
<td>(1.78)</td>
</tr>
<tr>
<td>FC*FC</td>
<td>3.014***</td>
<td>2.877***</td>
</tr>
<tr>
<td>Q1*Q2</td>
<td>(4.07)</td>
<td>(3.65)</td>
</tr>
<tr>
<td>Q2*Q3</td>
<td>-8534.7</td>
<td>285836.4</td>
</tr>
<tr>
<td>Q3*Q3</td>
<td>(-0.04)</td>
<td>(1.25)</td>
</tr>
<tr>
<td>Q1*FC</td>
<td>40368.3</td>
<td>71492.3</td>
</tr>
<tr>
<td>Q2*FC</td>
<td>(-1.52)</td>
<td>(-2.16)</td>
</tr>
<tr>
<td>Q3*FC</td>
<td>66725.4</td>
<td>67605.1</td>
</tr>
<tr>
<td>Q3*Q3</td>
<td>(0.45)</td>
<td>(0.44)</td>
</tr>
<tr>
<td>FC*FC</td>
<td>98448.3</td>
<td>70489.4</td>
</tr>
<tr>
<td>Socio-economic index (patients)</td>
<td>0.344</td>
<td>0.310</td>
</tr>
<tr>
<td>Practice type (Collaboration practice=1)</td>
<td>0.415***</td>
<td>4.385***</td>
</tr>
<tr>
<td>Constant</td>
<td>(3.55)</td>
<td>(3.49)</td>
</tr>
<tr>
<td>Number of GPs</td>
<td>174.2</td>
<td>-767.2</td>
</tr>
<tr>
<td>Number of GPs</td>
<td>(0.05)</td>
<td>(-0.20)</td>
</tr>
<tr>
<td>Constant</td>
<td>-143150.6</td>
<td>-155707.2</td>
</tr>
<tr>
<td>Constant</td>
<td>(-1.32)</td>
<td>(-1.38)</td>
</tr>
<tr>
<td>Constant</td>
<td>-307077.2</td>
<td>-265480.9</td>
</tr>
<tr>
<td>Constant</td>
<td>(-1.93)</td>
<td>(-1.60)</td>
</tr>
</tbody>
</table>

Note: a) See the included accounting cost entries in appendix

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Standard errors in ( ).

Model 1 is based on the tariff-weighted outputs (i.e., the revenue) as proxies for GP unit output. Model 2 includes unweighted outputs in terms of the number of consultations as proxies for GP unit output. Both the socio economic patient index and practice type (solo and company practice versus collaboration practice =1) were insignificant cost driver at the 5...
percent level. Apparently, patients with low socio economic status do not influence the cost of GPs significantly. The signs of the interaction terms in Table 2 indicate whether there are cost complementarities or anti-cost complementarities associated with the joint production of the three GP services. Also, the significance of the estimated interaction terms indicates whether significant cost complementarities exist. The results reveal insignificant anti-cost complementarities between standard consultations and home visits as well as between telephone consultations and home visits. However, the results show significant cost complementarities between standard consultations and the group of telephone and email consultations (model 2). The optimal amount of fixed cost (expenses for practice premises) was estimated to be 312,518 DKK.

**Cost complementarities and economies of scope**

Scope estimate for the mean vector of GP covariates in each of the size groups are shown in Table 4.

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short run</td>
<td>Long run</td>
</tr>
<tr>
<td>Overall</td>
<td>0.110</td>
<td>0.110</td>
</tr>
<tr>
<td>1 solo GP</td>
<td>0.022</td>
<td>0.027</td>
</tr>
<tr>
<td>2-3 GPs</td>
<td>0.049</td>
<td>0.067</td>
</tr>
<tr>
<td>5-7 GPs</td>
<td>0.073</td>
<td>0.095</td>
</tr>
<tr>
<td>&gt; 7 GPS</td>
<td>0.281</td>
<td>0.288</td>
</tr>
</tbody>
</table>

Table 4 shows positive overall economies of scope across all models and size groups. The positive sign indicates economies of scope. A negative sign indicate diseconomies of scope. According to expression (3) the nominal values of the estimates show how much more or less expensive (in percent) it is to increase the joint production on one GP unit instead of increasing production at three separate GP units. In general, the evidence consistently suggest that it is more cost efficient for a GP unit to produce a balanced mixture of standard consultations, email & phone consultations and home visits than a more unbalanced or specialized mixture of the three GP services. The reason is significant cost complementarities (negative interaction term) between standard consultations and email & phone consultations which outbalances a trend towards anti-cost complementarities between standard consultations and home visits (positive interaction term) as well as between standard
consultations and home visits (positive interaction term), respectively. In Table 1 both the number and revenue associated with standard and email & phone consultation are larger than the similar figures for home visits. Therefore, given the estimated cost function, the positive cost synergies between standard and email & phone consultations dominate the above mentioned negative synergies.

Table 4 reveals that economies of scope consistently increase as a function of the size of the GP practice units. This suggests that economies of scope increases as a function of practice unit size. In other words, larger GPs practice units measured in terms of number of GPs per practice unit appear to permit larger potential gains from joint production. This may be due to a row of practical and professional advantages that allows GP to better share inputs in larger GP practice unit. For instance, the ability to collaborate with a larger number of colleagues, the ability to hire relatively more non-physician staff, sharing of nurses as well as laboratory personnel, secretaries, other staff, common treatment guidelines, practice premises, IT, patient administrative system and professional knowledge (i.e. shared inputs). Furthermore, in larger practices, GPs are believed to be able to increase their list size per GP (for instance, from 1700 to 1900 patients per GP). Finally, larger GP practice units appear to be considered as attractive work place. This may allow such units to attract more physicians in training.

The distinction between short-run versus long-run cost function and weighted/unweighted outputs do not appear to result in very different estimates of economies of scope. In model 1 the short-run estimates are slightly larger than the long run. In contrast, the long-run estimates are slightly larger in model 2. The only difference between model 1 and model 2 is the operationalization of outputs. The results appear to be relatively insensitive to the two alternative set of outputs as well as the long-run versus the short-run specification. However, it can be seen that the casemix-adjusted model, which is believed to be more appropriate [11], imply lower scope estimates. This indicates that it may be important to adjust for casemix and that casemix adjustment can not be overlooked.
Discussion and final remarks

This study suggests that there are overall economies of scope associated with the joint production of stand, email & phone and home visits. This is due to significant cost complementarities between standard consultations and email & phone consultations which outbalance anti-cost complement associated with the joint production of standard consultations/home visit and email & phone consultations/home visits, respectively.

We do not find it surprising that home visits tend to increase the cost of GP production. The GP time used to commute to visit patients, direct travelling cost including depreciations and opportunity cost (such as lost revenue on alternative standard consultations or email & phone consultations) makes it obvious for GPs that it “expensive” to make home visits. However, reductions in the number of home visits are probably not an appropriate way to improve cost efficiency in GP units unless reductions can be conducted without reducing patient satisfaction and/or quality of services. For instance, in case a GP has a dying patient – the GP usually needs to make one or more home visit. It is probably not always feasible to substitute GP home visits by nurse visit or similar staff. Anyway, shortage of GPs and resources may still be a reason to assess whether home visit services can be reorganized.

In practice it may be impossible to separate the production of GP services into a) standard consultations, b) email & phone consultations and c) home visits. Nevertheless, the present results, partly confirm that it is more expensive to co-produce standard consultations and home visits.

According to the significance of the interactions terms reported in Table 2 our results only reveal statistically significant cost complementarities between standard/phone & email consultations at a 5 percent level and insignificant anti-cost complementarities between home visits and other consultations. Partly, insignificant estimates of cost complementarities could also signify insignificant scope estimates. However, we did not find any reason to exclude any part of the flexible functional form (1).

The fixed cost may be operationalized in a different ways. For instance, it could be argued that fixed cost should be defined in a broader way. In addition, some of the so called semi-fixed cost could be included as fixed cost. Sensitivity analysis to alternative definitions of
fixed cost indicates that the estimated scope estimates are sensitive to the way fixed costs are operationalized.

Seen from a business economic cost perspective (for instance, The Association of General Practitioners in Denmark) the present results and economies of scale results [2] reveal that the current configuration of the GP sector may be unsustainable in the long-run. It may be cost efficient to consolidate GP units. From a macro economic perspective, where traveling costs in contrast to the above mentioned, should be included, it may be less cost efficient to consolidate GP services in rural areas. This is due geographical limitations in terms on longer distances to GPs, which may mean that economies of scope may be changed into diseconomies of scope.

Seen in the light of the caveats within this field of research and this study, the results of this study only indicates that it might be relevant to consolidate the production of GP services on fewer GP units from a cost perspective. Hence, we suggest that further research should be carried out.
References


