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# Economic management instrument for enhanced supply of utilities to megacities

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**Abstract**. A cost structure is proposed to enhance the supply of utilities to megacities on a regional operating scale. The introduced methodology involves business administration theory and economics and employs the previously introduced equality principle and the EUROPE (Efficient Use of Resources for Optimal Production Economy) model to impose shadow costs on supply losses to induce economic incentives to improve the functionality of megacities. A case study presents the practical application in an Asian context. It is concluded that the introduced methodology makes the megacities more efficient and improve their functionality. Profitability increases, the technology is advanced, and the environment improves when the EUROPE model is applied on activities that involve supply flows at higher policy analysis levels. Application of an introduced key factor encapsulates megacity aspects. The equity of the regional access to facilities is improved. The developed methods support decision-making when managing megacity supply.

## 1. Introduction

This study emphasizes an earlier introduced economic tool that allocates constructed costs to residuals. This innovative economic instrument has previously been applied on various contexts and forms the mathematical expression of a concept that is denoted the equality principle [1–3]. Here, the equality principle is applied on how to cost-effectively supply megacities with utilities. Previous studies of a similar kind have focused on how to apply urban freight transportation concepts to megacities [4]. Goldstein described [5] how not to make a megacity in African context.

About earlier attempts to apply scientific findings about logistics to improve the situation in megacities, for example, Ding [6] has studied the relationship between transport costs and the concentration of regional economy while Dargay et al. [7] built a model for how the vehicle saturation level is related to observable country characteristics. Lin and Xie [8] studied how much of China's total oil demand that is taken up by the road transport sector while Zhou et al. [9] wrote about the size of urban energy consumption compared to the total energy consumption in China. Liu et al. [10] built a Beijing urban passenger transport carbon model backed up by Palazuelos and Enrique Garcia [11] who concluded that the increasing dependence on foreign hydrocarbons is the most striking feature of China's energy transition since the 1990s. Timilsina and Dulal [12] described the main factors that influence the choice of regulatory instruments available to design an urban road transportation externalities policy. Cavailhès et al. [13] found that costs determine the interregional and intra-urban economy and showed how decentralizing the production and consumption of goods in secondary employment centers contribute to companies located in larger cities to remain dominant. But efforts like the EUROPE model-approach are hard to find.

In the light of this scarce previous research of relevance, the present paper obviously develops a new cost structure to provide economic incentives for making utilities flow more efficiently to and from megacities. Thus, the introduced methodology represents a novel supply-concept specifically about improvement of facilities for the necessity provision on a regional scale.

Few scholars seem to have studied shadow costs in relation to systems for utility transportation. Works describe technical, economic and environmental aspects of supply issues.

No studies seem to have been made of how to monitor, manage and evaluate the performance of activities related to necessity flows just by one key monetary based factor. Thus, our work represents a novel approach of importance for the regional economy, technology development and the environment. The objective of this study is to provide practically useful methods that managers on mainly higher policy analysis levels can use to increase the cost-efficiency of activities and schemes to provide megacities with utilities, commodities and foodstuff.

## 2. The EUROPE model method

This study proposes equating residual products with regular products about the allocation of costs. The approach is the equality principle [14, 15] and forms the scientific basis for this paper based on the employment of shadow costs/prices. The term 'shadow price' or 'shadow pricing' refers to monetary values assigned to currently unknowable or difficult to calculate costs [16–18].

The residuals of the different resources of interest are regarded as a regular product output. This is expressed in (1) used to allocate costs to residuals through multiplication by the total costs by splitting the costs up in logical proportions. The EUROPE model works as follows.

$$PF = A \,/\, (B + C) \tag{1}$$

$$SC = \text{corporate-internal shadow cost additionally allocated to } A = PF * TC \tag{2}$$

$$TC = \text{Total Costs} = \text{Fixed Costs} + \text{Variable Costs} = FC + VC \tag{3}$$

$$SC = (A * (FC + VC)) \,/\, (B + C) \tag{4}$$

Where $PF$ = the Proportionality Factor (without sort, it is a mathematical fraction), $A$ = quantity of the residuals from a certain resource produced that are to be optimized, $B$ = quantity of the regular resource output, $C$ = sum of the quantities of all the different residual fractions stemming from 'the black box' of the studied system, $i$ = 1, 2 ... $n$ in order of estimated, descending and collocated economic and/or environmental relevance. Sort: kg, liters, Joule, CNY, RUB, €, $ or £, etc.

Equation (1) represents the economic implications of the equality principle, its name — The Efficient Use of Resources for Optimal Production Economy (EUROPE) model [19–21]. A suitable administrative unit must be defined by management, depending on the circumstances.

## 3. Application of the proposed cost structure on megacity supply enhancement

### 3.1. Theory for megacity supply enhancement by the EUROPE model

The flow loss shadow cost is:

$$FLOWLOST = \Sigma\, ((A_i \,/\, (B_i + C_i)) * TC_i * W_{air\ impact\ i} * W_{land\ impact\ i} * W_{water\ impact\ i} * W_i), \tag{5}$$

where $i$ = 1, 2, …, $j$, FLOWLOST = total shadow cost of the $n$ flow systems' inefficiency, $A_i$ = quantity of the spillages in a certain flow system $i$ (the 'bad'), $B_i$ = quantity of the regular main utility flow in question that produces, for example, $A_i$ (the 'goods'), $C_i$ = quantity of all the possibly unwanted system flow spillages or losses of the regular main utility flow $B_i$ that have a negative impact on $A_i$ (the 'bads') $TC_i$ = total societal cost of flow system's $i$ inefficiency employing (3), $W_i$ = the weight conferred to impact flow system $i$ related to air, land and water based on scientific evidence or in terms of the societal aims depending on the managers' judgments or personal preferences (without sort, it is a mathematical fraction), $W_i \geq 0$, $j$ = 1, 2, …, megacity m within a suitable and defined administrative unit during a certain time. Sort: CNY, RUB, €, \$, £ or ¥, etc.

FLOWLOST is inserted in the public budget, estimations and forecasts of, for example, the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP). The FLOWLOST will force the ESCAP to ensure an efficient flow of necessities in Asia. The principle is: the less FLOWLOST is, the more efficient the flow of supplies to the megacities in ESCAP will be. Less FLOWLOST allocated to trade bloc's accounting systems implies more efficient handling of the bloc's supply flow since it represents less disadvantageous costs. FLOWLOST constitutes a tool management can use to simultaneously monitor, manage and evaluate their projects' performance.

### *3.2. Case study: megacity Shanghai*

This case study concerns the city of Shanghai about its flows of the grocery rice, this commodity being essential for the local survival. Shanghai is the economic and financial center in mainland China with a land area of 6,340 $km^2$, a population of over 19 million people and a GDP of RMB 1,687 billion in the year 2011. The city is situated on China's eastern coast under control of China's government. It has well-developed transport and traffic systems. Shanghai Port is the world's busiest port and there are two airports in Shanghai. In 2009, Shanghai hosted sixty universities and colleges with more than half a million students.

Annually, China produces 147-billion-kilogram rice, imports 5-billion-kilogram rice and had in 2016 a total population of 1,376,120,000 persons. Thus, China supplies its citizens with approximately 110 kilograms rice per person and year. Annually, China consumes 150 billion kilograms of rice; hence, there is no over-production of rice in China. In 2014, central Shanghai, excluding its suburbs, had 18,630,000 inhabitants that is 1.4 per cent of China's total population. In 2013, the wastes of milled equivalent of rice were 6,393,241 tons while the wastes of paddy equivalent of rice were 9,585,070 tons.

Thus, each year, Shanghai receives 2,049 million kilograms of rice (110 kg rice per person and year * 18,630,000 inhabitants in central Shanghai). The wastes of rice per year received by Shanghai in relative terms = ((6.4 million tons + 9.6 million tons)/150 million tons) * 2,049 million kilograms of rice = 11 per cent * 2,049,000 tons of rice = 219,000 tons of rice.

In 2015, the market value of rice in China was \$5.64 billion, giving a \$38 price per ton of rice (\$5.64 billion/150 million tons of rice annually consumed in China). Thus, the value of the annual wastes of rice supplied to Shanghai = 219,000 tons of rice * \$38 per ton of rice = M\$8.2 = A in the EUROPE model.

The value of the domestic transportation of goods in Sweden 2016 was SEK 1,289 billion = approximately \$161 billion with an exchange rate of \$1 = SEK8 (November 2017). In 2016, the population of Sweden was 9,995,000 people = 0.7 per cent of China's population. If Sweden approximate China in terms of the transportation apparatus, the value of the domestic transportation of goods in China in 2016 was approximately \$23,000 billion (\$161 billion / 0.007)) Thus, the annual value of the goods transported to Shanghai is approximately \$322 billion (1.4% * \$23,000 billion) = B in the EUROPE model.

According to Kant, Department of Sustainable Waste and Water, City of Gothenburg (e-mail communication 2017), the annual spillages and losses in economic terms in the technical systems, such as for the supply of drinking water, energy flows and the sewage system, are approximately 0.4% in a larger modern city. The total expenditure budget of Shanghai for 2017 = RMB 737 billion = \$111 billion while 9.29 billion yuan is spent annually on energy saving and environmental protection. Thus, the term C in the EUROPE model = the total ‘bads’ = approximately M$600 (0.4% * approximately 10 billion yuan = 0.4% * $1.5 billion).

In 2015, the GDP in China was $11,007.72 billion. Thus, the value of a total collapse of Shanghai’s economy due to, for example, a non-functioning transportation system is approximately $154 billion (1.4% * $11,007.72 billion) = TC in the EUROPE model. An exchange rate of CNY100 = $15 is used throughout. See Table 1 for summary of the calculations to obtain the parameter-values.

**Table 1.** Scheme for calculation of the shadow cost FLOWLOST $_{\text{Shanghai}}$ by the EUROPE model.

| Parameter | Value (M$) | Calculation |
|---|---|---|
| *A* (the ‘bad’) | 8.2 | 219,000 tons of wastes of rice per year received by Shanghai * $38 as market price per ton of rice in China |
| *B* (the ‘goods’) | 322,000 | Central Shanghai’s 1.4% of China’s total population * $23,000 billion for the domestic transportation of goods in China in 2016 |
| *C* (the ‘bads’) | 6 | 0.4% annual spillages and losses in economic terms in the technical systems * 9.29 billion yuan spent 2017 in Shanghai on energy saving and environmental protection |
| TC (collapsed Shanghai economy) | 154,000 | Central Shanghai’s 1.4% of China’s total population * the GDP in China 2015 of $11,007.72 billion |
| FLOWLOST $_{\text{Shanghai}}$ | 3.9 | PF $_{\text{Shanghai}}$ * TC $_{\text{Shanghai}}$ = (*A* / (*B* + *C*)) * TC $_{\text{Shanghai}}$ = (M$8.2 / ($322 billion + M$6)) * $154 billion |

FLOWLOST Shanghai = PF Shanghai * TC Shanghai = (M$8.2 / ($322 billion + M$600)) * $154 billion = 0.0025% * $154 billion = M$3.9 = approximately M$4 to be inserted in the public budget, estimations and forecasts of, for example, the trade bloc ESCAP containing the megacity Shanghai considered in this case study to improve its supply flow-efficiency, see table 2.

**Table 2.** The schematic public finances for ESCAP related to Shanghai.

| | |
|---|---|
| Expenditure ESCAP | FLOWLOST Shanghai (M$4) |
| Total receipts ESCAP | PSBR ESCAP (+M$4) |

## 4. Results and discussion

The M$4 shadow cost FLOWLOST that is inserted into the budget of ESCAP (Table 1) constitutes a very reasonable 26 millionth of the TC Shanghai = $154 billion for the total collapse of Shanghai’s economy. Weights can be employed according to the general principles in section 3.2.

FLOWLOST constitutes a versatile tool for estimation of how the flows of necessities within a trade bloc with many megacities should be organized about the different flow quantities. The higher potential for reducing the different $A_i$ in a city, the more efforts to make the flows in and to that city more efficient should be made. The different megacities within the entire trade bloc can become more prosperous and the supply flows will be optimized, featuring a combined supply improvement. Business thrive if the EUROPE model is used to cost-effectively provide mega cities with goods.

When testing the model in the case study, a most reasonable shadow cost of M$4 emerges. According to Section 3.2, the wastes of rice per year received by Shanghai = 219,000 tons giving a FLOWLOST shadow cost of approximately $18 per wasted tons of rice but weighting is not applied. Thus, when applied in practice with real fact and figures for Shanghai, the suggested model gives a realistic outcome. This shadow cost of M$4 hence constitutes a versatile key factor for the managers to employ when deciding to take actions that makes the transport system flow smoothly.

## 5. Other Application of the proposed cost structure on megacity supply enhancement

The path-breaking EUROPE model represents an innovative usage of constructed shadow costs to create economic incentives for improvement of supply systems functionality. The single key factor to simultaneously monitor most aspects of interest for a supply system is also novel in transportation. The most interesting is the novel method to facilitate high level policy decisions.

The introduced methodology makes the megacities more cost-efficient and improves their functionality. Profitability increases, the technology is advanced, and the environment improves when the EUROPE model is applied on various activities that involve supply flows to megacities.

For Shanghai particularly, it is proposed to insert M$4 in the public finances of ESCAP as a constructed shadow cost to improve the supply flow-efficiency of Shanghai specifically about its flows of the grocery rice. This shadow cost denoted FLOWLOST Shanghai constitutes a key factor that makes the megacity more efficient and improve its functionality about feeding its inhabitants.

The major conclusions of this study are: the results show viability for improving mega city supply systems; the launched approach facilitates the supply transportation cost-efficiency; by applying the presented approach wisely, the well-being and profitability of mega cities increase.

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