TECHNOLOGICAL AND ECONOMIC DEVELOPMENT OF ECONOMY
Baltic Journal on Sustainability
2010
16(3): 555–566

FEASIBILITY OF THE LIBERAL ELECTRICITY MARKET UNDER CONDITIONS OF A SMALL AND IMPERFECT MARKET. THE CASE OF LITHUANIA

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Received 17 December 2009; accepted 5 August 2010

Abstract. At the end of the 20th century most governments of the world started adopting guidelines on the electricity market liberalization, and the liberal electricity market already operates in USA, Scandinavia and some EU Member States. In most cases the deregulated market has lived up to expectations but there were situations when priority was again given to the regulated market. The aim of this article is to assess whether the deregulated electricity market is a good choice for the countries with a small and imperfect market. Electricity is completely homogenous and it might not be warehoused and its price depends on the fuel used, so the examples of other economic sectors (natural gas, water, telecommunications, etc.) sometimes cannot be applied for this market. This paper analyses the advantages and disadvantages and the potential threats of the deregulated electricity market; moreover, the paper presents the main principles lying behind the electricity price setting and analyses whether the deregulated electricity market fits for Lithuania.

Keywords: energy, electricity price, deregulated price, price setting principles, small imperfect market.

Reference to this paper should be made as follows: Burinskienė, M.; Rudzkis, P. 2010. Feasibility of the liberal electricity market under conditions of a small and imperfect market. The case of Lithuania, *Technological and Economic Development of Economy* 16(3): 555–566.

1. Introduction

Before the nineties, almost all over the world electricity, natural gas and water were generated and supplied by state monopolies (Wenzler *et al.* 2005, 30–31). USA and Germany, with the private monopolies prevailing, could be mentioned as an exception (Štilinis 2006: 106). Since

ISSN 2029-4913 print/ISSN 2029-4921 online doi: 10.3846/tede.2010.34
http://www.tede.vgtu.lt

the nineties the free market ideas contributed to the changing attitude towards the ownership form, management and use of utilities companies not subject to state regulation. Since then Europe and USA launched such reforms as privatisation, liberalisation and abolition of state regulation (Crew and Kleindorfer 1999; Scott 2003; Veeneman and Mayer 2002). The opinion has been prevailing that liberalisation and privatisation determine price reduction, higher service quality and better use of resources (Wenzler *et al.* 2005: 30–34). The main advantage of the liberal electricity market is a possibility for consumer to choose both an electricity supplier and a price for the purchased electricity. Thus, trade in electricity faces competition which results in a more efficient management of the electricity sector (Štilinis 2006: 106).

Although for a long time the electricity industry has been perceived as a vertically integrated structure within which generation, transfer and distribution is performed by state regulated monopoly, at the end of the 20th century most governments started adopting guidelines on the electricity market liberalisation: at first that was seen in USA, later also in the EU Member States, and at the end of 2000 the liberal electricity market functioned in the UK, Germany, Sweden, Norway and some States of the USA. The EU draft directive produced in 2001 provided that all EU Member States should have the liberal market fully implemented by 2005 (Littlechild 2002).

The liberal electricity market has been rapidly spreading globally and in many cases it came up to expectations. The mechanisms of the liberal market functioning have been dealt with in numerous references analysing the influence of regulation and of deregulation on the behaviour of companies. In most cases there is a general understanding that institutional changes have caused changes in industry margins, attracted new market actors and encouraged changes in companies' behaviour (Bonardi 2004; Delmas and Tokat 2005; Fuentelsaz *et al.* 2002; Haveman 1993; Haveman *et al.* 2001; Meyer *et al.* 1990; Miller and Chen 1994; Smith and Grimm 1987). The above research publications stick to the opinion that the deregulated electricity market is more efficient, therefore authors are inclined to analysing further strategies of company development, impacts on different sectors of economy, green energy development potential, etc., rather than the concept of the deregulated market itself. However, some authors are sceptical about the deregulated market and say that its advantages may be smaller than its disadvantages. For example Banks (2002: 170–175) takes California, Alberta and Brazil – where the deregulated market did not prove to be efficient – as an example noting that deregulation of the electricity market was inefficient, and he is sceptical about the UK example which by other authors is often offered to be a model case of the liberal electricity market. Emerson (2002) noted that in the case of California the underlying problem was speculation in electricity by suppliers and brokers. Besides, in most cases large electricity markets with numerous different suppliers were analysed, while the functioning of the deregulated market in the case of small countries was hardly addressed. Tishler and Woo (2006) have doubts whether the deregulated market fits for Israel and state that in that case the advantages of the regulated market outweigh those of the deregulated market.

Although in other economic sectors the deregulated market usually proves to be efficient and the competition between the companies conditions the optimisation of activities and a drop in prices and costs (e.g. natural gas, telecommunications, etc.), the electricity sector is substantially different and the deregulation problems are generated by the nature of the product itself. The peculiarity of electricity lies in the fact that electricity cannot be warehoused and that it is completely homogeneous (Emerson 2002). Besides, its production is limited by the fuel (gas, oil products, coal) and generation capacities. Fuel accounts for about 80% of the electricity price, and the price of fuel is set in the competitive global market (Tishler and Woo 2007: 322–323). Deregulated market makes its actors to compete and increase their efficiency, which could be achieved through reduction of management, maintenance and repairs costs (Grundey 2008b). However, reduction of the above costs even by half would result only in 10% lower price of electricity generation, and it is questionable whether a reduction to such extent is ever possible. It is considered that, due to high fixed costs, the "perfect" competition involving numerous market actors sometimes might not be financially stable which could condition survival in the market of only several large actors, and this would result in rocketed prices (the Californian case). The deregulated market also enables larger market actors to foreclosure smaller ones or those who use less efficient technologies, and this poses risk that in future electricity prices will go up with exorbitant short-term prices. Besides, in the case of the deregulated market it is rather difficult to forecast electricity prices, as they depend not only on the global fuel prices but also on the strategy chosen by produces. On the other hand, the main advantage of the deregulated market – the enhanced efficiency of companies – is at the same time the main disadvantage. The main issue of the regulated market is the principle of regulation itself: a profit rate is usually fixed, thus, companies are not motivated to upgrade their technologies or to apply more efficient technologies what is one of the main principles of sustainability (Grundey 2008b). Besides, it is not easy to assess the validity of company management expenses, i.e. the necessary staff numbers, prices of purchased goods and services, etc. The efficiency of electricity companies also depends on the integrated effect of macrolevel variable factors, such as national economic, political and cultural development level, legal acts regulating activities (Šliogerienė *et al.* 2009: 496) The deregulated market solves these problems and a complicated and expensive regulation mechanism becomes unnecessary. However, in the short-term, this could limit the occurrence of the new generators as in the deregulated market it is difficult to access the potential profitability of the new generator, as it will depend also on other factors of market participants and profit is not guaranteed.

Hence, the deregulated market has a number of disadvantages and the advantages of the deregulated market should be assessed in each individual case. It is obvious that, where there exists a large power surplus and a sufficiently high number of generators, the advantages of the deregulated market outweigh its disadvantages. At the same time, authors fail to agree on a more specific number of generators and usually say that it should be high enough as it may differ with each individual market (Burinskienė and Rudzkienė 2009; Čiegis *et al.* 2009a, b). With a low surplus of generation capacity there appears space for manipulations: rising demand may result in skyrocketing electricity prices. With a low number of generators or several dominating generators there opens a possibility to adapt strategies: to act together rather than competing and to raise the price and, at the same time, the profit. For these reasons the deregulation in many cases should prove to be efficient in large electricity markets but it may cause a number of problems in small markets.

2. Principles behind electricity price formation

In the energy industry different models are possible, namely: long-term contracts, economic restrictions, price restrictions, auction, etc. However, liberal electricity markets usually apply the pool-based model (Isa *et al.* 2008: 524). Applying this model producers may offer different amounts of electricity at different prices (Ilic *et al.* 1998: 5–16). For consumers this results in lower prices as the main priority is given to the producer who offers the lowest price. Yet, as known in physics, in the case of electricity there should always be a balance: consumption should always level to production. So, electricity production depends on consumption and there should always be a balance:

$$g(t) = c(t)\,, \tag{1}$$

$c(t)$ – electricity consumed at moment t, while g(t) is the generated electricity defined as the sum of the capacity generated by all generators.

$$g(t) = \sum_i g_i(t), \tag{2}$$

where $g_i(t)$ is electricity generated by generator i at moment t. As not all generators operate at a particular moment, some of them are considered to be the hot reserve and some are considered to be the cold reserve. For the sake of simplicity, the hot reserve may be attributed to the operating generators as their characteristics are essentially the same. Hence, the function of generation could be defined as the function of two sums:

$$g(t) = g^1(t) + g^2(t) = g^1(t) + 0\,, \tag{3}$$

where $g^1(t)$ is the capacity generated by generators operating at moment *t*, while $g^2(t)$ is generators that do not operate at moment t and are attributed to the cold reserve. Let's then define the maximum generation capacity

$$\max g = \sum_i \max g_i\,, \tag{4}$$

where is the maximum generation capacity and it is understood as the sum of the installed estimated capacity of all generators. Besides, the following condition is valid:

$$\max g > c(t)\,,\ \text{where}\ t = 1..N. \tag{5}$$

Consequently, the maximum estimated capacity at any moment have to exceed consumption, as otherwise the system would become unstable.

As electricity generators are not able to start immediately operating the maximum capacity may differ at different moments, therefore it is a function that alters in time and depends on the electricity capacity demand. Thus, at a particular moment the maximum capacity may be defined as the sum of two functions:

$$\max g(t) = \max g^1(t) + \max g^2(t) \le \max g. \tag{6}$$

Hence, at moment t the maximum capacity consists of the maximum capacity of operating generators and supplementary capacity that could be generated by reserve generators. At a particular moment the maximum capacity depends on historic data, i.e. on the number of previously operating generators and the stage of the reserve generators.

$$\max g(t) = f(\max g^1(t-1), \max g^2(t-1)) = f(\max g(t-1), \max g). \quad (7)$$

Thereby, in general case the maximum capacity within the system depends on the number of generators operating and on the extent to which the reserve might be used. It could be stated then that the maximum capacity depends on historic data, i.e. on the stage of a particular generator and on the period of time needed by the generator to reach its maximum capacity. Knowing the specifics of generators and the state of the system we could forecast what maximum capacity could be reached within a moment or several moments forward.

Further the calculation of the electricity price in the pool-based model is reviewed. The principle of the model is the following: the electricity offered at the lowest price is purchased until the full demand is satisfied. Thus, the electricity price could be defined as follows:

$$p(t) = \frac{\sum_i^n g_i p_i}{\sum_i^n g_i}, \quad (8)$$

where $p_i \le p_{i+1}$ and price p at moment t is calculated as the weighted average of the amount of the lowest price electricity. Besides, the purchased amount of electricity is equal to the consumed amount of electricity. Accordingly, the total amount of energy generated by generators $g_1..g_{n-1}$ and the whole amount or part of electricity generated by generator g_n is purchased. For the sake of simplicity, it could be presumed that the total amount of electricity generated by this generator is purchased. The intention of each producer is to maximise its profit, i.e. to sell the maximum amount of energy for the maximum price. Under ideal competition the electricity price p_i should be equal to the marginal costs of generator I, however in the case of small and non-ideal market the situation is substantially different. In the small market the efficiency of generators and the marginal costs of each generator are known and they mainly depend on the price of the consumed fuel. This means that an electricity producer has only to forecast electricity consumption. As in the short term the electricity demand has low elasticity, consumption hardly depends on the price, therefore forecasting the demand is rather simple and the actual consumption should be dramatically different from the forecasted one. In such case producer could set the optimal price and the following condition should be valid:

$$p_i = p_n - \delta_i, \ \delta_i > 0, \quad (9)$$

$i = 1...n-1$, n – the number of generators, p_n would be the price of generator n, i.e. the last producer whose electricity is purchased, which should be at least as high as its marginal costs. Hence, where producers have the main information, the electricity price should depend on the marginal costs of the producer with the lowest efficiency whose energy is still purchased, while value δ would define the risk faced by producers. The higher is δ, the lower risk is faced by producers. Naturally, in a real case producers may sometimes set a lower price that their marginal costs, however this could happen only in short periods as such production is loss-making. With a large number of generators and similar efficiency this price should not dramatically differ from their marginal costs but with different efficiency of generators the major influence on price should be exerted by the generator of lowest capacity.

Another factor that exerts influence on the electricity price is $\max g(t)$. If the market sees a permanent production surplus this variable should not have impact on the price but energy consumption is dynamic and its alterations are rather steep with regard to both moment consumption and longer-term consumption. Therefore in the short term consumption may approach to the maximum system capacities of the moment and this could create conditions for large electricity consumers to gain advantage from its market position. That is to say, the following condition could occur:

$$\max g(t) - g_i < c(t),\ g_i \in \max g(t), \quad (10)$$

where g_i is the capacity of a particular operating generator that also conditions the maximum generation capacity at moment t. So, in this situation at least one generator without capacity of which the condition that $c(t) = g(t)$ would be violated occurs. Hence, this producer, knowing of the existing situation, might set any price for the electricity offered by it. Such situation might occur in case of unfavourable external factors, for example, in case of breakdown of a large generator, or in case of some agreement between generators, etc. Moreover, this condition may significantly increase the price only if information on its materialisation is available. Thus:

$$p(t) = f(c(t), \max g(t), L(g_i)), \quad (11)$$

$L(g_i)$ – defines the marginal costs of the generator. So, the electricity price depends on consumption, maximum generation power and marginal costs of a generator. Naturally, there are other undefined variables, such as producers strategy, risk tolerance, fuel price fluctuations, load of generators, etc. The present article, however, deals only with the above-mentioned variables.

3. Case of Lithuania

Before 2010 the electricity price in Lithuania was regulated and only a minimal amount used to be purchased in an auction. This system was reasonable as the Ignalina Nuclear Power Plant (INPP) that operated at that time was able to satisfy the market needs of all Lithuania and it was the cheapest electricity source. This system was fully reasonable as otherwise the remaining electricity producers would be made to go bankrupt. Changes in the structure of electricity supply, have promoted the government to review its current energy policy related to development of national and regional electricity market (Milčiuvienė and Tikniūtė 2009: 83; Grundey 2008a). In 2010, when INPP was decommissioned, an electricity exchange started operating in Lithuania and a substantial amount of electricity (about 40%) is purchased on the exchange. By 2015 almost all electricity will be purchased on the exchange (Streimikiene 2008; Ciegis *et al.* 2008, 2009a, b).

Table 1 represents the marginal costs and installed capacity of different Lithuania's electricity producers. After INPP was decommissioned in 2010, Lithuanian power plant (Lietuvos elektrinė (LE)) has become the largest electricity generator. Its installed capacity accounts for about 63% of the total electricity generation capacity of Lithuania. LE contains 8 blocks: 4 large ones with 300 MW each, and 4 smaller ones with 150 MW each. LE was built more than fifty years ago, so its efficiency is rather low which also determines very high marginal costs. Among the remaining generators of Lithuania, the major share falls to the thermofication power plants – about 26% of the total capacity, and the remaining power plants account only for about 11% of the generation capacity. The generation efficiency of the thermofication power plants is rather high but this is true only under thermal load, thus the major part of their capacity may be used only during the season of heating, i.e. about 6 months.

Table 1. The installed capacity and marginal costs of Lithuania's electricity producers

Lithuania	Estimated capacity, MW	Marginal costs with the gas price of EUR 200 / 1000 m^3	
		with thermal load, ct/KWh	without thermal load, ct/KWh
Lithuanian power plant (Lietuvos elektrinė (LE)), 300 MW blocks	1200	5.628	5.628
LE 150 MW blocks	600	6.29	6.286
Large thermofication power plants	630	3.34	8.80
Small thermofication power plants	105	3.51	9.24
Other power plants	315	–	–
Total	2850		

The marginal costs of electricity generators are close to the price of the used fuel which is a variable value. Hence, to compare the efficiency of generators the price of the used fuel should be fixed. In Lithuania the largest generators use gas as their main fuel, they also may use fuel oil but the marginal costs hardly differ in both cases (in case of fuel oil they are slightly higher). Among those generators the most efficient ones are thermofication power plants but they are efficient only under thermal load. The marginal costs of the thermofication power plants are about 40% lower than those of LE 300 MW blocks, about 47% lower than those of 150 MW blocks but only 14% lower than those of the combined cycle 400 MW block which is planned to put into operation in 2012. Nevertheless, without thermal load the efficiency of the thermofication power plants is the lowest one and in the warm season larger power plants may play only the role of the reserve, while the small power plants may be used for the electricity generation.

In the cold season competition is essentially possible among all electricity producers, while in the cold period only the small power plants could compete with LE.

In 2009 in the warm period the average capacity need in Lithuania reached about 1200 MW. Without considering the possibility of electricity import the small power plants in Lithuania could satisfy only 35% (420 MW) of the average consumption, and the remaining share would fall to LE. So, condition (10) would be valid, and LE would be able to manipulate within the market as without this electricity producer condition (1) would be violated. Hence, in the case of the deregulated market LE could choose the price, and electricity would still be purchased from it. It is obvious that such system could not normally operate. However, LE is a state managed enterprise thus, differently from electricity producers managed by the private capital, it would not be able to manipulate in the market, and it could be presumed that its price would be close to its marginal costs, i.e. about 5.7 ct/KWh (the gas price is presumed to be EUR 200/1000 m^3). In this case condition (9) would be valid for the small electricity producers, and the electricity price would be 5.7 ct/KWh, so it is obvious that this price would be higher compared to the regulated market.

In 2009 in the warm period the average capacity need in Lithuania reached about 1400 MW. Hence, besides electricity import and besides LE, the remaining power plants of Lithuania could satisfy up to 75% (1050 MW) capacity needed, and the situation would be similar to that in the cold period, so condition (9) would be valid and according to formula (8) the electricity price would be about 5.7 ct/KWh. Therefore, low competition and market imperfection would not result in the price changes even if cheaper generation sources occur. A completely different situation would be in the case of the deregulated market: the electricity price would be reduced due to reduced marginal costs.

Such situation in the market of Lithuania would occur if Lithuania would not import or would import only a small share of electricity. Therefore it would be necessary to assess any technical possibilities of electricity import. The technical possibilities of electricity import from neighbour countries are represented in Table 2.

Table 2. Maximum potential capacity flows with neighbourhood countries

Connection	Capacity, MW
Latvia–Lithuania	1170
Belarus–Lithuania	970

If the available electricity connections is used to the maximum capacity, more than 2000 MW capacity could be imported, which means that there would be technical possibilities to satisfy the total needs of Lithuania for electricity by only using the imported electricity. So the electricity import should also be included into the model. Subjects from Russia, Latvia and Estonia are also involved in the Lithuanian electricity market, and LE is an intermediate for electricity trade from Belarus. That is why these countries should be included as supplementary electricity producers and their strategies and electricity prices should be assessed. As the market also involves a Russian representative, assessment of capacities and marginal costs of such extent player could be difficult. That could be an object of a broader analysis. So let's presume that the import possibility is limited to 1000 MW, i.e. up to 50% of technical potential of connections would be used. In this case the situation changes and it is necessary to asses not only the average need for capacity but also changes in consumption in the course of the day. Figure 1 demonstrates minimum, maximum and average consumption of electricity in Lithuania in the cold period of 2010.

Assessment of the data between 1 January and 20 April 2010 reveals rather marked fluctuation. The maximum daily need fluctuated from 1000 MW in April to almost 1700 MW in February, and the average standard deviation of daily fluctuation was about 200 MW. The average daily consumption also saw considerable fluctuation: from about 650 to 1450 MW. The highest energy consumption was recorded in January-March, which was conditioned by rather low weather temperature. In April lower consumption was observed. I.e. rising weather temperature resulted in lower energy consumption.

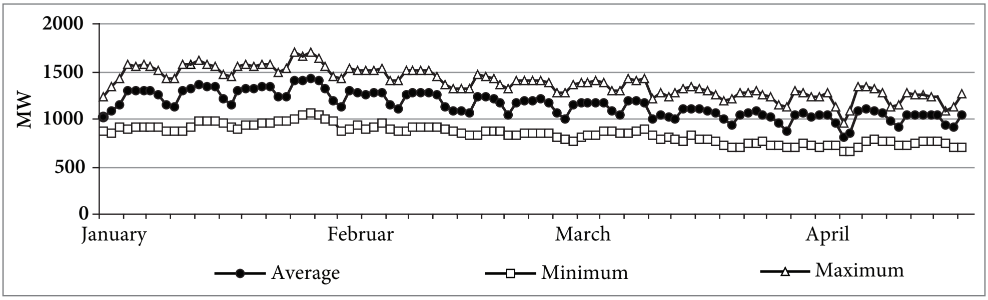

Fig. 1. The need for electricity capacity in Lithuania in January–April 2010, MW
Note: consumption is given without system balancing

As in January-March weather temperature was rather low, it could be presumed that the thermofication power plants had sufficient load to be able to operate to almost their full capacity, and it could be presumed that in April, when the weather became warmer and the heating season ended, only the small thermofication power plans were operating.

But the situation would substantially change if it is presumed that the amount of the imported energy is up to 1000 MW, and the remaining part should be generated in the power plants of Lithuania. In January-March the average need for the deficient capacity would fluctuate in maximum cases from 200 MW to 600 MW, and all thermofication power plants would compete for that capacity. In this case, under condition (9), the price should be close to the marginal costs of the thermofication power plant, i.e. 3.34 ct/KWh, if the price of the imported electricity would be oriented towards the prices set by the thermofication power plants. Otherwise, if the price for the imported electricity would be higher, in such case producers should orient towards the price of the imported electricity. In April, the maximum need for the deficient capacity would be up to 200 MW and the small producers would compete for it, so the price would be oriented towards the price of the imported electricity.

Considering the import, the electricity price would depend on the price of the imported electricity which would be set by the strategies and mutual competition of the main 4 players involved in the market (Latvia, Estonia, Russia and Belarus). In this case their potential and the impact of each of them on the price setting should be assessed. However, then the electricity market of Lithuania should be understood as a part of some large market that involves only several large producers. So the market might become vulnerable and condition (10) could become valid when one of the players is able of market manipulations. Still, to verify this condition the potential of the above players should be carefully analysed.

4. Conclusions

In the case of Lithuania, besides the import, the deregulated market would be inefficient and the electricity price would be oriented towards the price of the most expensive and largest producer, namely LE. Hence, with such market structure only a small share of electricity could be traded in the free market. However, considering the import potential, the market of Lithuania should be understood as a part of some large market in which the electricity price is influenced by 4 large producers (Latvia, Estonia, Russia and Belarus), and the price depends on their playing strategies and potential. In such case, to assess whether the deregulated market would be efficient, it is necessary to carry out a more detailed analysis of these players, still the market would nevertheless be vulnerable as the price would be set by importers and they can not be directly influenced by government or public institutions. Also, domestic producers would have to compete with producers from not EU countries (Russia and Belarus) with different environmental requirements and fuel prices. It can harm competitiveness, investment incentives and economic efficiency. So it would be safer and not necessarily more expensive to have long term contracts to ensure electricity supply.

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LIBERALIOS ELEKTROS ENERGIJOS RINKOS TINKAMUMAS MAŽOS NETOBULOS RINKOS SĄLYGOMIS. LIETUVOS ATVEJIS

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Santrauka. XX a. pabaigoje daugelis pasaulio valstybių pradėjo priiminėti gaires dėl elektros energijos rinkos liberalizavo. Liberali elektros energijos rinka jau veikia JAV, Skandinavijoje ir kai kuriose ES valstybėse. Daugeliu atvejų nereguliuojama rinka atitiko lūkesčius, tačiau pasitaikė situacijų, kai buvo grįžta prie reguliuojamos rinkos. Šio straipsnio tikslas – įvertinti, ar nereguliuojama elektros energijos rinka yra tinkama valstybėms su maža netobula rinka. Elektros energija yra visiškai homogeniška ir negali būti sandėliuojama, jos kaina priklauso nuo vartojamo kuro, todėl šiai rinkai ne visada gali būti taikomi kitų ūkio sektorių (gamtinės dujos, vanduo, telekomunikacijos ir kt.) rinkų dereguliavimo pavyzdžiai. Šiame darbe analizuojami nereguliuojamos elektros energijos rinkos privalumai ir trūkumai bei galimos grėsmės, pateikiami pagrindiniai elektros kainos formavimosi principai, analizuojamas nereguliuojamos rinkos tinkamumas Lietuvos elektros energijos rinkai.

Reikšminiai žodžiai: energetika, elektros energijos kaina, nereguliuojama rinka, kainos formavimosi principai, maža netobula rinka.

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