GLOBAL RETAIL: DETERMINANTS OF EFFICIENCY

by

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Abstract

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In our work we were aiming to find out whether retail companies are globally efficient. Using wide panel of data we have found huge inefficiencies in operation. We estimated efficiency score using DEA and SFA. We also found significant influence of Regulatory framework on efficiency. And we were not able to find support for so called home bias. Other results were mixed.

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Chapter 1

INTRODUCTION

An obvious tendency of modern business is that distribution of goods/services to the clients becomes more important than production and thus there is a shift in power from producers to retailers. In 2004 around 80% of all sales in USA were done through retail networks, the corresponding figure for Europe was around 60% (Comp&nioN, 2004). The market capitalization of the leading world retailer – Wal-Mart Stores is around 200 Bn. USD (Bloomberg.com, 2007) and world Sales for 2006 accounted for more than 360 Bn USD (Planet Retail, 2007). It is no surprise that there are really few producers all over the world who can dictate conditions to major retailers.

Moreover the operations of retailers are becoming a key concern to economists, since the influence of retailers often can be even seen on macro level and not only in small countries, but also in USA. There are three main dimensions of such influence. First of all the labor market, according to Business Week Wal-Mart is "America's largest private employer" (Business Week, 2003). But unfortunately the remuneration policy and medical insurance coverage for employees are so poor that many of them have to participate in government programmes (MedicAid etc.), which is additional burden for tax payers. Furthermore, Wal-Mart is often blamed for reducing retail employment and earnings of retail workers in the area, where a new store is opened (Neumark et al., 2007). Secondly, by reducing the cost of the goods being sold in the stores Wal-Mart pushes production to low cost countries, such as China and African countries. "The $12 billion worth of Chinese goods Wal-Mart bought in 2002 represented 10% of all U.S. imports from China." (Business Week, 2003). As a result "Wal-

Mart, by itself, is China's eighth-largest trading partner!" (Business Week, 2005). These makes a substantial pressure on USA trade deficit with China. And thirdly, Wal-Mart is known for lower prices, which produces additional savings to customer. According to Global Insight estimates in 2004 Wal-Mart helped to save 2 329 USD per household or 263 Bn USD for US totally (Dollar & Sense, 2006). As we can see these savings are almost as high as Wal-Mart revenues for the same period (see figure above).

But even more interesting is the question whether the lower price in Wal-Mart are lower only due to lower wages it pays and lower costs of goods imported from countries with cheap labor. Or alternatively what are the sources of efficiency of Wal-Mart. Or even: did Wal-Mart become world leading retailer, because it is much more efficient than others?

Currently we concentrated our attention only to number one world retailer, but the same reasoning may be applied to any big retailer in the world. Though Wal-Mart is about twice as large as any of the competitors the influence of Tesco in UK and Carrefour in France may be the same. Even more, not all the retailers are blamed by publics for their bad influences on economy. A positive example may be Costco, which is eighth biggest world retailer. Costco is often been shown as a good model of doing business in retail (Business Week, 2005; Dollar & Sense, 2006).

Therefore the main question to all retailers is what are the sources of their lower prices? If it is just due to retailers' power to get lower cost from suppliers, lower cost for labor or selling goods with lower quality, then these practices have to be tackled somehow by the government, publics, business etc. But if these lower prices are due to the fact that large chain retailers are more efficient, and, thus, are able to operate at lower cost, then all these arguments against retailers in press are just speculation. Hence, the main question is whether retailers are efficient or to put it broader: what are the determinants of retailers' efficiency.

However, the efficiency of retailers is not studied well in the literature (see Section II). The reason for these is probably that all studies encountered so far (e. g. Keh and Chu, 2003; Matsuura and Motohashi, 2005 etc.) are done on the data within some country and usually for short periods of time (Sellers and Mas, 2006). It may be useful however to study less detailed data (in terms of different variables included in the model), which enables to track efficiency in higher number of countries for longer period. As a result one can additionally assess cross countries differences.

Furthermore, cross country approach allows one to study whether the retailers are able to be equally efficient in different countries, or may be there is sort of 'home bias', i. e. retailers are more efficient in the countries of their origin. It is especially interesting, since it turns out that exporting businesses oversees is more difficult task then expected. And the stories about stupid mistakes being done while opening operations in other countries are told like anecdotes. The latest story in retail business is probably the experience of Wal-Mart in Germany. The company had to close operations and sell its business to the rival – Metro Group in 2006 (Economist, 2006). The main reasons for such failures are: cultural differences, differences in legal framework for business and inability to capture local externalities by international firms (or put in simple words: local firms always no more about peculiarities of doing business in the country). For retail these factors are really crucial. As a result "The most international big retailer France's Carrefour … has stores in just 29 countries, whereas multinationals in other industries might operate in 100 or more countries" (Economist, 2006).

These same questions are even more important for transition countries, since retail industry is still in development. Two development scenarios can be defined.

The first scenario: retail is dominated by international players. This scenario is what happens in Poland, Hungary, Czech Republic etc. The second scenario: retail is currently dominated by local players, but international chains are about to enter. This is the picture of retail in Russia, Ukraine, China, India etc. Therefore, it would be interesting to compare, which group (local or international) is more efficient[1]. Moreover, it would be interesting to know whether the same retailers are as efficient in transition countries as they are in developed countries.

Concluding this section, in our study we plan to take the country data for international retail chains and for retailers from transition countries. The time span is between 8 and 10 years, varying between retailers. Based on these data we plan to study how efficiency of retailers varies:

- Between countries;
- Between groups of transition countries and developed countries.
- Depending on the format of retail outlets (Hypermarket, Supermarket etc)

To facilitate further deeper discussion of the questions above let us give a formal definition for retailers. In our study under the common name of retailers we address to so called modern retail formats, which are Hypermarket (HM), Supermarket (SM) as defined by the Planet Retail.

[1] In the study of corporate governance in Ukraine by Zelenyuk and Zheka (2004) Ukrainian companies were found to be more efficient than international. So a priori assumption that big international companies are more efficient due to better technologies and management is not always correct on practice.

Chapter 2

LITERATURE REVIEW

At first glance productivity and efficiency studies have relatively long history. The first found papers on this issue dates back to 1985. However, the topic studied in these papers is not productivity and efficiency in modern sense, but rather labor productivity of retailers (e. g. see Ratchford and Brown, 1985). This approach is still taken by some modern papers (Matsuura and Motohashi, 2005). Later studies (Dickinson et al., 1992; Wileman, 1993) would include other factors into consideration, but then the productivity was measured as a ratio of outputs to inputs. There are many drawbacks of this measure and discussing them is beyond the scope of this paper. A discussion of these issues can be found in e. g. Parsons (1992) and Tucker and Tucci (1994). But a major drawback is that this ratio reflects actual productivity under specific weights (both for outputs and for inputs). And there is no methodology that allows to find consistent weights for all possible technologies. The only exception is 1-input/1-output case.

Further in these studies there is much confusion in terms between productivity and efficiency. In specific, Parsons (1992) uses three different terms: productivity, efficiency and effectiveness. Where efficiency is used in traditional sense, effectiveness means ability to achieve the goals and productivity is being both efficient and effective. The terminology is definitely relevant for this specific study (Parsons, 1992), but for most studies such distinctions in terminology are not needed.

To overcome the problems above, more recent papers define efficiency Farrel technical efficiency measure, defined as the reciprocal of Sheppard distance function (which is a distance from a given point to technology frontier). And productivity is defined as the ratio between output and input Sheppard distance functions. In order to estimate these efficiencies usually Data Envelopment Analysis (DEA) is used (e. g. Thomas et al., 1998; Keh and Chu, 2003 etc.). In principle for 1-output case it is also possible to use Stochastic Frontier Analysis to find elasticities to inputs and further treat them as measures for technical efficiency, but papers applying this methodology were not encountered so far. In addition, as SFA is a parametric approach, while DEA is non-parametric the resulting estimates are often different, even qualitatively (see illustration of this for banking industry in Ferrier, Lovell 1990). So whenever possible it is recommended to use both approaches (ib.).

Furthermore, even recent papers analyze efficiency and productivity of individual outputs (Keh and Chu, 2003; Davies et al., 2005; Thomas et al., 1998). This approach is relevant for assessing the performance of managers of individual outlets (Thomas et al., 1998). But it is cumbersome when one wants to analyze retail chain performance, since it is much simpler to estimate the efficiency score for entire chain in a country/region than to compute individual scores and then to aggregate them. The latter approach is consistent due to the fact most critical decisions are made on the country level. Moreover, aggregation approach may give wrong results if the researcher does not use appropriate weights, which are shares in total chain revenue (Zelenyuk, 2003).

And the last issue in existing literature that existing studies concentrate on specific countries. Therefore in the area there is lack of research that would based cross country data for more or less long periods (8-10 years) and use both econometric (SFA) and operations research (DEA) approach to get the efficiency estimates.

Chapter 3

THEORETICAL BACKGROUND

We start with assuming that every firm behaves accordingly to neoclassical production theory. That is every firm uses inputs to produce some outputs using some (though unobserved) production function $f(i,x,z)$, where i – investment (or what can be thought of as "long-term" inputs), x – inputs, z – external (usually macroeconomic) factors that influence firm production. Further, under some prices, which clear the market, each firm would produce output to maximize its profit. Additionally note that firm can be a price taker (in case of perfect competition), or firm can influence price on the market – case of monopolistic competition (we assume here monopolistic competition rather than oligopoly or even monopoly, since in most countries concentration indices for retail are quite low).

Next, we define revenue function as $R(p,y)=\{py: p\hat{y}-w\hat{x}\geq py-wx, \text{for } \forall \text{ y,x} \in \text{T and } \hat{\text{y}},\hat{\text{x}} \in \text{T}\}$, where T is technology set defined as $T=\{(y,x): y \text{ producible from } x\}$. In words, we defined Revenue function as revenue that corresponds to maximal profit[2]. We define revenue function this way, since we believe that profit maximization (rather than revenue maximization) is more appropriate assumption to describe the behavior of the firms.

[2] Note that traditional way to define revenue function would be $R(p,y)=\max\{py: y\in \text{P(x)}\}$, and P(x) is just another way to define technology set (equivalent to T). That is Revenue function defined in usual way would mean that company maximizes revenue rather than profit.

Further, we observe that $R(p,y) \geq py$, for $\forall$ y $\in$ P(x) . When at the first glance it looks counter intuitive, this inequality should hold in medium and long runs for all firms (though of course it will not hold in the short run). The motivation for this is the following: assume that in some period t actual revenues of the firm were higher, than predicted by revenue function (i. e. $py_t \geq R(p,y)_t$). This means that firm haven't received optimal profit. In case, of perfect competition it was actually negative, while it could be even positive (though not optimal) for the case of monopolistic competition. Therefore, firm investors haven't received the returns on investment that they were expecting for. So in period t+1 expectations about returns on investment will decrease and (keeping everything else constant) firm would receive less investment. Having received less investments firm would need to reduce it's output (since it can not get the same amount of inputs), and, therefore, in medium term revenue will also decrease. Of course, firm can take credit, to maintain the same level of output, but it would increase cost of production, so optimal profits would also be lower (if assume decreasing returns to scale), so in medium run firm would also exhibit lower revenues. In real life, there could also be soft budget constraint induced by the government, but retail is not the industry, where this assumption is realistic in general. Thus, we get that firms would increase profit only up to R(p,y).

Given the argument above, on average firms are not likely to have actual revenues higher than optimal R(p,y). So further, we assume that higher revenues are better. Now, when we observe that actual revenue of firm i is greater that the revenue of firm j ($py_i > py_j$) on some long period of time, this can be caused by two possible reasons. First, it can be that firm i gets revenue that is closer to the optimum ($py_j < py_i \leq R(p,y)$). And second, it can be that optimal revenue for firm j is lower ($R(p,y)_j < R(p,y)_i$). The first means that firm j should increase it's revenue to get closer to the optimal point. The second implies that firm j has higher costs of production. From the point of view of social welfare both situations are not optimal and should be improved either by increasing output by firm j (first case), or by eliminating firm j from the market (second case).

In real life however it is possible that firm faces losses (negative profits) for a long time (most famous examples of this among others would be Airbus and Chrysler). But such cases persist usually in highly concentrated industries, to which retail surely does not belong. So in the presence of perfect or monopolistic competition assumption of revenue maximization is quite plausible.

Next define revenue efficiency as $RE = \inf\{\theta : y/\theta \in P(x)\}$. We immediately observe that $RE \in (0,1]$ and $py = R(p, y) \cdot RE$. We also note that this way of defining efficiency is known in the literature as Shephard output distance function. The reason we use it here is that it has very intuitive interpretation: RE can be thought of as how many percents of potential revenue the company earns.

At this point it is clear that being revenue efficient (RE = 1) is a necessary condition to be profit efficient (i. e. to get optimal profits). This implies that we can make some conclusions about whether firms are operating optimally from society point of view even when we do not observe actual cost. Though of course, comparing profits is beneficial (but it need additional information on costs).

This observation goes in line with actual behavior observed from big companies. E. g. consider a big multinational company operating on different regional markets. As a whole the company certainly maximizes the profits. But each regional office gets some targets on revenue, market share, cost and other parameters. Of course, these targets are based upon analysis of the market in the corresponding region and are set at the level needed to maximize profit of the company as a whole. So branches are not actually maximizing profits, but rather achieving some "profit maximized" targets.

Summing up the discussion above, we note that each country office (which is appropriate DMU for our analysis) solves the following problem: $\max R(p,y) = f(\text{investment}, \text{cost}, \text{external factors})$, where "*investment*" – is the group of factors that determine capital of the company in the long run, "*costs*" are operating costs, and "*external factors*" are macroeconomic factors that influence company revenue. In addition, any actual observed revenue is a fraction of optimal level of revenue ($py = R(p,y) \cdot RE$, where $RE \in (0,1]$).

To conclude this chapter we want additionally to discuss possible measures, which researchers can use to assess whether the company is operating optimally from the point of view of society. As suggested by neoclassic economic theory this should be profit per unit of investment, market price of stock (as a sum of expected future profits of the company), and as proposed above in this chapter company revenue. First, profit looks very appealing measure; but it would be important to mention that this should be so called *economic* profit, i. e. profit received after subtracting all costs including entrepreneurial rent. In real life this profit is never observed. What we observe is so called *accountant* profit, which is obtained by adding economic profit and entrepreneurial rent. Second, stock price also looks nice in the theory, but in practice it is very volatile. Moreover, stock price is a good mirror of future profits of the company only when the stock market in the country is sound. If it is not the case various distortions may occur, e. g. in Ukraine stock price often is based upon the market value of real estate owned by the company. That is the only sure money that investor will get is money received from selling the land and buildings. Finally, revenue can be used only in highly competitive markets. Therefore, one may argue which measure of social efficiency would fit the best. In our case we have data only for revenues, so the question is solved virtually automatically.

Chapter 4

ESTIMATION

It is clear from previous chapter that in order to measure efficiency of the DMU we need to get estimates of revenue efficiency terms (*RE*). There are two possible ways to obtain estimates of efficiency: nonparametric, operational research – Data Envelopment Analysis (DEA) approach, and parametric econometric – Stochastic Frontier Analysis (SFA) approach. Both approaches are biased, but consistent in estimating actual production frontier. We note, however, that the source of the bias is different. DEA is non-stochastic, so it is sensitive to random noise. On the contrary, SFA is robust to random noise, but it assumes specific functional form, so the actual error may be due to incorrect guess of functional form. This is why in empirical works these two methods sometimes yield different results (even qualitatively). Therefore, it became a good tradition to use both methods in empirical works (see Ferrier, Lovell 1990).

First, let us consider SFA estimation in more details. Recall that actual revenue of company i in period t (for the ease of notation further we denote it simply by y) on the one hand is a function of investment, inputs and external macroeconomic factors and on the other – of efficiency term and random error (we assume that the latter two enter function multiplicatively:

$$Y_{it} = F(k_{it}, x_{it}, z_{it}) \cdot RE_{it} \cdot e_{it}$$

Taking logs on both sides and denote $y_{it} = \log Y_{it}$, $f(\cdot) = \log F(\cdot)$, $u_{it} = -\log RE_{it}$, $v_{it} = \log e_{it}$, we get:

$$y_{it} = f(k_{it}, x_{it}, z_{it}) - u_{it} + v_{it}$$

SE we are interested now in estimating u_{it}. To be able to do so we need to restrict *f*(.) to some specific functional form and impose some distributions on u_{it} and v_{it}.

In our estimation we assume that actual production frontier is described by translog production function:

$$\ln y_{it} = b_0 + \sum_n b_n * \ln X_{nit} + b_t * t + \frac{1}{2} * \sum_n \sum_k b_{nk} * \ln X_{nit} * \ln X_{kit} + \frac{1}{2} * b_{it} * t^2 + + \sum_n b_{nt} * \ln X_{nit} * t + v_{it} - u_{it}$$

,

where y_{it} – is revenue of firm i in period t, X_{nit} – is "resource" n in production of firm i in period t (resource include all three types discussed above: investment, cost and external factors), t – time (measured in years), b – corresponding coefficients, v_{it} – normally distributed random error of firm i in period t, and u_{it} is inefficiency term of firm i in period t.

As mentioned above resulting estimates of efficiency term may suffer from incorrect specification of functional form. To circumvent this we used translog as second order approximation to any smooth functional form. So specification error will persist only to the level of preciseness of approximation (second order is usually the one all economists are comfortable with).

Additionally we also use standard distributional assumptions: normal distribution for error term and half-normal for inefficiency term.

$v_{it} \overset{iid}{\sim} N(0, \sigma_v^2)$ and $u_{it} \sim |N|(0, \sigma_v^2)$

These are pretty standard assumptions for SFA formulation first justified by Aigner, Lovell and Schmidt (1977), so we are not going to discuss it in details. Note however, that it is not very clear how one split the difference between observed and predicted revenues to obtain an estimate of individual inefficiency score u. This is done by calculating expected values $u_{it} = E(u_{it} \mid v_{it})$. And for calculating the latter quite complicated procedure is used, which we are not going to discuss here, since it is included in most statistic packages (e. g. Stata 8.2). Another option is possible for panel data. It is to assume that inefficiency is constant over time ($u_{it} = u_i$), or that inefficiency is decreasing function of time – so called time-varying decay model (Battese, Coelli, 1992):

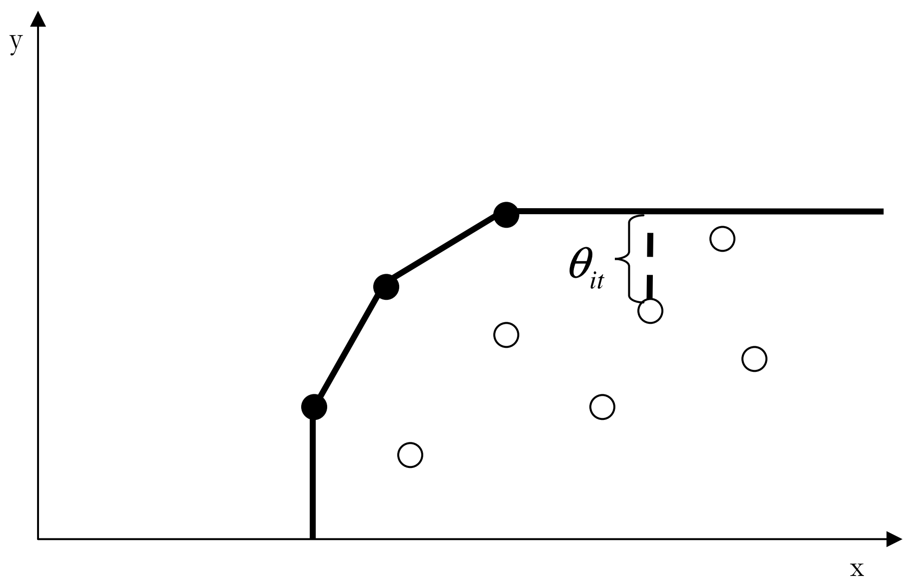
$u_{it} = u_i \cdot e^{\varphi \cdot (t-T)}$; where $u_i \sim N(\mu, \sigma^2)$, truncated at 0, T is the last period, and φ - parameter to be estimated.

In our work we would use traditional method of calculating expecting values, and, since we have panel data, time-varying decay model.

Next, after obtaining estimates on revenue efficiencies we are interested in understanding in the determinants of these efficiencies. Therefore, we regress obtained scores (RE_{it}) on set of dummies (regional, format and whether company is operating in home country) and on regulation quality of the country government (see more about factors included on the second stage in Data Description). In principle, we can include these factors already on the first stage (estimating inefficiency scores by SFA). However, stochastic frontier is estimated by maximum likelihood, and the likelihood function often has low concavity or is not concave at all. Therefore, not to overcomplicate calculations we have split the procedure into two steps. Additionally, on the second step we use simple OLS, fixed effects and random effects estimator (the latter two to gain more efficiency from panel data). Also worth mentioning that one would need to impose restrictions for fitted values to be between 0 and 1 (since revenue efficiencies are defined as percentage measure of efficiency). But since in our estimations all fitted values were in needed range, to save on computations we didn't impose additional restrictions.

Next to get more powerful results we would like to get also non-parametric (DEA) estimates of revenue efficiencies. In order to do so, we denote $\theta_{it} = \frac{1}{RE_{it}}$. Then it is possible to estimate θ_{it} as:

$$\theta_{it} = \max\{\theta_{it} : \sum_{i=1}^{N} z_{it} y_{it} \geq \theta_{it} y_{it}, \sum_{i=1}^{N} z_{it} x_{it} \geq x_{it}, \sum_{i=1}^{N} z_{it} x_{it} = 1; \theta_{it}, z_{it} \geq 0, \text{for } \forall \text{ i, t}$$
$$\text{i} = 1,..., \text{N - number of companies}, t = 1,..., T - \text{number of periods}\}.$$



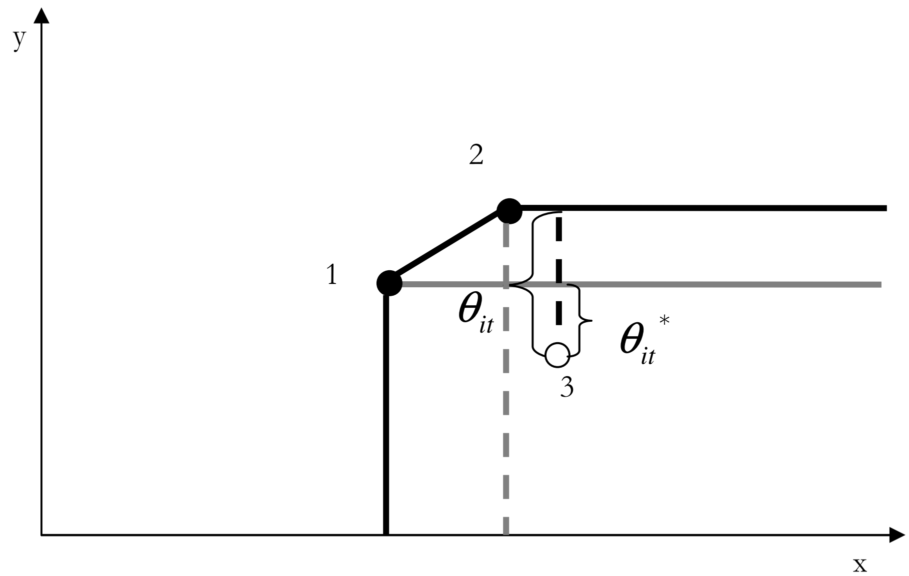
To understand the intuition behind this estimator, consider 1-input-1-output case on the graph. First, we have observations denoted by points. Next we built production possibility frontier from the most distant points (bold line on the graph). Then, inefficiency score θ_{it} would simply measure the distance from each point to the frontier. Ideally we would want θ_{it} =1, which would mean that the point is on the frontier (as points marked black). All the rest observations (white points) are inefficient, having $\theta_{it} \in (1, \infty)$.

This estimator is known at least since Fare, Grosskopf, Norris and Zhang (1994). Note that the only restrictions we imposed on production function are free disposability of both inputs and outputs (in our case simply revenue), and variable returns to scale.

So at first glance DEA estimator looks quite appealing. It also has several drawbacks however. Except sensitivity to random noise (already mentioned above), DEA has slow than usual rates of convergence. As reported by Kneip at al. (1998) DEA converges at the rate $n^{-\frac{2}{p+q+1}}$, where "curse of dimentionality". Secondly, as every non-parametric estimator DEA is very computationally intensive. Even calculating DEA scores on the sample of 1000 obervations may be a problem for a personal computer. So when one want to have smaller sample to be able to get estimates, they may be far from real values since asymptotics haven't started to play yet.

To solve computational issues, in our work we used little bit different approach to estimate DEA scores. First, without loss of generality we split observations into M groups. Then we find θ_{it}^{1m} as a DEA score for point in group 1 with respect to frontier built from observations in group m. Then we find the final DEA score for group 1 as $\hat{\theta}_{it} = \max\{\theta_{it}^{11}, ..., \theta_{it}^{1M}\}$. Then we calculate in the same way DEA scores for groups from 2 to M. For large datasets this method works much faster than usual procedure (already on the sample of 100 observations our method was about 10 times faster than usual procedure). In addition, theoretically both methods yield the same results $\hat{\theta}_{it} = \theta_{it}$.

To see that both methods should theoretically produce identical results let us again consider 1-input-1-output case (see the graph).



Without loss of generality assume that we have three points (taking more points would not yield additional information, but just complicate our considerations). The usual frontier as previously is marked by black bold line. Let us first take points 1 and 2. Since both are on the frontier, the estimates for both would be equal to 1 (as in the case of normal DEA). Estimate for point three will also correspond to estimate of distance to actual frontier. Now let us build frontier with respect to points 1 and 3. It partially coincides with actual frontier (below point 1), but differs from it to the right of point 1 (new frontier is marked by solid bold grey line). The estimate for point 1 is still equal to 1. Point 3 is now closer to frontier and distance is measured by θ_{it}^*. Point 2 is above the frontier, so it's distance is smaller than 1. And finally, consider frontier built from points 2 and 3. It corresponds to actual to the right of point 2, but is different below point 2 (dashed bold grey line on the graph). Point 2 is on the frontier, so it's estimate is equal to 1. Distance from point 3 to frontier is equal to θ_{it}. Distance from point

1 to frontier is infinity since for this point set is unbounded. However, for such cases we can artificially restrict distance to be equal to zero.

Next let us calculate DEA estimates:

$$\hat{\theta}_1 = \max\{1,1,0\} = 1 = \theta_1$$
$$\hat{\theta}_2 = \max\{1, \theta < 1, 1\} = 1 = \theta_2$$
$$\hat{\theta}_3 = \max\{\theta_3, \theta_3^*, \theta_3\} = \theta_3, \text{since } \theta_3 > \theta_3^*$$

Since each actual observation would be either on the frontier (as points 1 and 2) or below it (as point 3), we have shown that DEA estimate from our procedure for any point is equal to actual DEA estimate.

When theoretically the two estimators are equivalent, in numerical computations difference may occur. But as offered by Monte Carlo simulations the difference is about two orders smaller, than the difference between DEA estimate and actual value. Additionally, one may expect that the difference would be smaller, when number of groups is smaller (i. e. when number of observations in the group is closer to total number of observations). And clearly the number of observations in group should be greater than 1 (though as looks from above 2 are already enough).

Unfortunately, we have not encountered this estimate in the literature so far, so asymptotic properties of it are not clear. One would expect that since these estimates are theoretically equivalent to usual DEA, their asymptotic features remain the same. But this should be additionally proved.

Further in the work we calculate scores by splitting set into groups, since the size of the set does not allow us to perform usual DEA calculations.

Next, as offered by Simar and Wilson (2007) we do second stage regression:

$\theta_{it} = x_{nit}b_n + d_{kit}b_k + e_{it}$, where x_{nit} - macroeconomic variables, d_{kit} - set of dummies (as above in SFA case), b_n, b_k - corresponding coefficients and $e_{it} \overset{iid}{\sim} N(\mu, \sigma^2)$ - random error. For more detailed description of variables included both on first and second stages in DEA estimations see Data Description. We need to include macroeconomic variables (and also some of the inputs), because they violate the assumption of free disposability, which is one of the building blocks of DEA.

As one may probably remember in SFA approach we included macroeconomic variables into frontier estimation, thus, implicitly assuming that they are not correlated neither with inefficiency score (u_{it}) nor with random error (v_{it}). But here in 2nd stage DEA estimation we regress inefficiency scores (θ_{it}) on these factors. However, if to look more carefully, we can do this. The reason for it is that while SFA estimates (u_{it}) correspond to part of revenue that can not be attributed to any input (or external variable); in DEA we get estimates that correspond to the revenue purified only from freely disposable inputs, so macroeconomic information is still contained there. Since we can not purify DEA scores from this information, we have to control for it. So we do it already in the second stage regression. This is also the reason why we will not be able to compare directly DEA and SFA estimates, since they were obtained by accounting for different factors (or more precisely SFA accounts for all information in DEA plus some additional information). So reiterating once more, on the second stage in DEA we would control for the information not included there.

Finally, as in previous SFA case, on the 2nd stage in DEA estimation we would also use simple OLS, fixed and random effects estimators to get more powerful results. Additionally, one should restrict outcome efficiency score on the second stage to be between 0 and 1, but since predicted value in our regressions on the second stage for DEA for all methods were in this region we didn't impose additional restrictions.

One more thing should be mentioned explicitly without going unnoticed. On the first stage both DEA and SFA calculate inefficiency score measured on interval $[1,\infty)$. This is what is known in the literature as Farrell technical efficiency measure (TE). Then on the second stage (also for both DEA and SFA) we recalculate efficiency measure (which we call in our work as revenue efficiency) to be $RE = \frac{1}{TE}$. We use the latter measure for it's nice intuitive interpretation (since it is measured between 0 and 1). As was already mentioned above, this measure is known in literature as Shephard output distance function. All calculations on the 2^{nd} stage for both DEA and SFA are performed with this second measure.

Concluding this chapter we note that in the absence of costs (short term), both DEA and SFA estimates will probably be biased. But since we have data for relatively large period (8 years), and it is reasonable to assume that expenses are proportional to number of stores and total area (i. e. assuming that in the long-run companies strive to work efficiently). As a result we expect that the bias will not be large enough to change the results at least qualitatively.

Chapter 5

DATA DESCRIPTION

To perform the calculations from previous section we need the following types of data: retail chain Revenue, retail chain investments (which we assume to be proportional to number of stores and total area), costs (which as was already mentioned above we do not have), external macroeconomic variables, and, finally, set of dummies to capture different influences discussed above. One can see descriptive statistics for all of these variables in the table below. We only note that Sales are measured in Mn USD, Number of stores in units, Area in sq. m.

The use of retail chain specific variables (revenue, investment proxies) was already justified in Introduction chapter. We only note that data on the variables discussed we obtained from Planet Retail, which is considered to be one of the major retail expert over the world. Thus, we have data on 1607 decision making units. These are 393 different companies in 113 countries all over the world. These DMUs represent huge variation of retailers, from small – represented in only 1 country, with 1 store of 400 square meters; to huge giants like Wal-Mart (champion by store size) or Carrefour (champion by number of countries penetrated). For most of DMUs we have data from 1999 till 2006, which totals to 9311 observations.

Among macroeconomic factors that we would like to include are GDP per capita, CPI and Population size. These factors are often considered by retailers, when they make their decision about operations in the region. First of all every retailer wants to enter richer region, because purchasing power per capita there is higher. In our work we try to grasp this purchasing power by GDP per capita in specific country.

Variable	Obs	Mean	Std. Dev.	Min	Max
Retail chain characteristics					
Sales (Revenue)	9311	1149.23	4567.753	.5	194046
Number of stores	9311	80.39276	207.7013	1	3392
Total area	9311	199076.8	877451.3	400	3 920 000
Macroeconomic factors					
GDP per capita	9311	17488.79	15133.06	5.203	87955.37
CPI	9311	247.6518	982.4834	.225	11340.49
Population	9311	161.9895	551.8116	.279	6331.931
Regulation quality	5911	.7680728	.7836225	2.271068	2.06826
Country regional dummies					
Advanced economies	9311	.5148749	.4998055	0	1
Emerging markets	9311	.4851251	.4998055	0	1
Africa	9311	.0886049	.2841878	0	1
CEE	9311	.1330684	.3396669	0	1
CISM	9311	.032757	.1780094	0	1
Developing Asia	9311	.0707765	.2564649	0	1
Middle East	9311	.0492965	.2164981	0	1
Latin America	9311	.1106218	.3136801	0	1
Home country dummy (equal to 1 for operations in parent country)					
Home country	9311	.5983246	.4902633	0	1
Retail chain format					
Convinience stores	9311	.0129954	.1132602	0	1
Hypermarkets	9311	.1922457	.3940863	0	1
Hypermarkets and Superstores	9311	.0979487	.2972612	0	1
Supermarkets	9311	.432714	.4954785	0	1
Supermarkets and Neighbourhood stores	9311	.033831	.1808036	0	1
Superstores	9311	.1085812	.3111298	0	1
Cash&carry	9311	.121684	.3269381	0	1

Secondly, among regions with equal purchasing power per capita, retailer would be interested first of all in those with higher population. And finally, retailers also observe the price level that is already on the market (e. g. strategy of Metro C&C in all countries is to have lowest possible prices in the region). So we use Consumer Price Index (CPI) to measure price level (since consumers are usually target audience for retailers).

We also should note that factors that we use in many countries may have substantial variation. E. g. in Ukraine as reported by Derzhkomstat (2006) average income for Kyiv (capital) accounts for approximately 1 500 UAH (around 300 USD), for city with 1 million of inhabitants – 1 000 UAH (200 USD), while average for Ukraine is between 600-700 UAH (120-140 USD). Price differences among regions may also be significant. In our research we saw that price level in the same chain (Sil'po supermarkets, owned by Fozzy group) differed by 15 % in cities Kyiv, Zaporizhya and Dnipropetrovs'k. And difference among cities was bigger that difference in prices between retail banners within the city. The latter effect however is due to low development of Ukrainian retail market, but what holds for other countries is that difference between regions may be high.

Such intercountry differences is not a big problem. The reason for it is that every retailer starts it's operation in the region of the country that is on the one hand the richest with higher population (and so with higher price level) and on the other hand in the region that is less penetrated already by competitors. Thus, we can assume that within the country DMU is making optimal decisions. So we take country GDP, CPI and population to capture cross-country differences.

We may only add that the data for these variables is taken from IMF. So that overall number of observations is still 9311. Here we must also add that GDP per capita is measured in USD at current prices, CPI is index (equal to 100 for the year 2000) and Population is measured in millions of persons.

Furthermore, on the second stage we are interested how regulation framework of the country influences the efficiency of retailer. To capture this effect we use Regulation quality index from World bank survey. When regulation framework is more restrictive index becomes more negative, and more favorable framework has positive index. And neutral levels would correspond to zero. Overall, index varies between – 2.5 and 2.5. Unfortunately, before 2002 index was calculated only once in two years. And earlier levels of index are not available for all countries. For this reason, on the second stage number of observations drops to 5911. However, in order to gain in efficiency on the first stage (when we calculate efficiency scores, so that regulation quality is not needed) we use all 9311 observations.

Next to capture regional patterns in efficiency, on the second stage we use dummies for Advanced economies (Euro Area, G7, Newly Industrialized Asian Economies and other advanced economies – as defined by IMF), and Emerging markets (constitute of African countries, Central-Eastern Europe /CEE/, Commonwealth of Independent states together with Mongolia /CISM/, Developing Asia, ASEAN-4, Middle East, and Latin America /Western Hemisphere in terms of IMF/). All groups are defined by IMF. In addition we also include Serbia, Bosnia and Herzegovina, which were omitted by IMF due to some reasons, into CEE group. Finally, we note that corresponding dummy is equal to 1 if country belong to the group and zero otherwise.

Another dummy is what we call home country. It is equal to one for operations of the company in the country of origin, and zero for operation in other countries. We do this to test whether there is sort of home bias (the name is due to The Economist) in retail industry. The data for this variable is taken from Planet Retail.

And final set of dummies would capture retail format of the chain. The dummy is equal to 1 if chain belongs to the specific format and zero otherwise. All formats are defined as by Planet Retail, and we take data on the dummies from there.

The last issue that we would like to discuss is Inflation. First, we note that each factor that is measured in monetary units is transferred to USD at average nominal exchange rate in corresponding year (this is done by Planet Retail and IMF). So in principle we may capture only the inflation of USD. Further, in SFA estimation we can eliminate inflation by accounting for time, since all data are in logs. In DEA estimation on the second stage, however, inflation persists. But, since all monetary variables (revenue, GDP) – both dependant and independant are capturing the same inflation, the influence of inflation should not be high enough to alter results. So we neglect this problem.

Chapter 6

RESULTS

As was already previously mentioned, on the first stage we estimate SFA and DEA inefficiency scores. Let us first discuss in brief SFA estimation. To estimate the scores we assumed that Revenue (Total retail sales) is translog function of inputs (Number of stores and Total sales area), external macroeconomic factors and time (in case of simple SFA we explicitly include it into production function, and in case of time-varying decay SFA model we include time only in function of error term). Note also that in case of simple SFA variable Year was dropped in estimation due to multicollinearity. However, cross-products of other factors with Year an squared Year was left.

Since our prime interest is not in estimation of the frontier per se, but obtaining estimates of inefficiency scores we do not discuss the estimation results in details here. Full estimation output for both simple SFA and time-varying decay estimations may be found in Tables A.1 and A.2 in Appendix. Here we only note that both estimations were overall significant at 1% level (using Wald test). However, some factors were not significant at conventional 5% level (using individual t-test). In addition some coefficients have sign that was not expected, and for some coefficients signs were different for different estimation procedure. Since we don't have a-priori expectations about the signs further we report results from both of this methods.

Next on the first stage in DEA estimation we applied the method, which we haven't encountered in the literature before (see discussion in Chapter 4). At the first stage we used 1-input-1-output model (Revenue as unknown function of

Total sales area). We didn't include other inputs on this stage into DEA estimation, since they would violate the assumption of free disposability of inputs. Therefore, we control for this inputs at the second stage.

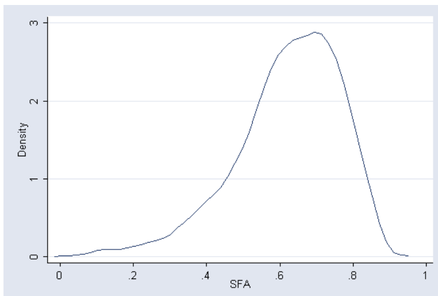
Finally, before we will start studying efficiency estimates in more details, we want to acknowledge that in our estimations we used Stata 8.2 (for both SFA estimations on the first stage, and for all estimations on the second stage), and we used Matlab for DEA scores estimation. Here we would like to thank Valentin Zelenyuk for providing us with the code for DEA estimation. Though in principle any other software may be used for this purpose.

In the table below we present descriptive statistics for obtained inefficiency scores:

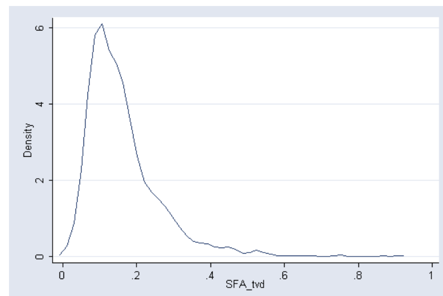
	Obs	**Mean**	**Std. Dev.**	**Min**	**Max**
SFA	9311	.6228378	.145012	.0040284	.9313887
SFA_tvd	9311	.1634491	.1023708	.0034169	.9130314
DEA	9311	.206306	.153869	.0000293	1

First thing we note here is that on average there are huge inefficiencies. Average retailer is only 20 % efficient as predicted by DEA (and even less efficient as predicted by SFA time-varying decay model. Only usual SFA shows more expected a-priori results, predicting 62% of efficiency for average firm. Additionally we want to comment maximums. Such difference in both SFA maximums compared DEA can be attributed to the fact that whenever we have observation close to frontier any of SFA procedure attributes this to random error, while DEA treats this as being close to frontier. In principle, in DEA estimation it is possible to think of those extremely efficient companies as outliers and exclude them. But since we do not have the information that would allow to say whether these observations belong to the same data generating process or not, we do not exclude them. To have even more vivid picture of he efficiency in the industry, let us present the distributions estimated by kernel density estimator.

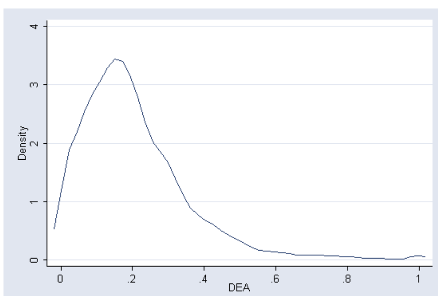
SFA density



SFA_tvd density



DEA density



As we can see from the graph, indeed there is no tendency for retailers towards efficient operation (if there was such tendency efficiency scores would be distributed with more mass near 1).

Additionally, we may say that in our kernel density estimation we used Epanechnikov kernel. In density estimation for inefficiency score, one should Silverman reflection method, since scores are expected to have active bound support (a lot of mass should be near 1). However, we see that this is not the case with our scores. Only DEA density is probably little bit shifted more to the left than it should be. Since we were estimating densities only to show more vivid picture, but not for further estimation, we are not going to correct this minor drawback.

Further, as was first offered by descriptive statistics, and further supported by density plots, DEA and SFA scores may be quite different. Therefore, next we examine correlation about different inefficiency scores.

	SFA	SFA_tvd	DEA
SFA	**1**		
SFA_tvd	**.6787**	**1**	
DEA	**.6409**	**.4649**	**1**

As we can inefficiency scores are correlated to some extend. In formal tests correlation is significant, though one may expect higher. As was already discussed in Chapter 4 DEA and SFA estimates due to different source of bias may be poorly correlated with each other and may yield different qualitative results (in terms of efficiency ranking of companies). Since we do not have any guess about which bias is larger (DEA or SFA), further, in 2nd stage estimations we continue to use all three estimates of efficiency scores.

Now, as we have seen that there is tendency to inefficient operations let us examine potential sources of it. In particular, we would like to know how inefficiency is (or is not) correlated with geographical region of operations, whether we are operating in home country or overseas, regulatory framework, and, finally, retail format. In order to do so we first examine evidences provided by both types of SFA estimation, and then proceed with DEA 2nd stage result.

Further in the table we present second stage results from SFA estimation.

	SFA			SFA_tvd		
	OLS	**FE**	**RE**	**OLS**	**FE**	**RE**
Regional dummies						
Advanced economies as defined by IMF	-0.0071000	0.0000000	**-0.0434144**	0.0061277	0.0000000	0.0002803
	(0.71)	(.)	(2.24)*	(0.90)	(.)	(0.02)
Africa	**-0.0410193**	0.0000000	-0.0068659	**0.0483808**	0.0000000	**0.0577738**
	(3.85)**	(.)	(0.31)	(6.64)**	(.)	(4.00)**
Central and Eastern Europe	-0.0016680	0.0000000	-0.0079194	**0.0428035**	0.0000000	**0.0400167**
	(0.16)	(.)	(0.37)	(6.16)**	(.)	(2.94)**
Commonwealth of Independent States and Mongolia	0.0886780	0.0000000	**0.1202084**	**0.0794358**	0.0000000	**0.0849459**
	(6.52)**	(.)	(4.42)**	(8.54)**	(.)	(4.89)**
Developing Asia	**-0.0267539**	0.0000000	-0.0111433	**0.0222481**	0.0000000	0.0229865
	(2.43)*	(.)	(0.49)	(2.96)**	(.)	(1.57)
Latin America	**0.0289630**	0.0000000	0.0250532	**0.0835580**	0.0000000	**0.0800827**
	(2.89)**	(.)	(1.20)	(12.21)**	(.)	(5.93)**
Home country dummy						
Home country	0.0037196	0.0000000	0.0144977	-0.0052766	0.0000000	-0.0000915
	(0.94)	(.)	(1.79)	(1.95)	(.)	(0.02)
Regulation framework						
Regulation quality	**0.0116098**	**0.0671904**	**0.0518249**	-0.0045343	**0.0038137**	**0.0037828**
	(2.68)**	(13.35)**	(11.65)**	(1.53)	(12.37)**	(12.29)**
Format dummies						
Hypermarkets	0.0218378	0.0000000	0.0040447	**0.0621876**	0.0000000	**0.0513892**
	(1.31)	(.)	(0.12)	(5.46)**	(.)	(2.43)*
Hypermarkets & superstores	**0.0396733**	0.0000000	0.0183243	**0.0654185**	0.0000000	**0.0532940**
	(2.31)*	(.)	(0.53)	(5.57)**	(.)	(2.42)*
Supermarkets	**0.0331569**	0.0000000	0.0151456	**0.0398991**	0.0000000	0.0291583
	(2.03)*	(.)	(0.47)	(3.57)**	(.)	(1.41)
Supermarkets & Neighbourhood stores	-0.0065642	0.0000000	-0.0370699	0.0216787	0.0000000	0.0080076
	(0.35)	(.)	(0.99)	(1.67)	(.)	(0.33)
Superstores	-0.0011092	0.0000000	-0.0310414	**0.0380699**	0.0000000	0.0240166
	(0.07)	(.)	(0.92)	(3.27)**	(.)	(1.11)
Cash & Carry	0.0286684	0.0000000	0.0129470	**0.0709134**	0.0000000	**0.0599476**
	(1.69)	(.)	(0.38)	(6.11)**	(.)	(2.77)**
Constant	**0.5901754**	**0.5719426**	**0.5718779**	**0.0947562**	**0.1609840**	**0.0909743**
	(32.53)**	(145.08)**	(15.70)**	(7.64)**	(666.84)**	(3.88)**

NOTE: developing economies, Middle East, convenience stores dropped to avoid multicollinearity

First thing that we note from results of the regression, is that in Fixed effects estimation all dummies appeared to be collinear to individual fixed effects, and as a result dummies dropped in estimation. Additionally, we want to note that for both SFA estimations (and further for DEA 2nd stage results too) Hausman test was in favor of fixed effects, but the difference between coefficients in fixed and random effects estimation (which is tested in Hausman procedure) may be due to the fact that all dummies have dropped, therefore we keep both results of fixed and random effects and present them here. We also tried to omit other dummies than those presented here, but that had no influence on FE results.

Next, as we can see from the tables there are some regional patterns in efficiency. However, in different procedures different effects dominate, and also sign may change. But overall, we may conclude that most procedures didn't show significant differences in efficiency between Advanced and Developing economies. So retail technologies are being fast spread all over the world. All other patterns were rather random then systematic. Additionally, we may note here, that the fact that we were able to get data from some country and to estimate efficiency score already offers that there are modern retail outlets there. So there is sort of self-selecting procedure.

Further, surprisingly (after so much buzz in business press) we didn't find any evidence (not a single specification!) supporting the fact of existence of home bias. So it looks like retailers (like other businesses) can successfully export their operations to other countries (at least they are as inefficient there as in there "native" countries).

However, we have found strong evidences that regulating framework does matter. It was significant in all but one specification. Increasing regulation quality by 1 (remember, positive value of regulation quality mean that framework is more friendly) would increase efficiency by levels from 1 to 6.7% (keeping everything else constant).

And finally, there are slight evidences that retail format may matter. In particular, in half of the specifications hypermarkets and superstores (either mutually or separately were found to be more efficient).

Next, let us see which of these effects survive in DEA estimation. See table on the next page

	DEA		
	OLS	**FE**	**RE**
Internal retailer characteristics			
Number of stores	**0.0000934**	**-0.0001597**	0.0000278
	(10.10)**	(5.56)**	(1.82)
Macroeconomic factors			
GDP per capita	**0.0000015**	0.0000003	**0.0000005**
	(5.83)**	(1.05)	(2.03)*
CPI	0.0000009	0.0000026	0.0000005
	(0.50)	(0.74)	(0.21)
Population	-0.0000047	0.0000422	0.0000085
	(1.20)	(3.73)**	(1.40)
Regional dummies			
Advanced economies as defined by IMF	**0.0378297**	0.0000000	**0.0402785**
	(3.75)**	(.)	(2.38)*
Africa	**-0.0577341**	0.0000000	**-0.0566957**
	(5.36)**	(.)	(2.96)**
Central and Eastern Europe	**-0.0227198**	0.0000000	-0.0316361
	(2.19)*	(.)	(1.74)
Commonwealth of Independent States and Mongolia	**0.0283489**	0.0000000	0.0256449
	(2.11)*	(.)	(1.10)
Developing Asia	**-0.0446921**	0.0000000	**-0.0577356**
	(3.74)**	(.)	(2.80)**
Latin America	**-0.0009180**	0.0000000	**-0.0127733**
	(0.09)	(.)	(0.71)
Home country dummy			
Home country	0.0007850	0.0000000	0.0078248
	(0.20)	(.)	(1.14)
Regulation framework			
Regulation quality	**0.0142714**	**0.0428917**	**0.0308428**
	(3.21)**	(7.13)**	(6.29)**
Format dummies			
Hypermarkets	0.0138456	0.0000000	-0.0295279
	(0.85)	(.)	(1.06)
Hypermarkets & superstores	0.0301430	0.0000000	-0.0091928
	(1.80)	(.)	(0.32)
Supermarkets	0.0118800	0.0000000	-0.0269808
	(0.74)	(.)	(0.99)
Supermarkets & Neighbourhood stores	-0.0123122	0.0000000	-0.0452380
	(0.66)	(.)	(1.41)
Superstores	-0.0121818	0.0000000	**-0.0567184**
	(0.73)	(.)	(1.98)*
Cash & Carry	0.0259254	0.0000000	-0.0158793
	(1.57)	(.)	(0.56)
Constant	**0.1418920**	**0.1742374**	**0.1804323**
	(7.86)**	(25.77)**	(5.81)**

NOTE: developing economies, Middle East, convenience stores dropped to avoid multicollinearity

Since we included number of stores and macroeconomic variables to control for them we do not discuss them in details. In addition, we do not discuss the fact of dropped dummies in Fixed effect estimation (since it is the same as in SFA 2nd stage, see discussion above).

What we see in DEA estimation is that regional effects turned out to be more pronounced. First of all countries with advanced economies are on average more efficient. Secondly, there are significant differences within developing countries. In particular, most regions unexpectedly turned out to be less efficient than omitted category (Middle East).

Further, there is no evidence of existence of home bias. Regulation framework has still very significant (at 1 % level) positive effect on efficiency, though the effect is somewhat less pronounced (between 1.5% and 4%). And finally, for DEA scores retail format does not matter.

So summing up the results, we have seen that all methods show existence of significant inefficiencies in world retail industry. This inefficiency does not depend on the fact whether company is operating in home country or overseas. On the contrary, efficiency depends on country regulatory framework of the country (the better framework – more efficient are the operations). These two effects were supported by all specifications. In addition, some specifications offer that countries with advanced economy are more efficient, while other show some evidences in favor of hypermarket and superstore format. Though the last two effects does not survive in all specifications.

Note, the above results show that there is (or there is no) correlation between efficiency scores and specific factors. This does not imply automatically that there is causal relationship. One would need to perform additional test to find (or to find no) causality. We leave it as one of potential further developments.

Chapter 7

CONCLUSIONS

The goal of our work was to study efficiency in retail industry on a large panel (including data on retailers from 113 countries for the years between 1999 and 2006). In particular, we aimed to test whether companies strive to operate efficiently, as is predicted by neoclassical production theory, and if inefficiencies would be found – study potential sources. To answer these questions we estimated efficiency scores both by nonparametric DEA and parametric SFA approaches, since it was already known in the literature that the methods may produce different results, even qualitatively (in terms of efficiency ranking). To be able to perform nonparametric estimation using large dataset, we modified DEA procedure, so that decrease number of computations. This increased speed of estimation, while resulting estimates are equivalent to classical DEA.

In our research we have found that retail industry is globally inefficient. The average firm in the world is only 20% efficient (some specification offer 60% average efficiency, which is still low). Further, we found that firms in countries with friendlier regulatory framework are about 3-5% more efficient. This result holds in all specifications except one. However, we found no evidence for so called home bias (i. e. company is operating more efficiently in parent country). This result survived in all specifications. In addition, some specifications offered that firms working in countries with advanced economy operate more efficiently. But this result does not hold in all specifications. And finally, in some specifications there were evidences that hypermarkets and superstores are more efficient retail format than others. Unfortunately, this result does not hold in all specifications either.

Among interesting further developments would be to examine in more details internal sources of inefficiency (if one could obtain disaggregated information on costs). Additionally, it may be interesting to test our findings to see whether there are any causal effects, but not just correlations that we have found.

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APPENDIX

Table A.1. First stage: frontier estimation by usual SFA

	Dependant variable: **Sales**
Area	5.295
	(0.85)
Number of stores	-15.743
	(2.62)**
GDP per capita	-12.135
	(3.14)**
CPI	-29.226
	(3.66)**
Population	0.208
	(0.06)
*0.5 **	
Area*Number of stores	-0.017
	(3.65)**
Area*GDP	0.007
	(0.72)
Area*CPI	0.075
	(3.61)**
Area*Population	-0.060
	(7.28)**
Number of stores*GPD	0.018
	(1.94)
Number of stores*CPI	-0.089
	(4.87)**
Number of stores*Population	0.036
	(4.31)**
GDP*CPI	-0.158
	(15.28)**

GDP*Population	-0.034
	(6.62)**
CPI*Population	-0.125
	(9.41)**
Year^2	-0.000
	(3.21)**
Area*Year	-0.002
	(0.71)
Number of stores*Year	0.008
	(2.64)**
GDP*Year	0.006
	(3.30)**
CPI*Year	0.015
	(3.71)**
Population*Year	0.000
	(0.14)
Constant	109.670
	(2.94)**

all variables except Year are in logs

Observations	9311
Absolute value of z statistics in parentheses	
* significant at 5%; ** significant at 1%	
Wald chi2	89692.22
Prob > chi2	0.0000

Table A.2. Table A.1. First stage: frontier estimation by SFA using time-varying decay model.

	Dependant variable: **Sales**
Area	0.262
	(2.20)*
Number of stores	0.478
	(4.22)**
GDP per capita	0.548
	(7.85)**
CPI	0.048
	(0.40)
Population	0.403
	(4.67)**
*0.5**	
Area*Number of stores	-0.055
	(8.78)**
Area*GDP	0.082
	(5.11)**
Area*CPI	0.087
	(2.96)**
Area*Population	0.020
	(1.08)
Number of stores*GPD	-0.004
	(0.24)
Number of stores*CPI	-0.042
	(1.64)
Number of stores*Population	0.030
	(1.56)
GDP*CPI	-0.143
	(10.26)**
GDP*Population	-0.130
	(13.13)**
CPI*Population	0.043

	(2.07)*
Constant	-4.352 (4.62)**

Observations	9311
Number of DMUs	1607
Absolute value of z statistics in parentheses	
* significant at 5%; ** significant at 1%	
Wald chi2	27337.44
Prob > chi2	0.0000

Table A.3. 2nd stage estimation: SFA, simple OLS

	SFA
Regional dummies	
Advanced economies as defined by IMF	-0.0071000 (0.71)
Africa	-0.0410193 (3.85)**
Central and Eastern Europe	-0.0016680 (0.16)
Commonwealth of Independent States and Mongolia	0.0886780 (6.52)**
Developing Asia	-0.0267539 (2.43)*
Latin America	0.0289630 (2.89)**
Home country dummy	
Home country	0.0037196 (0.94)
Regulation framework	
Regulation quality	0.0116098 (2.68)**

Format dummies	
Hypermarkets	0.0218378 (1.31)
Hypermarkets & superstores	0.0396733 (2.31)*
Supermarkets	0.0331569 (2.03)*
Supermarkets & Neighbourhood stores	- 0.0065642 (0.35)
Superstores	- 0.0011092 (0.07)
Cash & Carry	0.0286684 (1.69)
Constant	0.5901754 (32.53)**
Observations	5911
R-squared	0.04
Absolute value of t statistics in parentheses	
* significant at 5%; ** significant at 1%	
F(14, 5896)	15.65
Prob > F	0.0000

NOTE: developing economies, Middle East, convenience stores dropped to avoid multicollinearity

Table A.4. 2nd stage estimation: SFA, fixed effects

	SFA
Regional dummies	
Advanced economies as defined by IMF	0.0000000 (.)
Africa	0.0000000 (.)
Central and Eastern Europe	0.0000000

	(.)
Commonwealth of Independent States and Mongolia	0.0000000
	(.)
Developing Asia	0.0000000
	(.)
Latin America	0.0000000
	(.)
Home country dummy	
Home country	0.0000000
	(.)
Regulation framework	
Regulation quality	0.0671904
	(13.35)**
Format dummies	
Hypermarkets	0.0000000
	(.)
Hypermarkets & superstores	0.0000000
	(.)
Supermarkets	0.0000000
	(.)
Supermarkets & Neighbourhood stores	0.0000000
	(.)
Superstores	0.0000000
	(.)
Cash & Carry	0.0000000
	(.)
Constant	0.5719426
	(145.08)**
Observations	5911
Number of DMUs	1511
R-squared	0.04
Absolute value of t statistics in parentheses	
F(1, 4399)	178.23
Prob > F	0.0000

NOTE: developing economies, Middle East, convenience stores dropped to avoid multicollinearity

Table A.5. 2nd stage estimation: SFA, random effects

	SFA
Regional dummies	
Advanced economies as defined by IMF	-0.0434144 (2.24)*
Africa	-0.0068659 (0.31)
Central and Eastern Europe	-0.0079194 (0.37)
Commonwealth of Independent States and Mongolia	0.1202084 (4.42)**
Developing Asia	-0.0111433 (0.49)
Latin America	0.0250532 (1.20)
Home country dummy	
Home country	0.0144977 (1.79)
Regulation framework	
Regulation quality	0.0518249 (11.65)**
Format dummies	
Hypermarkets	0.0040447 (0.12)
Hypermarkets & superstores	0.0183243 (0.53)
Supermarkets	0.0151456 (0.47)
Supermarkets & Neighbourhood stores	-0.0370699 (0.99)
Superstores	-0.0310414 (0.92)
Cash & Carry	0.0129470 (0.38)
Constant	0.5718779

	(15.70)**
Observations	5911
Number of DMUs	1511
Absolute value of z statistics in parentheses	
* significant at 5%; ** significant at 1%	
Wald chi2	185.57
Prob > chi2	0.0000

NOTE: developing economies, Middle East, convenience stores dropped to avoid multicollinearity

Table A.6. 2nd stage estimation: SFA time-varying decay model (SFA tvd), simple OLS

	SFA_tvd
Regional dummies	
Advanced economies as defined by IMF	0.0061277 (0.90)
Africa	0.0483808 (6.64)**
Central and Eastern Europe	0.0428035 (6.16)**
Commonwealth of Independent States and Mongolia	0.0794358 (8.54)**
Developing Asia	0.0222481 (2.96)**
Latin America	0.0835580 (12.21)**
Home country dummy	
Home country	-0.0052766 (1.95)
Regulation framework	
Regulation quality	-0.0045343

	(1.53)
Format dummies	
Hypermarkets	0.0621876 (5.46)**
Hypermarkets & superstores	0.0654185 (5.57)**
Supermarkets	0.0398991 (3.57)**
Supermarkets & Neighbourhood stores	0.0216787 (1.67)
Superstores	0.0380699 (3.27)**
Cash & Carry	0.0709134 (6.11)**
Constant	0.0947562 (7.64)**

Observations	5911
R-squared	0.12

Absolute value of t statistics in parentheses
* significant at 5%; ** significant at 1%

F(14, 5896)	54.80
Prob > F	0.0000

NOTE: developing economies, Middle East, convenience stores dropped to avoid multicollinearity

Table A.7. 2nd stage estimation: SFA time-varying decay model (SFA tvd), fixed ts

	FA_tvd
Regional dummies	
Advanced economies as defined by IMF	0.0000000 (.)
Africa	0.0000000 (.)
Central and Eastern Europe	0.0000000 (.)
Commonwealth of Independent States and Mongolia	0.0000000 (.)
Developing Asia	0.0000000 (.)
Latin America	0.0000000 (.)
Home country dummy	
Home country	0.0000000 (.)
Regulation framework	
Regulation quality	0.0038137 (12.37)**
Format dummies	
Hypermarkets	0.0000000 (.)
Hypermarkets & superstores	0.0000000 (.)
Supermarkets	0.0000000 (.)
Supermarkets & Neighbourhood stores	0.0000000 (.)
Superstores	0.0000000 (.)
Cash & Carry	0.0000000 (.)

Constant	0.1609840 (666.84)**

Observations	5911
Number of DMUs	1511
R-squared	0.03

Absolute value of t statistics in parentheses
* significant at 5%; ** significant at 1%

F(1, 4399)	153.12
Prob > F	0.0000

NOTE: developing economies, Middle East, convenience stores dropped to avoid multicollinearity

Table A.8. 2nd stage estimation: SFA time-varying decay model (SFA tvd), random effects

	SFA
Regional dummies	
Advanced economies as defined by IMF	0.0002803 (0.02)
Africa	0.0577738 (4.00)**
Central and Eastern Europe	0.0400167 (2.94)**
Commonwealth of Independent States and Mongolia	0.0849459 (4.89)**
Developing Asia	0.0229865 (1.57)
Latin America	0.0800827 (5.93)**
Home country dummy	
Home country	- 0.0000915 (0.02)

Regulation framework	
Regulation quality	0.0037828 (12.29)**
Format dummies	
Hypermarkets	0.0513892 (2.43)*
Hypermarkets & superstores	0.0532940 (2.42)*
Supermarkets	0.0291583 (1.41)
Supermarkets & Neighbourhood stores	0.0080076 (0.33)
Superstores	0.0240166 (1.11)
Cash & Carry	0.0599476 (2.77)**
Constant	0.0909743 (3.88)**

Observations	5911
Number of DMUs	1511

Absolute value of z statistics in parentheses
* significant at 5%; ** significant at 1%

Wald chi2	333.55
Prob > chi2	0.0000

NOTE: developing economies, Middle East, convenience stores dropped to avoid multicollinearity

Table A.9. 2nd stage estimation: DEA, simple OLS

	DEA
Internal retailer characteristics	
Number of stores	0.0000934 (10.10)**
Macroeconomic factors	
GDP per capita	0.0000015 (5.83)**
CPI	0.0000009 (0.50)
Population	-0.0000047 (1.20)
Regional dummies	
Advanced economies as defined by IMF	0.0378297 (3.75)**
Africa	-0.0577341 (5.36)**
Central and Eastern Europe	-0.0227198 (2.19)*
Commonwealth of Independent States and Mongolia	0.0283489 (2.11)*
Developing Asia	-0.0446921 (3.74)**
Latin America	-0.0009180 (0.09)
Home country dummy	
Home country	0.0007850 (0.20)

Regulation framework	
Regulation quality	0.0142714 (3.21)**
Format dummies	
Hypermarkets	0.0138456 (0.85)
Hypermarkets & superstores	0.0301430 (1.80)
Supermarkets	0.0118800 (0.74)
Supermarkets & Neighbourhood stores	-0.0123122 (0.66)
Superstores	-0.0121818 (0.73)
Cash & Carry	0.0259254 (1.57)
Constant	0.1418920 (7.86)**

Observations	5911
R-squared	0.20

Absolute value of t statistics in parentheses
* significant at 5%; ** significant at 1%

F(18, 5829)	82.79
Prob > F	0.0000

NOTE: developing economies, Middle East, convenience stores dropped to avoid multicollinearity

Table A.10. 2nd stage estimation: DEA, fixed effects

	DEA
Internal retailer characteristics	
Number of stores	-0.0001597 (5.56)**
Macroeconomic factors	
GDP per capita	0.0000003 (1.05)
CPI	0.0000026 (0.74)
Population	0.0000422 (3.73)**
Regional dummies	
Advanced economies as defined by IMF	0.0000000 (.)
Africa	0.0000000 (.)
Central and Eastern Europe	0.0000000 (.)
Commonwealth of Independent States and Mongolia	0.0000000 (.)
Developing Asia	0.0000000 (.)
Latin America	0.0000000 (.)
Home country dummy	
Home country	0.0000000 (.)
Regulation framework	

Regulation quality	0.0428917 (7.13)**
Format dummies	
Hypermarkets	0.0000000 (.)
Hypermarkets & superstores	0.0000000 (.)
Supermarkets	0.0000000 (.)
Supermarkets & Neighbourhood stores	0.0000000 (.)
Superstores	0.0000000 (.)
Cash & Carry	0.0000000 (.)
Constant	0.1742374 (25.77)**

Observations	5911
Number of DMU	1511
R-squared	0.02

Absolute value of t statistics in parentheses
* significant at 5%; ** significant at 1%

F(5, 4395)	19.95
Prob > F	0.0000

NOTE: developing economies, Middle East, convenience stores dropped to avoid multicollinearity

Table A.11. 2nd stage estimation: DEA, random effects

	DEA
Internal retailer characteristics	
Number of stores	0.0000278 (1.82)

Macroeconomic factors	
GDP per capita	0.0000005 (2.03)*
CPI	0.0000005 (0.21)
Population	0.0000085 (1.40)
Regional dummies	
Advanced economies as defined by IMF	0.0402785 (2.38)*
Africa	-0.0566957 (2.96)**
Central and Eastern Europe	-0.0316361 (1.74)
Commonwealth of Independent States and Mongolia	0.0256449 (1.10)
Developing Asia	-0.0577356 (2.80)**
Latin America	-0.0127733 (0.71)
Home country dummy	
Home country	0.0078248 (1.14)
Regulation framework	
Regulation quality	0.0308428 (6.29)**
Format dummies	
Hypermarkets	-0.0295279 (1.06)
Hypermarkets & superstores	-0.0091928 (0.32)
Supermarkets	-0.0269808 (0.99)
Supermarkets & Neighbourhood stores	-0.0452380 (1.41)

Superstores	-0.0567184 (1.98)*
Cash & Carry	-0.0158793 (0.56)
Constant	0.1804323 (5.81)**

Observations	5911
Number of DMU	1511

Absolute value of z statistics in parentheses
* significant at 5%; ** significant at 1%

Wald chi2	457.90
Prob > chi2	0.0000

NOTE: developing economies, Middle East, convenience stores dropped to avoid multicollinearity