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**Do opening hours and unobserved  
heterogeneity affect economies of  
scale and scope in postal outlets?**

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Decanato della Facoltà di Scienze economiche  
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# Do opening hours and unobserved heterogeneity affect economies of scale and scope in postal outlets?\*

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## ABSTRACT

The purpose of this study is to analyze the cost structure of Swiss Post's postal outlets. In particular, the idea is to assess economies of scale and scope in post offices and franchised postal agencies. Information on their optimal size and production structure is of importance from the policy-makers' point of view because this hypothetical situation may be a basis for calculation of reimbursements when providing the universal service. Two important novelties are introduced in this study. First, the latent class model accounts for postal outlets with different underlying production technologies, caused by unobserved factors. Second, the cost model includes standby time as an indicator of public service because regulated accessibility and negotiated opening hours that enhance public service frequently lead to opening hours that exceed the time necessary to operate the demand. Overall, this analysis confirms the existence of increasing unexploited economies of scale and scope with falling outputs in the Swiss Post office network. Furthermore, the results for the latent class model point to the existence of unobserved heterogeneity in the industry.

**Keywords:** economies of scale, economies of scope, postal outlet network, unobserved heterogeneity, latent class model, opening hours, standby time

**JEL classification:** C21, C81, D24, H42, L92

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## 1 INTRODUCTION

Over the last two decades, several countries around the world have been gradually liberalizing their postal markets. The key objectives of these reforms are better efficiency within the sector, improvement of product innovation, higher quality levels, and affordable prices while maintaining the provision of a minimum universal postal service. One of the most challenging tasks for the universal service providers in this process is to improve efficiency given the universal service obligations they face.

In Switzerland, the postal market is also affected by such regulatory changes. The largest and most important provider of postal services in the country is the incumbent Swiss Post, a publicly owned company. Swiss Post operates a nationwide network of postal outlets, consisting mainly of self-operated post offices and some franchised postal agencies. These postal outlets conduct mail and parcel collection, banking operations and sales activities. An important characteristic of the postal outlet network is regulated accessibility and, to some extent, politically negotiated opening hours to enhance public service and customer comfort. Consequently, the duty to operate a comprehensive postal outlet network implies minimum opening hours. Frequently, these hours exceed the time necessary to operate local demand, which gives rise to standby time. The supply of such a service is financially unattractive, especially in rural areas, where post offices are characterized by a relatively high percentage of standby time.

To promote the reorganization of the postal market successfully, it is important to have information on economies of scale and scope, along with the impact on cost of a predefined universal postal service. From a methodological point of view, this requires the specification of a cost model that appropriately reflects the supply of the universal postal service. We propose to introduce standby time as an indicator of public service in the cost model. We argue that for the estimation of the optimal size of postal outlets it is important to account for the impact of the public service obligation in the empirical cost analysis.

Apart from making use of economies of scale for considerations concerning size, we calculate economies of scope to answer strategic questions such as *how* the optimal output should be produced – whether jointly within the same infrastructure or in separate outlets. Among others, this question arises specifically for banking services and the sale of further products.

The paper is organized as follows. Section 2 outlines the main contribution of this paper with regard to the relevant literature available on the subject. Section 3 presents the model specifications. Section 4 introduces the data, Section 5 addresses the econometric approaches for heteroskedasticity and unobserved heterogeneity and Section 6 provides the estimation results and measures for economies of scale and scope for different model specifications. We draw the conclusions in Section 7.

## 2 PREVIOUS STUDIES ON ECONOMIES OF SCALE AND SCOPE

In the last decades, various studies have investigated economies of scale and scope in network industries such as the energy and transport sector, healthcare, the banking industry, or even in higher education.<sup>5</sup>

As far as postal services are concerned, however, most empirical studies pay attention to economies of scale and scope in delivery or combined activities (Wada et al. (1997), Cohen and Chu (1997) Mizutani and Uranishi (2003), Cazals et al. (2005), Filippini and Zola (2005), Bradley et al. (2006), and Farsi et al. (2006)).<sup>6</sup> With the exception of Mizutani and Uranishi's contribution, their results accord well with intuition and confirm the existence of economies of scale and scope. Wada et al. (1997) estimated a multiproduct total cost function of the Japanese mail service by treating the delivery of letter mail and that of parcels as two independent outputs. Using a translog specification and panel data, they found evidence for the existence of overall economies of scale. Furthermore, their study highlights significant product-specific economies of scale for letter mail, but not for parcels. Cohen and Chu (1997) examined the issue of whether the postal services were natural monopolies, and estimated the total cost impact of splitting the U.S. Postal Service into two equally sized but separate organizations. They found the sum of the costs under the new arrangement to be greater than the costs of single-firm delivery and attributed the cost difference to scale economies in street delivery. Cazals et al. (2005) found evidence for economies of scale estimating a log-linear cost model of panel data of 509 delivery offices of Royal Mail operating in 2001 and 2002. In their paper, the authors emphasize the importance of treatment of heterogeneity between delivery offices.

Bradley et al. (2006) have built a structural model including delivery street time in a two step process and estimated a quadratic model of 145 delivery offices of U.S. Postal Service. They have found evidence for both large scale and scope economies. Filippini and Zola (2005) estimated a Cobb-Douglas cost frontier function for a small sample of post offices in Switzerland with combined collection and distribution processes and found empirical evidence for economies of scale. Their results suggested that efficiency gains could have resulted from merging smaller post offices operating in the same or in a small adjacent service area. Farsi et al. (2006) have examined a subset of 327 delivery offices in Switzerland and found evidence for economies of scale, density and scope, especially for units in remote areas with low mail volume.

Apart from delivery, only a few studies are available on economies of scale and scope in postal services. Bradley and Colvin (1999) focused on mail sorting and estimated a multiproduct total cost function for 250 US sorting centers between 1988 and 1996. They found evidence for substantial

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<sup>5</sup> For example, see for example Caves et al. (1981), Caves et al. (1984), Cabini and Filippini (2003) or Farsi et al. (2007) (transport sector), Koshal and Koshal (1999) or Sav (2004) (higher education), Fu and Heffernan (2008) (banking sector), Preyra and Pink (2006), Filippini (2001) or Farsi et al. (2008b) (health sector), Nerlove (1963), Filippini (1996), Fraquelli et al. (2004), Farsi et al. (2007) or Farsi et al. (2008a) (electricity distribution), Filippini and Luchsinger (2007) (hydropower).

<sup>6</sup> See also NERA (2004) for an overview on the relevant empirical literature.

economies of scale and enhanced productivity within the observed time span. The most recent investigations relevant for this study are those by Cazals et al. (2002) and Gazzei et al. (2002) on economies of scale in postal collection. Cazals et al. (2002) applied a multiproduct log-log cost function to analyze a cross-section dataset consisting of 9'168 French post offices operating in the year 1999. The results of their empirical analysis provide evidence of the existence of economies of scale, at least for small- and medium-sized post offices. No estimation of economies of scope is provided because the deployed functional form impedes straightforward computation. Gazzei et al. (2002) have implemented parametric (translog cost function) and non-parametric techniques to analyze a cross-section dataset consisting of 11'415 Italian post offices operating in the year 2000. They addressed the problem of unsaturation in post offices and its impact on the estimation of economies of scale. Their empirical analysis indicates the presence of economies of scale irrespective of the size of the offices. Table 1 recapitulates the most important studies on economies of scale and scope in the postal sector.

**Table 1: Relevant previous literature on economies of scale and scope in the postal sector**

Authors	Process	Data	Cost function	Scale	Scope
Wada et al. (1997)	distribution	panel, m.p.	translog	*, **, ***	n.c.
Cohen and Chu (1997)	distribution	cross-s. m.p.	quadratic	*, **, ***	n.c.
Bradley and Colvin (1999)	sorting	panel, m.p.	quadratic	*, **, ***	n.c.
Cazals et al. (2002)	collection	cross-s.; m.p.	log-log	*, **, ***	n.c.
Gazzei et al. (2002)	collection	cross-s.; s.p.	translog	*, **, ***	n.c.
Mizutani and Uranishi (2003)	distribution	pooled; s.p.	translog		n.c.
Cazals et al. (2005)	distribution	panel; s.p.	log-log	*, **, ***	n.c.
Filippini and Zola (2005)	collection / distribution	cross-s.; m.p.	log-log	*, **, ***	n.c.
Bradley et al. (2006)	collection / distribution	cross-s.; m.p.	quadratic	*, **, ***	*, **, ***
Farsi et al. (2006)	distribution	cross-s.; m.p.	quadratic	*, **, ***	*, **, ***

\*, \*\*, \*\*\*: large, medium and small units; n.c.: not calculated; m.p.: multi-product; s.p.: single-product

In this paper, we raise the question of economies of scale and scope of Swiss Post's collection network. Unlike earlier, when post office clerks conducted the processes of collection and distribution, both of these are now separated from each other organizationally and in most of the cases geographically. This restructuring measure was a trade-off between gaining economies of scale through merger of distribution bases and losing economies through vertical disintegration of the collection and distribution processes. The whole restructuring process was driven by the commissioning of new, more centralized sorting centers enabling the disentanglement of collection and distribution.

Generally, the reviewed studies present some limitations. First and most importantly, the issue of unobserved heterogeneity remains mainly undiscussed. Only Bradley and Colvin (1999) and Cazals et al. (2005) address this problem in the distribution process using fixed and random effects models, respectively, but none of the studies on the collection process takes a closer look on this issue. Second, Gazzei et al. (2002) indeed allude to the problem of unsaturation in post office networks

in their paper, but neither they nor the other authors propose a satisfying solution to quantify the impact of unsaturation.

We therefore introduce these two points as main novelties into the discussion of economies of scale and scope in postal collection networks. First, Swiss Post's collection units are characterized by considerable observed and, possibly, unobserved heterogeneity of the environmental and production situation. The unobserved part of the heterogeneity could create some econometric problems. In order to take into account this unobserved unit-specific heterogeneity, We apply a latent class model. Second, we include standby periods of opening time in the cost model specification. This variable will allow us to consider production process situations in which an office has to remain open even if demand is zero. Moreover, we control heteroskedasticity using a weighted least squares and a multiplicative heteroskedastic model. With these specifications, we expect more meaningful results than from crude approaches such as ordinary least squares.

### 3 COST MODEL SPECIFICATION AND ESTIMATION METHODS

We specify a cost model that explains total costs of Swiss Post's collection network with six aggregated output variables, one input variable, and two environmental characteristics. Under the assumption of cost-minimizing behavior of postal outlets and convex production technology, we write this model as follows:

$$C = f(Q_1, Q_2, Q_3, Q_4, Q_5, Q_6, P_C, dBM, dRA) \quad (1),$$

where the dependent variable  $C$  represents total cost. The first five outputs ( $Q_1 - Q_5$ ) are measured by the following parameters: letters, parcels, payment services, account management services, and sale of further products.

The sixth output,  $Q_6$ , is the variable that represents standby periods during the opening time of these post offices. This variable allows us to account for situations in which a post office counter has to remain open even if demand is zero. In these situations, the employees at the counters are not performing any specific tasks but are waiting to serve the next customers. Gazzei et al. (2002) classify this time as 'unsaturation' and point out that its presence causes misleading efficiency estimates and biased results for economies of scale. This (upward) bias arises due to the cost of unsaturation. In a saturated process, either costs are lower or outputs higher. Hence economies of scale in saturated processes are lower than in unsaturated processes. Standby time that causes this bias is not *a priori* a negative economic phenomenon such as inefficient organization or laziness of the employees, but it can be commercially optimal or politically desired. In the latter case, it might be set indirectly as a constraint by the universal service obligation regulations that require a comprehensive postal net-

work.<sup>7</sup> Consequently, the duty to operate such a network would imply a certain number of opening hours, even though the time absorbed by local demand might be lower. Our analysis has shown that the share of standby time is negatively correlated with opening hours; hence, it is relatively large in post offices with short opening hours. Note that post offices with short opening hours are usually small ones located in rural areas. Hence, despite short opening hours, these post offices still exhibit relatively high standby times.

In short, standby time arises due to the difference in the time absorbed by local demand and the opening time. As argued above, the provision of long opening hours is a service that is indirectly politically desired. Consequently, standby time is, to a large extent, a result of political obligations. We therefore interpret, unlike previous authors, this seemingly unproductive time as an output in the form of a public service.<sup>8</sup> A comparison might be drawn with emergency services characterized by a considerable number of standby hours. The standby time of fire brigades, for example, is widely accepted as public service.

For comparability reasons, we estimate the same model (2) (specified below) with the first five outputs ( $Q_1 - Q_5$ ) and treat  $Q_6$  as a hedonic characteristic of every single observation instead of standby time.

$P_C$  is the price of capital, measured by the cost of physical capital. The price of labor was not included in the model because it is set by a collective labor agreement and therefore does not vary significantly among units and regions.

Swiss Post's postal outlets differ considerably. Therefore, the dummy variables  $dBM$  (franchising business model, where the franchisees run a core business other than postal operations within the same infrastructure) and  $dRA$  (peripheral rural areas and alpine tourist center regions) are introduced in the model as environmental characteristics.<sup>9</sup> For a complete description of the variables with the corresponding data see Section 4.

The estimation of cost model (1) requires the specification of a functional form. We apply a quadratic functional form as it is locally flexible, straightforward to estimate and as it has the advantage of being able to take zero values into account.<sup>10,11</sup> As Section 4 will show, zero outputs occur in about

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<sup>7</sup> At least 90 percent of the population should be able to reach a post office within 20 minutes by foot or public transport.

<sup>8</sup> Standby time as a public service is not a pure public good because it is characterized only by nonrivalry, but not by nonexcludability. Standby time might appear to be an input to provide the other outputs, but the other outputs are provided without standby time, which is an independent service derived from the input labor.

<sup>9</sup> We are aware that model (1) does not completely capture the heterogeneity that characterizes the production process in postal outlets. However, the specification of six outputs should reduce the potential unobserved heterogeneity bias. Additionally, we use econometric approaches that minimize the residual bias (see Section 5).

<sup>10</sup> Other functional forms such as Cobb-Douglas or translog require adjustments, for instance through a Box-Cox transformation, because logarithms are not defined for non-positive arguments (see Box and Cox (1964)). In combination with the latent class model, such (non-linear) transformations might cause problems that lie far beyond the scope of this paper. As a first alternative, the zero values could be replaced with small values for example 0.00001 (small value transformation). But according to some authors (e.g. Pulley and Braunstein



one third of all observations for payment and/or account management services in agencies and in small post offices. The quadratic cost function was widely used by previous studies on economies of scale and scope in network industries, for example in Baumol et al. (1982), Jara-Diaz et al. (2003) or Farsi et al. (2007). In the non-homothetic form,<sup>12</sup> it can be written as:

$$C_i = \alpha_0 + \sum_{m=1}^M \beta_m Q_{mi} + \frac{1}{2} \sum_{m=1}^M \beta_{mm} Q_{mi} Q_{mi} + \sum_{m=1}^M \sum_{n>m}^M \beta_{mn} Q_{mi} Q_{ni} + \gamma_{P_C} P_{C_i} + \frac{1}{2} \gamma_{P_C P_C} P_{C_i} P_{C_i} + \sum_{m=1}^M \lambda_m P_{C_i} Q_{mi} + \delta_1 dBM_i + \delta_2 dRA_i + \varepsilon_i \quad (2),$$

where subscript  $i$  denotes postal outlet  $i = 1, 2, \dots, I$ .  $\varepsilon_i$  is the error term and subscripts  $m$  and  $n$  are product indices. As the quadratic function is a second order Taylor-approximation, the values of the explanatory variables have to be normalized to the approximation point. For this purpose, we choose the median value of the variables.<sup>13</sup>

#### 4 DATA

This study is based on a cross-section dataset of 2006 with information on 2,466 postal outlets operating in Switzerland.<sup>14</sup> These outlets have been subdivided into two classes according to their business model. The major part of it, namely 2'348 common post offices, are run by Swiss Post, whereas 118 agencies are run by franchisees.<sup>15</sup> The variable for the business model ( $dBM$ ) takes the value 1 for agencies, and 0 for common post offices. Approximately one-fifth of the post offices and one-third of the agencies are located in peripheral rural areas and alpine tourist center regions. These

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(1992) or Pulley and Humphrey (1993)), this transformation may lead to strongly biased results for economies of scope. Further alternatives are non-linear econometric approaches such as e.g. the composite cost function of Pulley and Braunstein (1992).

<sup>11</sup> For more on functional forms, see Lau (1986) or Kuenzle (2005). The textbook of Jehle and Reny (2001) offers in addition a closer look on duality and on Shephard's Lemma.

<sup>12</sup> A cost function is non-homothetic, if input prices depend on output levels, hence if input prices and output levels are not separable. In contrast, a homothetic cost function is separable in the sense:  $C(\mathbf{P}, \mathbf{Q}) = h(\mathbf{Q})c(\mathbf{P})$ . Further properties of the quadratic functional form: symmetry ( $\beta_{mn} = \beta_{nm}$ ), positivity ( $\beta_m \geq 0$ ) and non-linearity in input prices. Linearity (linear homogeneity) in input prices ( $C(t\mathbf{P}, \mathbf{Q}) = tC(\mathbf{P}, \mathbf{Q})$  for any  $t > 0$ ) cannot be imposed by parametric restrictions without scarifying the flexibility of the quadratic functional form (Caves et al. (1980)).

<sup>13</sup> The median value is better suited as an approximation point than the mean value, as it is less affected by outliers.

<sup>14</sup> This is an updated version of the data used by Jaag et al. (2009). We had to exclude four of the post offices and seven of the agencies due to missing values for total costs. Four more post offices turned out to be severe outliers with a Cook's distance exceeding the mean by a factor of more than 300. We excluded them as well.

<sup>15</sup> Agency is a generic term for different types of franchisee models; most of the franchisees run grocery stores or other retail businesses.

outlets are indicated by the value 1 of the corresponding dummy variable  $dRA$ . The reference region takes the value 0 and consists of urban areas and extended agglomerations.<sup>16</sup>

The postal outlets cover a wide range of costs and outputs. Total costs ( $C$ ) include expenditures for infrastructure such as capital costs or rental fees, and variable costs originate from counter activities. Total costs vary by a factor of more than one thousand among the postal outlets. All of these outlets collect mail and parcels and sell further products, whereas zero outputs may occur for payment and account management services in agencies and small post offices. These first four outputs are weighted sums of different subproducts of the corresponding output. We use the internal standards of performance as the weighting factor. As all postal outlets must comply with the same internal quality guidelines and principles, we assume comparable quality levels for all units.

Mail output ( $Q_1$ ) is a generic term for regular, express and registered letters including single piece and mass mail. It is calculated as the weighted sum of thousand letter items collected. Parcel output ( $Q_2$ ) is also measured in thousands, but incorporates more diverse products. Due to the similar nature of the processes involved, the weighted number of either single or bulk parcels collected is added to the weighted number of items picked up at the postal outlets by the clients. The output of payment services ( $Q_3$ ) is measured in million Swiss Francs transacted and can be understood analogously. The weighted volume of incoming payments is added to the weighted volume of outpayments. The fourth output, account management services ( $Q_4$ ), is the weighted number of thousand account openings (closings) and the weighted number of related consulting services. The fifth output, sale of further products ( $Q_5$ ), is measured by sales volumes of further products such as mobile phones, prepaid cards, tickets or stationery, measured in thousand Swiss Francs.

The variable representing standby time ( $Q_6$ ) is an important cost driver at least for smaller post offices, measured in hours per week. This variable allows us to consider production process situations in which a post office counter has to remain open even if local demand is zero. As standby time is neither directly observable nor measurable, we calculated it in the following way:

$$\text{Standby time} \equiv OH_i - \frac{\sum_{m=1}^M Q_m t_m}{n_i} \quad (3),$$

hence we multiplied the standard of performance value  $t_m$  necessary to completely operate one item or transaction  $m$  with the corresponding number of items or transactions  $Q_m$  occurring in a postal outlet and added it up. We divided this value by the number of active counters  $n$  and subtracted the result from the opening hours  $OH$ . In the case of zero demand we assume that all counters close down except for one. Hence, we assume that at most one employee is confronted with standby time at the

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<sup>16</sup> Classification implemented by the Federal Office of Spatial Development. The other data were provided by Swiss Post.

same time.<sup>17</sup> For the reasons provided in Section 3, we interpret standby time as public service and hence as output. It takes the value zero in post offices working at full capacity and in all agencies because neither is confronted with unsaturated processes (time not spent on servicing postal customers would presumably be absorbed by complementary activities of the core business). The share of standby time is negatively correlated with  $OH$  and positively with  $dRA$ .

The cost of physical capital ( $P_C$ ) is measured by the rental fee per square meter (ratio of the rental fee and rented surface area). These costs are, as expected, clearly higher in urban areas and agglomerations than in rural areas.

## 5 ECONOMETRIC APPROACHES

As expected, a preliminary econometric analysis showed that the data are affected by heteroskedasticity. We expected heteroskedasticity due to a wide range of costs and outputs between ‘small’ and ‘large’ postal outlets (see Section 4). In order to account for this problem, an advanced econometric specification of the error term has been considered and compared to the ordinary least squares (OLS) model. The weighted least squares (WLS) model is a version of a robust regression, where variances of the error terms are calculated in an iteratively accomplished process and assumed to be proportional to the square of the dependent variable. The process starts with the variance predicted by the OLS model and stops when changes in the variances fall below a certain limit. The specification of the variances of these two models can be summarized as follows:

$$\text{OLS model: } \varepsilon_i \sim iid(0, \sigma^2)$$

$$\text{WLS model: } \varepsilon_i \sim iid(0, \sigma_i^2), \sigma_i^2 = \sigma^2 (C_i^{\text{iteratively weighted}})^2 \quad (4).$$

Apart from heteroskedasticity, we anticipate unobserved unit-specific heterogeneity across the postal outlets, for example originated by other output or environmental characteristics that are not included in the model. It is further conceivable that operational procedure differs among various units because they might use different technical equipment or serve more high-volume customers in relative terms. Such unobserved factors could influence the marginal effects of the observed variables and therefore affect the estimates of economies of scale and scope.

These possible effects can be taken into account with common approaches like random effects or random coefficients models, if panel data are available. With cross-section data, however, other methods such as clustering, latent class estimation or quantile regression techniques are suited to cap-

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<sup>17</sup> This is of course a strong assumption for very short periods of zero demand, but it certainly holds during off-peak hours.

ture unit-specific effects.<sup>18</sup> Latent class analysis, originally introduced by Lazarsfeld and Henry (1968), is a stochastic procedure for identifying distinctive class membership among subjects regarding their cost structure and estimating a separate cost function for each of these categories simultaneously. This technique has lately been applied in different fields of science and industry sectors.<sup>19</sup> Latent class estimation involves maximizing a log-likelihood function and outplays many of the cluster analysis methods because no decisions about the scaling of mixed measurement levels are necessary. Furthermore, rigorous statistical tests and diagnostic statistics as the Akaike Information Criterion (AIC) or the Bayesian Information Criterion (BIC) are included in the model setting to estimate the optimal number of classes.

The primary problem of latent class models is that their estimation requires a large number of parameters. The current latent class model specified in Equation (3) contains 37 independent variables and one constant *per class*. This might cause severe numerical problems maximizing the likelihood function with increasing number of classes and uses umpteen degrees of freedom. The higher the expected unit-specific heterogeneity among postal outlets, the higher the required number of classes. With a sufficiently large number of classes, the model approximates a full random-parameters model (Greene (2008)). The estimation of a homothetic model could solve the problem, as the number of parameters is less. However, separability of the cost function is a strong assumption in the actual case<sup>20</sup> such that the results of homothetic models might differ severely from non-homothetic models.

We therefore estimate a non-homothetic latent class model using cost model (1) with the quadratic functional form (2) for each class  $j$  in  $J$ :

$$\begin{aligned}
C_i = & \alpha_{0i} + \sum_m^M \beta_{mi} Q_{mi} + \frac{1}{2} \sum_m^M \beta_{mni} Q_{mi} Q_{ni} + \sum_{m(m \neq n)}^M \sum_n^M \beta_{mni} Q_{mi} Q_{ni} \\
& + \gamma_{P_{ct}} P_{Ci} + \frac{1}{2} \gamma_{P_c P_{ct}} P_{Ci} P_{Ci} + \sum_m^M \lambda_{mi} P_{Ci} Q_{mi} + \delta_{1i} dBM_i + \delta_{2i} dRA_i + \varepsilon_i
\end{aligned} \tag{5}$$

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<sup>18</sup> Quantile regression, originally introduced by Koenker and Basset (1978), is actually well suited to capture unobserved heterogeneity. But disadvantageously for our case, the coefficients have to be estimated separately for every quantile. The resulting economies of scale and scope are therefore not comparable to economies of scale and scope calculated from coefficients effective for the entire dataset.

<sup>19</sup> For example in the banking industry (Orea and Khumbhakar (2004), Greene (2005)), in the energy sector (Cullmann (2009)) or in agriculture (Corral et al. (2009)). The book *Applied Latent Class Analysis*, edited by Hagenaars and McCutcheon (2002), shows further applications of latent class models in marketing, psychology and other social sciences.

<sup>20</sup> Especially outputs that are not covered by the Universal Service Obligation, for instance account management or the sale of further products are not independent of the location hence not of the capital price of a post office as there is competition for banking services and retail goods.

The subscript  $i$  in Equation (3) denotes the postal outlets and  $\varepsilon_i \sim N(0, \sigma_i^2)$ .  $\alpha_i$ ,  $\beta_i$ ,  $\gamma_i$ ,  $\delta_i$  and  $\sigma_i$  are discrete random parameters identified in  $j = 1, 2, \dots, J$  classes, endowing each observation with the class-specific characteristics. These random parameters are distributed among the classes by the following rule:

$$\{\alpha_i, \beta_i, \gamma_i, \delta_i, \sigma_i\} = \{\alpha_j, \beta_j, \gamma_j, \delta_j, \sigma_j\} \text{ with probability } p_j \text{ and } \sum_{j=1}^J p_j = 1 \quad (6).$$

Hence, each observation belongs to class  $J$  with a certain probability  $p_j$ , which has been obtained using Bayes Theorem. For estimation, the number of classes  $J$  is assumed to be known, but, as the ongoing discussion in literature shows, there is no reason to expect this (Greene (2008)). A likelihood ratio test could in principle be used to test a model with  $J$  classes against one with  $J-1$  classes, but the accurate number of degrees of freedom remains unclear.  $J$  is, therefore, typically chosen on the basis of diagnostic criteria such as the Akaike Information Criterion (AIC) or the Bayesian Information Criterion (BIC). The smaller these statistics, the more likely is the corresponding model.<sup>21</sup>

## 6 RESULTS

This section shows the estimation results of the two basic models (OLS and WLS) and of the latent class model as well as considerations to the distribution of the class memberships of the latent class model in Subsection 6.1 and the corresponding values for economies of scale and scope in Subsection 6.2.

### 6.1 Estimation results and classification of the sample

We first throw light on the estimation results of the two basic model (OLS and WLS) and of the latent class model with two latent classes, listed in Table 2.

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<sup>21</sup> These statistics are the values of  $-2 \cdot \ln(\text{likelihood})$  corrected by  $2 \cdot \#\text{parameters}$  for the AIC and  $\#\text{parameters} \cdot \log(N)$  for the BIC, respectively.

**Table 2: Regression results**

Variable	OLS		WLS		Latent Class (classes 1 and 2)			
	Coefficient	(SE)	Coefficient	(SE)	Coefficient	(SE)		
Mail output ( $Q_1$ )	1080.844 ***	(56.14)	1290.086 ***	(34.04)	1464.911 ***	(103.2)	1003.143 ***	(43.85)
0.5*( $Q_1 Q_1$ )	-0.284 ***	(0.028)	-0.137 ***	(0.017)	-0.763 ***	(0.138)	-0.186 ***	(0.026)
Parcel output ( $Q_2$ )	15780.892 ***	(1190)	14073.189 ***	(723.1)	8307.438 **	(3381)	20653.499 ***	(856.7)
0.5*( $Q_2 Q_2$ )	270.193 ***	(59.37)	370.084 ***	(35.97)	71.873	(189.1)	-422.570 ***	(74.48)
Payment services ( $Q_3$ )	3689.264 ***	(162.2)	2775.712 ***	(98.24)	3372.123 ***	(354.5)	2674.364 ***	(107.1)
0.5*( $Q_3 Q_3$ )	-2.225 **	(1.116)	2.947 ***	(0.702)	-7.519 ***	(2.51)	1.053	(0.966)
Account mgmt ( $Q_4$ )	263'643 ***	(46023)	330'065 ***	(28068)	482'166 ***	(102604)	230'989 ***	(28683)
0.5*( $Q_4 Q_4$ )	166'741 ***	(49260)	72'800 *	(42261)	-348'950 **	(148525)	-153'969 ***	(35230)
Further sales ( $Q_5$ )	361.864 ***	(79.67)	458.407 ***	(48.3)	423.533 **	(208.4)	378.957 ***	(53.39)
0.5*( $Q_5 Q_5$ )	-0.165	(0.411)	0.062	(0.25)	0.813	(1.037)	-1.159 ***	(0.308)
Standby time ( $Q_6$ )	162.346 ***	(18.18)	147.879 ***	(11.05)	118.418 *	(62.99)	130.328 ***	(12.11)
0.5*( $Q_6 Q_6$ )	-0.055	(0.054)	0.002	(0.033)	-0.042	(0.161)	-0.010	(0.037)
( $Q_1 Q_2$ )	-7.173 ***	(1.304)	-17.260 ***	(0.791)	0.869	(4.799)	-8.743 ***	(1.506)
( $Q_1 Q_3$ )	-0.066	(0.213)	-0.933 ***	(0.129)	-0.613	(0.44)	2.028 ***	(0.171)
( $Q_1 Q_4$ )	101.108 **	(49.52)	-157.718 ***	(30.04)	100.279	(91.1)	-143.249 ***	(53.51)
( $Q_1 Q_5$ )	0.538 ***	(0.167)	2.313 ***	(0.101)	0.663 **	(0.336)	0.032	(0.144)
( $Q_1 Q_6$ )	0.255 ***	(0.087)	0.493 ***	(0.053)	0.144	(0.168)	0.211 ***	(0.065)
( $Q_2 Q_3$ )	-29.226 ***	(7.641)	24.566 ***	(4.645)	6.760	(17.11)	36.581 ***	(6.799)
( $Q_2 Q_4$ )	-2571.837	(1867)	-2227.768 *	(1151)	1499.923	(3927)	-4587.311 **	(1917)
( $Q_2 Q_5$ )	-3.248	(4.949)	-39.607 ***	(2.999)	-28.384 ***	(10.23)	-10.776 **	(4.703)
( $Q_2 Q_6$ )	2.162	(1.676)	-5.662 ***	(1.015)	8.723 **	(3.899)	-8.893 ***	(1.257)
( $Q_3 Q_4$ )	664.912 ***	(184.1)	766.183 ***	(133)	1769.239 ***	(510.7)	-889.885 ***	(175.1)
( $Q_3 Q_5$ )	2.448 ***	(0.542)	-1.726 ***	(0.33)	3.706 ***	(0.997)	-4.716 ***	(0.443)
( $Q_3 Q_6$ )	-0.473 **	(0.198)	0.216 *	(0.12)	-0.219	(0.441)	0.091	(0.149)
( $Q_4 Q_5$ )	-591.450 ***	(142.1)	24.648	(87.56)	-673.928 ***	(258.3)	2061.495 ***	(129.5)
( $Q_4 Q_6$ )	114.372 **	(49.72)	141.790 ***	(30.15)	112.909	(107.6)	194.126 ***	(39.47)
( $Q_5 Q_6$ )	0.168	(0.12)	0.103	(0.073)	-0.238	(0.275)	0.267 ***	(0.09)
Price capital ( $P_C$ )	1206.521 *	(684.9)	2398.950 ***	(415.1)	-2452.424	(2490)	2562.538 ***	(446.1)
0.5*( $P_C P_C$ )	-75.603	(67.5)	75.375 *	(41.01)	82.441	(132.3)	101.775 **	(48.99)
( $P_C Q_1$ )	4.404 **	(2.095)	4.118 ***	(1.272)	22.617 ***	(4.742)	-17.846 ***	(1.811)
( $P_C Q_2$ )	317.738 ***	(70.2)	193.145 ***	(42.53)	224.946 *	(123.9)	319.082 ***	(58.47)
( $P_C Q_3$ )	-18.072 **	(7.805)	-54.306 ***	(4.736)	-42.283 ***	(14.93)	60.766 ***	(5.213)
( $P_C Q_4$ )	-3873.413 **	(1919)	-940.279	(1163)	-5287.129	(3912)	-195.553	(1347)
( $P_C Q_5$ )	-1.629	(4.26)	19.047 ***	(2.583)	-5.085	(7.731)	-5.442 **	(2.571)
( $P_C Q_6$ )	7.089 ***	(1.309)	2.528 ***	(0.793)	9.506 **	(3.903)	2.361 ***	(0.9)
Business model ( $dB_M$ )	-88'620 ***	(22906)	-82'305 ***	(13888)	-166'146 **	(72677)	-60'071 ***	(17774)
Region ( $dRA$ )	61'920 ***	(13548)	30'339 ***	(8208)	187'400 ***	(46158)	17'337 *	(9454)
Constant	715'180 ***	(6912)	706'515 ***	(4195)	750'465 ***	(31734)	715'141 ***	(4953)
Sigma					259'649 ***	(6476)	90'167 ***	(2345)

\*\*\*, \*\*, \*: significant at 1%, 5% and 10%, respectively; standard errors are given in brackets; values not in CHF.

n = 2'466

Irrespective of the model, the entire first- and most of the second-order coefficients of the output variables have the expected sign and are highly significant. In particular, the values for the standby time confirm the expectation that unsaturated processes occur and increase cost substantially. The input price of capital shows that parts of the differences among postal outlets can be explained by high capital costs. Further, the coefficients for the business model and the region leave no doubt: firstly,

agencies generate considerable cost reductions compared to common post offices, and secondly, postal outlets in sparsely populated and touristic regions drive costs.

As expected, the results of the OLS model differ strongly from the WLS model. These differences suggest that ignoring heteroskedasticity may cause bias in the calculation of economies of scale and scope. Therefore, the WLS model is more relevant for the empirical analysis of the economies of scale and scope. Nevertheless, we use both of them to compute the economies of scale and scope at the approximation point (sample median) and at the quartiles in the sample to shed light on the impact of the magnitude and the composition of the output.<sup>22</sup>

To test the hypothesis if postal outlets in Switzerland operate with different methods, we estimate a latent class model. Within this framework we allow post offices to have different underlying methods or even production technologies, caused by unobserved factors or variations in customer structure. Estimating a latent class model requires an à priori determination of the number of classes (see Section 5). Applying the Akaike Information Criterion, the empirical analysis with two up to four classes favors the definition of two classes, as the maximum likelihood estimation with three and four classes did not converge to meaningful solutions. Two classes are appropriate to test the hypothesis of unobserved heterogeneity for smaller and larger postal outlets. The estimation results of the two classes support this hypothesis, as most of the variables differ significantly in terms of level and significance.

The prior class probabilities in Table 3 show a latent sorting of the postal outlets into the classes with just under one third (31%) belonging to the first and the remaining (69%) to the second class. With little exceptions, which are all located in urban areas, agencies belong to the second class whereas post shops (integrated stores, mostly in intra-urban post offices) occur disproportionately often in the first class.

**Table 3: Prior class probabilities**

	p (class)	(se)	n	<i>dB</i> M	<i>dR</i> A	<i>dB</i> M & <i>dR</i> A	P-Shop
Class 1	0.311 ***	(0.018)	375	8	35	0	37
Class 2	0.689 ***	(0.018)	2'091	110	274	38	39
	1.000		2'466	118	309	38	76

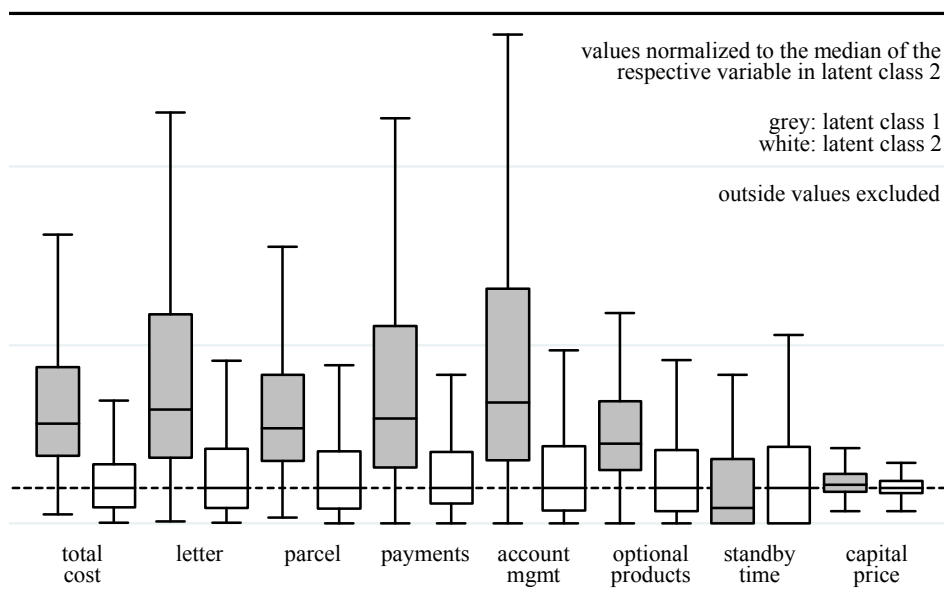
\*\*\*, \*\*, \*: significant at 1%, 5% and 10%, respectively; standard errors are given in brackets.

To get deeper insights into the characterization of both classes, we compare important economic and physical data. Figure 1 shows the box plots for total costs and the outputs of both classes, normalized to the median of the respective variables in the second class. We can derive one clear trend: class 1 incorporates larger post offices with considerably higher costs and outputs; class 2 seems to

<sup>22</sup> Taking into account the experiences from other studies, the levels of the variables listed in Table 4 and Table 5 should be treated with caution because of the lack of panel data.

include smaller post offices and agencies. Especially, the demand of cost-intensive and complex services subsumed under “account management” is higher, its median value triples in class 1 compared to class 2, and even the difference in the sale of further products is obvious. Only the output standby time does not correspond to this pattern as it is smaller in class 1 than in class 2. However, this observation is in line with my argumentation in Section 4 where we stated that the share of standby time is negatively correlated with opening hours, hence that larger offices have relatively low standby time.

**Figure 1: Box plots of important characteristics in latent classes 1 and 2**



To summarize, the post offices in class 1 can be characterized as larger concerning total costs, volume and opening hours than post offices in class 2, and they further exhibit a higher share of post shops and a lower share of agencies, whereas the standby time of post offices in class 2 is superior. Hence, class 1 subsumes large and class 2 small postal outlets. In Subsection 6.2, we will test if economies of scale and scope differ significantly between these two classes.

## 6.2 Results for economies of scale and scope

The results of the econometric estimation of the multiproduct cost function (2) can be used to compute economies of scale and scope.

The concept of economies of scale investigates whether or not a company operates at an economically reasonable size. Economies of scale are measured by the ratio between average and marginal costs, and the optimal size of a unit is reached if this ratio equals unity. In the presence of (dis)economies of scale, ray average costs increase (decrease) when all outputs increase proportionately. In such a situation, postal outlets would be oversized (undersized).



The concept of economies of scope examines whether or not a company operates with an optimal product mix. If (dis)economies of scope are present between the different products and services offered in postal outlets, it is advantageous to offer them jointly in the same unit (separately in different units). Economies of scope can arise from two sources: first, the spreading of fixed costs over an expanded product mix (e.g. the sale of further products in the same infrastructure as the collection of mail and parcel), and second, cost complementarities among product categories in production (e.g. the provision of payment services reduces the cost to provide account management services, as the first is often conditioned on having an account at Swiss Post).<sup>23</sup>

Widely used definitions of economies of scale and scope of multi-output companies go back to Baumol et al. (1982). According to these definitions, the values of (global) economies of scale can be computed as follows:

$$\text{Economies of Scale} \equiv \frac{C_i}{\sum_{m=1}^M Q_{mi} \frac{\delta C_i}{\delta Q_{mi}}} \quad (7),$$

where  $\delta$  denotes the partial derivative operator and, hence,  $\frac{\delta C_i}{\delta Q_{mi}}$  the marginal cost of output  $m$ .

Accordingly, the values of (global) economies of scope are given by:

$$\text{Economies of scope} \equiv \frac{\sum_{m=1}^M C_i(Q_{mi}, 0, 0, 0, 0, 0) - C_i(Q_{1i}, Q_{2i}, Q_{3i}, Q_{4i}, Q_{5i}, Q_{6i})}{C_i(Q_{1i}, Q_{2i}, Q_{3i}, Q_{4i}, Q_{5i}, Q_{6i})} \quad (8),$$

where  $C_i(Q_{mi}, 0, 0, 0, 0, 0)$  represents the cost of specialized and  $C_i(Q_{1i}, Q_{2i}, Q_{3i}, Q_{4i}, Q_{5i}, Q_{6i})$  of integrated postal outlets. Note that none of the outlets in our sample is highly specialized such that it only produces one of the six outputs. However, as Pulley and Braunstein (1992) argue, measuring economies of scope requires estimating the cost function at points with some empirical support, hence simulating situations really occurring in the data. Consequently, they suggest the estimation of *quasi economies of scope*, where firm specialization is imperfect, as it stands for producing basically one output and the others to a very small extent  $\mu$ .<sup>24</sup> Nevertheless, we focused on economies of scope as pro-

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<sup>23</sup> Pulley and Humphrey (1993) expounded different functional forms to differentiate between these two sources. Disadvantageously with the quadratic functional form, fixed cost and cost complementarities are not distinguishable. Therefore, economies of scope are quite sensitive to the constant and have to be interpreted with caution. An alternative specification when having single-output outlets in the sample would be a flexible fixed cost model, which includes several intercepts depending on the outlet's output combination, suggested by Mayo (1984) and Panzar (1989).

<sup>24</sup> To simulate such situations, they extended the formula for economies of scope in the following way:

posed by Baumol et al. (1982) for two reasons: firstly, partially specialized postal outlets with at least some of the outputs being zero occur in the sample, and secondly, previous analysis has shown that the differences between the two methods are marginal.<sup>25,26</sup>

The results of the economies of scale and scope are provided in Table 4 and Table 5. We distinguish between economies stemming from simulation and from sample data. In the first four lines of each model, we depict the values of economies of scale and scope for hypothetical (simulated) postal outlets with all outputs set at the sample median and the sample mean at the first or third quartiles, respectively. Of course, a unit exhibiting exactly these values might hardly or mere coincidentally exist in the data, but representative points are best suited for comparison reasons. As an exception, the values for  $Q_6$  (standby time) are set at the sample median throughout all representative points. The standard errors for the latent class model were not computed due to calculation restrictions on the one hand and due to uncertainties on interdependencies between the two classes on the other.<sup>27</sup> The four subsequent lines belong to representative postal outlets in the sample, separately for post offices in urban and rural regions, for agencies and for all of the postal outlets existing in the data set. As these are mean values of the economies of each observation, standard errors do not exist.

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$$\text{Quasi economies of scope} \equiv \frac{\sum_{m=1}^M C(\mu Q_{\neq mi}, (1 - (M - 1)\mu)Q_{mi}) - C(Q_{1i}, Q_{2i}, Q_{3i}, Q_{4i}, Q_{5i}, Q_{6i})}{C(Q_{1i}, Q_{2i}, Q_{3i}, Q_{4i}, Q_{5i}, Q_{6i})}. \text{ Thus, } \mu \text{ must be smaller}$$

than  $1/M$  to achieve post office specialization.

<sup>25</sup> In this preliminary analysis, we choose  $\mu = 0.05$ , which seems to be reasonable with  $1/M = 0.167$ .

<sup>26</sup> Caves et al. (1984) propose a refinement of the analysis of economies of scale in network industries. A variable representing the density of the network is used to distinguish between economies that stem from expanding the outputs and the network size by the same factor (economies of scale) and those that stem from expanding the output in the existing network (economies of density). This differentiation is of no relevance in the case of postal collection networks, because unlike mail and parcel distribution, railways or energy distribution, only the nodes of the network cause costs, the network itself is of a virtual nature.

<sup>27</sup> The standard errors have been calculated using the delta method:  $\text{se}(\text{SC}) = ((\text{Avar}(\text{SC})) * n^{-1})^{0.5}$ , where  $\text{Avar}(\text{SC}) = [\delta \text{SC} / \delta \beta]' [\text{VCE}(\beta)] [\delta \text{SC} / \delta \beta]$  with  $[\delta \text{SC} / \delta \beta]$  as a  $\#p \times 1$  and  $[\text{VCE}(\beta)]$  as a  $\#p \times \#p$  matrix. For more details on the delta method, see Hayashi (2000). For the latent class model the number of parameters and hence the number of partial derivatives to be calculated ( $\#p = 79$  for the model with two classes) is prohibitive for a sensible estimation of the errors using the available software. Besides that, one has to decide whether the classes should be considered as independent from each other or not. On the one hand, if so, only the second and the fourth quadrant of the  $\text{VCE}(\beta)$  with all the variances and the intra-class covariances should be considered, i.e. the inter-class covariances in the first and third quadrant are assumed to be zero. This is a very strong assumption and might entail misleading results. On the other hand, if the classes are considered as dependent, the standard errors of one class are affected by the parameters, variances and covariances of both classes to the same degree, which might be wrong, too. As the assumption on the dependence of the two classes is arbitrary, we did not calculate the standard errors for the economies of scale and scope of the latent classes.

**Table 4: Economies of scale (OLS-, WLS-, and LC-model)**

Economies of Scale		OLS	WLS	WLS	Latent Class	
				5 Outputs	Class 1	Class 2
Simulation	1 <sup>st</sup> quartile, post office	1.018 ** (0.008)	1.020 *** (0.005)	1.098 *** (0.005)	1.037 (n.c)	1.120 (n.c)
	Median, post office	1.001 (0.043)	1.030 (0.027)	1.333 *** (0.020)	(1.163) (n.c)	1.107 (n.c)
	3 <sup>rd</sup> quartile, post office	1.278 *** (0.074)	1.190 *** (0.038)	1.608 *** (0.042)	(1.578) (n.c)	1.163 (n.c)
	Mean, post office	1.043 *** (0.010)	1.048 *** (0.006)	1.102 *** (0.005)	1.071 (n.c)	1.079 (n.c)
Sample	Mean, post offices urban	1.085	1.115	1.286	1.027	1.228
	Mean, post offices rural	1.292	1.349	1.924	(1.481)	1.257
	Mean, agencies	1.815	0.981	0.981	(1.692)	1.114
	Mean, all postal outlets	1.143	1.140	1.372	1.299	1.220

\*\*\*, \*\*, \*: significant at 1%, 5% and 10%, respectively; standard errors are given in brackets, n. c.: not calculated.  
Several values of latent class 1 are given in brackets as hardly offices of this size or type occurs in the data. n = 2'466

These results suggest that the postal outlet network in Switzerland is considerably affected by unexploited *economies of scale*, irrespective of the model, of the number of outputs or of the simulated and sample outlets.

The results for the hypothetical offices show for the heteroskedasticity-corrected WLS model that economies of scale increase with falling outputs and therefore with smaller post offices, even though we did not vary the magnitude of the standby time. Therefore, this finding is more pronounced in the same model with five outputs, as the share of standby time is negatively correlated with opening hours and hence with the size of an office. In other words, the difference between five and six outputs is highest in smaller offices (simulated in the third quartile) as these offices are most affected by standby time. The two latent classes display a different pattern: economies of scale of the first class increases fast, whereas it is almost stable in class 2. However, the median and third quartile offices in class 1 get hardly empirical support in real data and are put in brackets, as most of them are large. Therefore, only the value of the first quartile is representative for post offices in class 1.<sup>28</sup> Interestingly, simulated offices with mean values exhibit similar values for economies of scale, irrespective of the model.

The results for the sample offices show that rural offices are more affected by unexploited economies of scale than the ones located in urban and suburban regions. The mean value of the agencies in the WLS model is the only one that falls below one and is of the same magnitude for five and six outputs because agencies do not exhibit standby time. At large, sample mean values must be interpreted with caution, especially for agencies, as they are strongly influenced by outliers. For example,

<sup>28</sup> The results of the latent class analysis argue for a supplemental quantile regression analysis. Due to the lack of comparability, we dispense with it.

only eight out of the 118 agencies and 35 of the rural post offices are in class 1 (see Table 3). Again, as in the simulated case, these values are put into brackets.

The overall findings on economies of scale are well authenticated through the scatterplots of the WLS model for every post office in the sample with five and six outputs (see Figure 2 in the appendix, scatterplots on the left hand side). The postal outlet network in Switzerland is considerably affected by unexploited economies of scale and the smaller the office (approximated through the regulator's ranking), the higher the value for the economies of scale.

Like the results for economies of scale, considerable *economies of scope* appear in almost every category of postal outlets. Hence, the models suggest that it is generally favorable to provide postal products and services jointly within the same infrastructure. Again, for the simulated offices, economies of scope increase with falling outputs and therefore with smaller post offices, and the specification with five outputs is less favorable in terms of economies of scope. Overall, rural post outlets appear to face higher economies of scope than urban or suburban outlets. At large, sample mean values must be interpreted with caution, especially for agencies, as they are strongly influenced by outliers. Besides, note that in agencies economies of scope arise not primarily between postal products themselves, but mainly between postal products and all other products such as groceries etc., see Buser et al. (2009). As we analyze agencies from Swiss Post's point of view, such third-party further products are not included in the dataset and hence our measures of economies of scope are limited to postal products. However, economies of scope between groceries and postal products might be reflected indirectly by *dbm* which can be interpreted as Swiss Post's share of cost savings that are realized by the agency model by exploiting economies of scope between postal services and groceries.

**Table 5: Economies of scope (OLS-, WLS-, and LC-model)**

Economies of Scope	OLS	WLS	WLS	Latent Class		
			5 Outputs	Class 1	Class 2	
Simulation	1 <sup>st</sup> quartile, post office	0.225 *** (0.060)	0.471 *** (0.039)	0.623 *** (0.030)	0.223 (n.c)	0.088 (n.c)
	Median, post office	-0.177 (0.131)	0.402 *** (0.077)	1.553 *** (0.051)	(0.775) (n.c)	0.244 (n.c)
	3 <sup>rd</sup> quartile, post office	0.028 (0.236)	0.690 *** (0.135)	2.157 *** (0.064)	(1.854) (n.c)	0.618 (n.c)
	Mean, post office	0.262 *** (0.068)	0.528 *** (0.043)	0.584 *** (0.032)	0.380 (n.c)	0.117 (n.c)
Sample	Mean, post offices urban	0.241	0.655	1.018	0.710	0.549
	Mean, post offices rural	0.893	1.154	1.731	(0.134)	0.531
	Mean, agencies	-2.399	1.097	0.194	(0.838)	-5.362
	Mean, all postal outlets	0.173	0.736	1.123	0.659	0.415

\*\*\*, \*\*, \*: significant at 1%, 5% and 10%, respectively; standard errors are given in brackets, n. c.: not calculated.  
Several values of latent class 1 are given in brackets as hardly offices of this size or type occurs in the data. n = 2'466

Astonishingly, economies of scope are more accentuated in latent class 1. At first glance, this result is somewhat contra-intuitive, as the offices in this class are larger concerning outputs and there-

fore an office specialization seems to be more legitimate than in offices with lower outputs. However, latent classes might comprise information that is not enclosed output data, but refers to further heterogeneity that raises the level of economies of scope in class 1. This argument is supported by the fact that economies of scope in both classes follow an expected pattern as it increases with falling outputs.

The overall findings on economies of scope are well authenticated through the scatterplot of the WLS model for every post office in the sample with five and six outputs (see Figure 2 in the appendix, scatterplots on the right hand side). The postal outlet network in Switzerland is considerably affected by unexploited economies of scope and the smaller the office (approximated through the regulator's ranking), the higher the value for the economies of scope.

For what economies of scope are concerned, global values are somewhat unnatural measures. To get deeper insights, product-specific measures could improve the explanatory power of the analysis. For example, a comparison of offices partly specialized in logistics (letter and parcel) and in banking (payment services and account management) with fully integrated offices would be more enlightening. Nevertheless, we desisted from it, because the allocation of the sale of further products and particularly of the standby time was arbitrary.

Last but not least, the question arises whether the two classes of the latent class model are statistically different. This can be confirmed by means of the Kruskal-Wallis equality-of-populations test, which examines the hypothesis that there is no difference between the two samples. For the economies of scale, the p-value is 0.0002 and for the economies of scope 0.0003. These results indicate that we can reject the hypothesis of equal distribution of the classes. We can, therefore, conclude that accounting for unobserved heterogeneity in the econometric specification of the model leads to more robust results than common techniques as we adapt differences in methods and technologies more accurately.

## 7 SUMMARY AND CONCLUSIONS

The purpose of this study was to analyze the cost structure of Swiss Post's postal outlets, and in particular to assess economies of scale and scope in post offices and franchised postal agencies. Information on the optimal size and production structure is of importance from a policy-makers' point of view, as this hypothetical situation may be a calculation basis of reimbursements for providing the universal service. Furthermore, from a company's perspective, the question of the optimal organization of the network also arises. Important questions are the optimal size of post offices, whether and where common post offices should be transformed into agencies, or whether product lines should be offered in post offices or agencies operated by partners.

Two important novelties are introduced in this study. First, the latent class model accounts for postal outlets with different underlying methods or even production technologies, caused by unob-

served factors. Second, the cost model includes standby time as an indicator of public service because regulated accessibility and negotiated opening hours that enhance public service frequently lead to opening hours that exceed the time necessary to operate the demand.

A quadratic total cost function was estimated using a cross-section consisting of 2'466 post offices and agencies operating in the year 2006. The estimation results with two latent classes and the corresponding equality-of-populations test support the hypothesis of unobserved heterogeneity: many of the variables vary significantly in level, but scarcely concerning significance. The segmentation of the data reveals one class with high outputs and one with high standby time. Moreover, the empirical analysis shows that standby time has an important effect on cost and hence on economies. Overall, the subsequent empirical results indicate the presence of strong economies of scale and economies of scope, especially for postal outlets with low output volumes.

The empirical results suggest that the postal outlet network in Switzerland is considerably affected by unexploited *economies of scale*, irrespective of the model, of the number of outputs or of the simulated and sample outlets. Rural offices are more affected by unexploited economies of scale than the ones located in urban and suburban regions, and agencies more than post offices. Further, the latent class analysis of unobserved heterogeneity points on two highly different courses of economies of scale. Beyond that and even more importantly, economies of scale of the hypothetical offices increase with falling outputs, even though the share of standby time is larger in smaller offices. This gives rise to a more pronounced increase of economies of scale with falling outputs in the model without standby time. Therefore, Swiss Post would benefit from transforming smaller post offices in rural regions into agencies. This change of the business model would also reduce standby time and, therefore, cost.<sup>29</sup>

Considerable *economies of scope* appear in almost every category of postal outlets, much like the results for economies of scale. Hence, the models suggest that it is generally favorable to provide postal products and services jointly within the same infrastructure. However, the results for economies of scope do not reveal a likewise accentuated pattern as for economies of scale because its values in latent class 1 are higher than in class 2. However, economies of scope follow an expected pattern in both classes because it increases with falling outputs, as it is the case in the other models. Again, rural post offices are more affected by unexploited economies of scope than the ones located in urban or suburban regions. These results support Swiss Post's policy to offer postal and financial services as well as the sale of further products within the same infrastructure. Sales expansion of further products and other services might be an alternative second-best strategy for transforming common post offices into agencies in the case of political or regulatory opposition.

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<sup>29</sup> Note that standby time is not meaningful for agencies as time not spent on servicing postal customers would presumably be absorbed by complementary activities of the core business.

Opposition against post office closures (or replacements by third-party agencies) is mainly based on two factors in Switzerland. Firstly, agencies do not provide payment services in cash due to security and anti-money-laundering measures. Therefore, they fail to fulfill a small share of the universal service. For this situation, the issue of the legitimate extent of the universal service needs to be discussed and, if necessary, properly reimbursed. Secondly, common post offices appear to contribute to the identity of villages, especially in remote areas. Closing down other retail businesses and small enterprises may foster resistance against post office conversions. On the other hand, joint use of infrastructure in the case of agencies could help to ensure continuing postal and other service in rural areas, which would otherwise be too costly for a dedicated post office, as well as providing more convenient opening hours.

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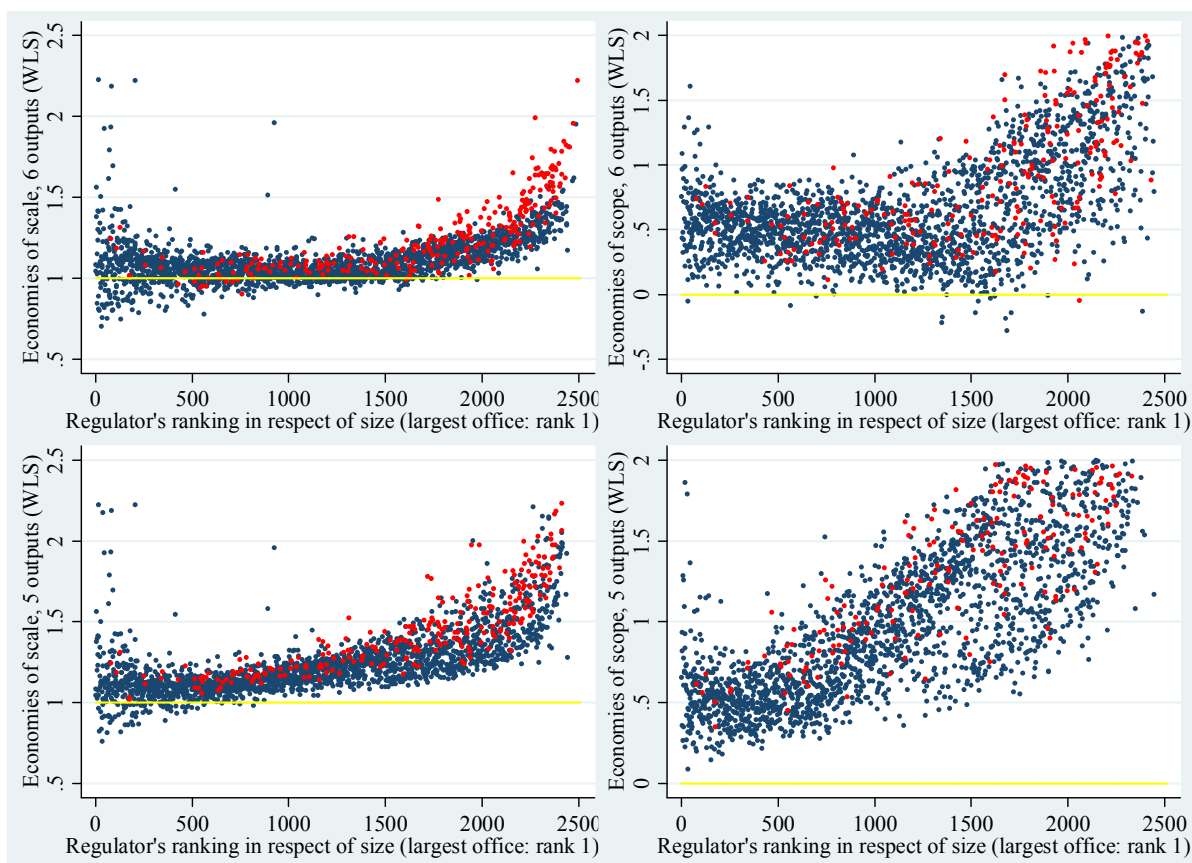
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## APPENDIX

**Figure 2: Sample economies of scale and scope with 6 vs. 5 outputs; agencies excluded; rural offices red**



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