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REGULATION OF ENERGY PRICES IN RUSSIA*

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ABSTRACT: Russia prices its energy commodities domestically much lower than the prices prevailing in the international market. Using a general equilibrium framework, we analyse reasons for why Russia should or should not use such a price regulation. First, being a major exporter of energy commodities and having considerable monopolistic market power, the country is able to use its supply in order to influence the international energy prices. A rational way to channel this rent to the domestic non-energy sector and to domestic consumers is through a lower, i.e., competitive, domestic price on energy than that in the world market. Second, we introduce the classic infant-industry argument with positive intertemporal spillovers through learning-by-doing linked to current production. These spillovers are likely to be relevant for manufacturing in a transition economy, which argument creates a further reason for a deviation in the pricing of energy to domestic industrial producers from the world market prices. However, an empirical consideration of these results and the estimation of the learning-by-doing curve suggest that the first effect can in principle be sizeable, while the second is only marginal and that, overall, Russia is currently subsidising its domestic energy prices clearly too much. Further, we conclude that the country should not subsidise its domestic consumers more than its domestic industry, as it does in reality. We also derive the optimal domestic energy tax and show that it is modest in comparison to its current rate. The optimal pricing policy could therefore have a marked positive effect on the international supply of energy by Russia.

Key Words: Energy, Russia, international and domestic prices

JEL Classification: F13, F15, H23

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TIIVISTELMÄ: Tutkimus tarkastelee käyttäen yleisen tasapainon kehikkoa syitä sille, miksi Venäjä hinnoittelee kotimaassa energiatuotteensa halvemmalla kuin kansainvälisillä markkinoilla, kuten se tekee voimakkaasti käytännössä. Ensimmäinen näistä syistä on se, että koska Venäjä on energiatuotteiden laajamittainen viejä ja sillä on markkinavoimaa, maa kykenee rajoittamaan tarjontaansa, jotta se olisi nostamassa kansainvälisiä hintoja. Rationaalinen tapa kanavoida tämä ylijäämä kotimaiselle ei-energiasektorille ja kotimaisille kuluttajille on asettaa kotimaan markkinoilla matalammat, kilpailulliset hinnat energialle kuin maailmanmarkkinoilla. Toiseksi tarkastelemme klassista alkuvaiheessa olevan toimialan argumenttia, jolloin teollisessa tuotannossa vallitsevat kumulatiiviset tekemällä oppimisen intertemporaaliset heijastusvaikutukset, joiden voidaan olettaa olevan merkittäviä siirtymätaloudessa. Osoitamme, kuinka tämän seurauksena aiheutuu lisäpoikkeama maailmanmarkkinahinnoista energian kotimaisissa hinnoissa. Näiden tulosten empiirinen arviointi ja empiirisen tekemällä oppimisen -käyrän estimointi osoittavat kuitenkin, että mainituista argumenteista ensimmäinen voi olla merkittävä, mutta toinen on vain hyvin marginaalinen käytännössä ja että Venäjä kiistämättä subventoi liikaa kotimaisia energiahintojaan. Edelleen päättelemme, että maan ei tulisi subventoida kuluttajia enempää kuin teollisia yrityksiä energian hintojen suhteen, päinvastoin kuin nyt ja että kotimaisen energiahintojen pitäisi nousta suhteessa kansainvälisiin hintoihin. Johdamme myös optimaalisen energiaveron ja päättelemme, että se on melko pieni nykyiseen verrattuna. Näin ollen optimaalisella hintapolitiikalla voi siksi olla huomattava positiivinen vaikutus Venäjän energian tarjontaan kansainvälisille markkinoille.

Asiasanat: Energia, Venäjä, kansainväliset ja kotimaiset hinnat

JEL-luokitus: F13, F15, H23

1. Introduction

There are two basic strategic endowments of energy resources that Russia has: oil and natural gas. There is also major state involvement in both sectors. The domestic prices of oil are free, but extraction of oil is subject to a natural resource extraction tax, and exports of oil are, being around two-thirds of its total production,[1] subject to export duty, in addition to the excise and VAT taxes levied on domestic sales. The overall rate of marginal tax on oil is some 85 per cent (Oxford Analytica, 2005). There is thus effectively a big wedge between the international and domestic prices, see Figure 1. The low domestic price on natural gas has been a key issue in the WTO accession process of Russia, as foreign competitors have complained about a subsidy being extended to domestic Russian production in that form. In the bilateral agreement on WTO accession of Russia, reached in May 2004, the EU strived to a reach a deregulation of the gas industry in Russia.[2] However, Russia insisted on maintaining the key position of its state-owned monopoly, Gazprom, in gas production and exports, but agreed to raise the domestic gas price gradually so that by 2010 it will be double (CEPS, 2007). The situation in domestic vs. international gas prices in 2004 is displayed in Figure 2. However, irrespective of the planned rise in the domestic gas price, the relative price is likely to rise only marginally, as the international gas prices have risen substantially recently.

It is a standard result of international economics that free trade is optimal from the point of view of allocation of production and consumption in an open economy. This means that the domestic prices should be adjusted to the world market level so that they properly reflect the true opportunity costs available to the economy. However, as Russia keeps its domestic prices of energy quite low in comparison to the international prices, we are inclined to ask, why?

In the literature, there has been conflicting argumentation on this issue. Kerkelä (2004) has simulated with the aid of the global GTAP model that Russia loses some 5-10 per cent of its GDP by pricing energy domestically lower than in the world market. The model notably presumes perfect competition, but considers general equilibrium effects of a variety of domestic policies. Tarr and Thomson (2004) have in contrast argued, using a partial equilibrium framework, that there is a case for Russia to price dual its gas reserves and to effectively utilise its strong position in the EU and other markets for energy. They also derive the optimal monopo-

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1 For a recent analysis of the role of oil in the Russian economy see Suni (2007).

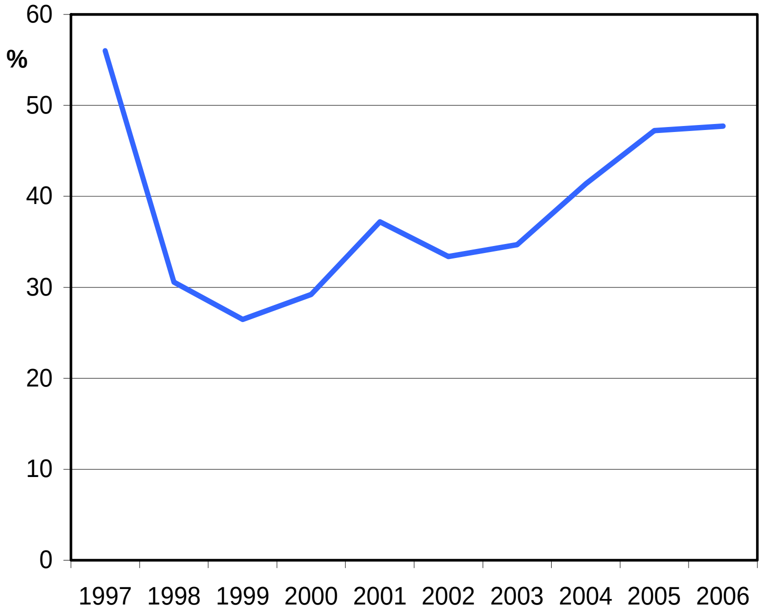
2 See for quantitative evaluations and overall assessments of Russian WTO accession Jensen, Rutherford and Tarr (2004), Rutherford and Tarr (2005) and Simola (2007).

listic price in the various markets. Instead of price liberalisation, they suggest more competition in the domestic market for energy.

In this paper our aim is make an evaluation of the domestic price regulation of energy in relation to the foreign, using a general equilibrium framework for resource allocation. We evaluate two reasons for domestic pricing to differ from that in the world market. The first is based on the fact that, as Tarr and Thomson (2004) argue, Russia has a strong market power in the international market for energy, especially gas, but also oil. We show that a natural consequence of this position is to limit the export supply of energy in order to drive up its international price, and that a rational way to do this is to create a larger incentive for domestic use of energy by lowering the domestic price of energy input in non-energy industrial production and to deliver the consequent monopoly rent to domestic consumers by pricing energy domestically lower, i.e., competitively, than in the world market. Second, we raise the point that the old argument of an infant industry may make sense in a transition economy, with an intertemporal spillover in production of industrial goods, based on the cumulation of production, and show that this creates a further incentive to deviate from the world market by extending a price subsidy in energy to industrial production, but not a further gain to the consumers.

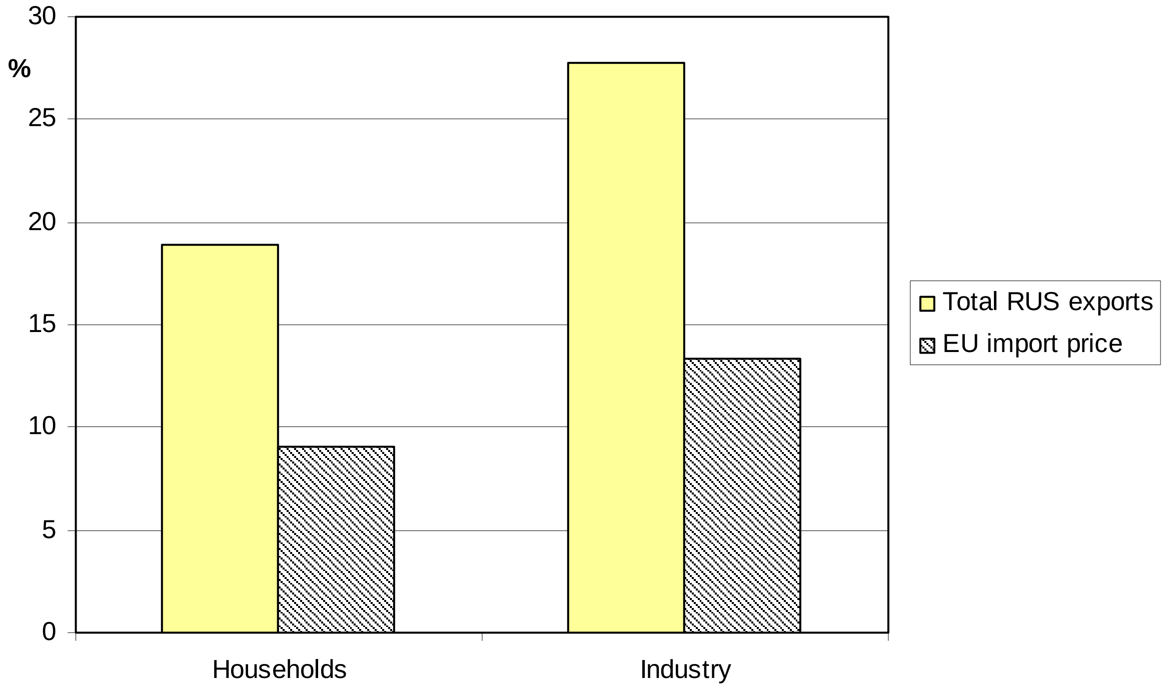
However, an empirical consideration of these results and estimation of the learning-by-doing function suggests that the former effect on domestic regulation of the energy price can be fairly sizeable while the latter is only very marginal from a policy point of view. The empirical specification and estimation of the learning-by-doing curve for the transition economies is in itself a novelty to our knowledge. It shows that there clearly exists a significant statistical relationship of this kind, but that its practical meaning is fairly small as a factor influencing the domestic price on energy. Overall, the results also imply that Russia is currently subsidising far too much its domestic prices of energy from the point of view of optimal resource allocation and that she should commit to a rising path for domestic energy price in relation to foreign. The optimal policy can also have a remarkable effect on the optimal allocation of resources between the energy and industrial sectors. Based on the fact that the optimal price policy may cause through a rise in Russian supply of energy an adverse impact on the international energy prices, we demonstrate that the optimal policy only gradually outperforms the regulated outcome with respect to price setting from a welfare point of view. This may be a rationale for the slow pace of taking corrective measures in liberalising of domestic energy prices, as seen in practice many countries being in such a position.

Figure 1. Domestic price of oil in Russia in ratio to the export price, %



Source: Russian Economic Trends

Figure 2. The domestic price of natural gas in Russia in relation to the export price on total Russian natural gas exports and to the overall EU import price on natural gas in 2004, %



Source: IEA and own calculations

The paper proceeds in such a way that in Section 2 we analyse the case of a country with market power in the international market for its exportables, and in Section 3 the case of the infant-industry argument. Section 4 examines the results from an empirical point of view, i.a., by estimating the learning-by-doing curve, and Section 5 concludes.

2. Optimal domestic price of energy under international market power

Consider an economy producing two commodities, industrial good Q and energy E. The industrial good is in the following the numerairé and its price is fixed to unity throughout. Its production depends on the amount of resources R_Q allocated to it and the amount of energy E_Q used in this production,

$$Q = F(R_Q, E_Q) \quad . \tag{1}$$

The industrial output is used to domestic consumption C_Q and exports X_Q,

$$Q = C_Q + X_Q \, . \tag{2}$$

Energy is produced with non-energy resources devoted to this use and by depleting the amount S of the existing stock of energy resources,

$$E = G(R_E, S) \, . \tag{3}$$

The functions F and G in (1) and (3) have the normal properties of a production function with constant returns to scale. We do not further in this paper consider the optimal depletion S of the energy resources, but simply assume that this decision has been taken by the government so that throughout in the sequel S is a fixed desired quantity $\overline{S}$. The energy product E is used in three ways, in domestic production E_Q, domestic consumption E_C and in exports E_X,

$$E = E_Q + E_C + E_X \quad . \tag{4}$$

The resource constraint of the economy is

$$R_Q + R_E = \overline{R} \quad , \tag{5}$$

where $\overline{R}$ is the fixed amount of domestic non-energy resources. The imports of the country consist of foreign consumer goods C_M, the price of which is p_M. Welfare U of the consumers depends on the consumption of domestic industrial goods, imported consumer goods and consumption of domestic energy products used in private consumption,[3]

$$U = U(C_Q, C_M, E_C) \ , \tag{6}$$

with U having the normal properties of concavity. Let p* be the world market price of energy. Let us first consider the static case of resource allocation with a balanced foreign trade. The Lagrange function L can be derived by inserting (3), (4) and (5) into (1) and using (2) to be the following, where λ_1 and λ_2 are the Lagrange multipliers of the constraint (1) and of the trade balance, respectively,

$$\begin{aligned} L = U(C_Q, C_M, E_C) + \lambda_1 (C_Q + X_Q - F(\bar{R} - R_E, G(R_E, \bar{S}) - E_C - E_X)) + \\ \lambda_2 (p_M C_M - X_Q - p^* E_X) . \end{aligned} \tag{7}$$

The international market for energy is monopolistic and Russia has market power there. We now assume Cournot competition in the energy market, similarly as in Tarr and Thomson (2004). The total supply of energy E_T in the relevant market, say in the EU, is made of Russian exports E_X and supply from other producer countries E_R. The total demand E_T of energy depends on its price so that $E_T = E_X + E_R = E(p^*), E' < 0.$ We can with some manipulation derive the following standard expression for marginal revenue from Russian exports of energy,

$$\frac{\partial (p^* E_X)}{\partial E_X} = p^* (1 - s\varepsilon^{-1}) < p^* , \tag{8}$$

where s is the Russian market share in the international market for energy, i.e., $s = E_X/E_T$, and ε is the absolute value of the price elasticity of the demand E_T.

We now get from the Lagrange function (7) for the optimal allocation of resources after some intermediate stages by maximising it with respect to energy exports E_X, industrial exports X_Q and the use of domestic resources in the industrial use R_E,

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[3] Note that we discard for simplicity the disutility related to, say, labour input as we assume that the supply of total resources is fixed in the economy.

$$F_2 = \frac{F_1}{G_1} = p^*(1 - s\varepsilon^{-1}) \ , \tag{9}$$

and for consumption allocation

$$\frac{\partial U}{\partial C_Q} = \lambda_1, \frac{\partial U}{\partial C_M} = \lambda_1 p_M, \frac{\partial U}{\partial E_C} = \lambda_1 p^*(1 - s\varepsilon^{-1}) \ . \tag{10}$$

Consider now how the optimal command allocation implied by (9) and (10) can be realised in a market economy by inserting the price ratios into these expressions of marginal rates of transformation in production and substitution in consumption. From these we can derive the result that the domestic price p of energy is the same for domestic industrial production (i.e. F_2) and for consumption (i.e. the last expression in (10)), but lower than the price p* in the international market. The intuition of this result can be presented in several ways. The first of them is that it is optimal for a monopolistic country in the export market to limit its export supply from that which would prevail under perfect competition in order to drive the price p* up, and a rational way to do this is to price energy lower domestically. Another way to state this outcome is that the rent linked to the international monopolistic position in energy is channelled to the domestic economy by pricing energy lower domestically. Still another way to state this is that the domestic price of energy should be based on the price of energy prevailing under perfect competition, while the export price should be based on monopolistic pricing. So, there is an export duty of magnitude p*−p per unit of energy product.

The domestic resource R is priced so that its reward W is equal to F_1. The gain of an autonomous rise in the international energy price p* is channelled to the domestic economy so that the resource allocation shifts from industry to energy and this drives up the marginal return F_1.

From these results we see that the higher the market share of Russia in the international, say EU markets, the lower it should price its domestic energy in relation to the foreign. And on the other hand, the less price elastic is the world market demand, the lower the domestic price. Under perfect competition, of course, the standard result of uniform domestic and international pricing would hold. We continue with an empirical evaluation of these results in Section 4.

Let us finally consider pricing of the energy resources S under a domestic monopoly in the energy sector. The aim of the government is to impose a natural resource tax q in such a way that the monopolist extracts the amount $\overline{S}$ of energy resources desired by the government. Maximising the profit pE − qS under the production function (3), and assuming the same price elasticity ε of energy demand as above, we come to the conclusion that

$$q = p(1-\varepsilon^{-1})G_2(E_{\mathrm{R}},\overline{S}) \ . \qquad (11)$$

This implies that the higher the desired extraction, the lower the tax on natural resources. This tax is also directly linked through (9), which produces the optimal domestic price on energy, further to the international price p* of energy.

3. The argument of an infant industry

Let us then enlarge the model to allow for also the case of the infant industry, which is a long-standing issue in international trade theory, see e.g. Feenstra (2004) and Evans (1989). The argument quite simply runs so that it can pay to deviate from free trade, at least temporarily, if this deviation gives an incentive for the domestic producers to grow and become more competitive in the world market later on. A necessary condition behind this phenomenon is that the marginal cost of domestic production depends negatively on actual production, i.e. that there is a kind of learning-by-doing argument leading to this type of intertemporal spillover in production. In principle, we can argue that this situation could make sense also in a transition country like Russia. Here we consider this phenomenon only in relation to the internal pricing of energy in Russia, not in terms of its trade policy.[4]

We now formulate our model in a dynamic setting and use time notation t for variables dated to period t. Assume in the above spirit that the more industrial capacity is built up, the more the cost of production is lowered. Following this idea, we specify the intertemporal spillover to be of the following kind,

$$Q_t = f^T(Q_{t-1}^T)F_t, \tag{12}$$

where Q^T is function of accumulated past levels of industrial production, $Q_t^T = \sum_{s=0}^{t} Q_s$, analogously as the learning-by-doing is formulated in Melitz (2005). So, f^T is the total factor productivity. We assume that the *future* change in f^T created by current production is a social externality which is not internalised by manufacturing companies in their current production decisions. To be more specific, we define f^T as follows,

$$f^T(Q_{t-1}^T) = A_t^* a_0 f(Q_{t-1}^T), f' \geq 0 , \tag{13}$$

where A_t^* is the total factor productivity (TFP) in the international economy, say in the EU-15, and a_0 the relationship between the initial TFP in Russia and the international level of TFP. We further define the learning-by-doing f-function in such a way that initially at t = 0 when

[4] The original modern formulation of learning by doing in growth economics was presented by Arrow (1962), with the intertemporal spillover in production stemming from cumulative investment flows, see d'Autume and Michel (1993). In trade theory the first modern formulation was done by Bardhan (1971), see Melitz (2005). See for a general discussion of the argument by Stiglitz (2007, 70-73), and a recent analysis of it in trade policy by Greenwald and Stiglitz (2006).

the transition starts, f = 1.[5] Then it grows as $f' \geq 0$, and finally converges to the value $1/a_0$ so that the TFP in Russia converges to the international level when learning-by-doing comes to an end, see the discussion on this below in connection with Figure 3.

To make the model dynamic we also introduce foreign capital flows so that the net foreign debt B of the country (at the end of the period) with the international real rate of interest r on it cumulates by the current account deficit,

$$B_t = p_{Mt}C_{Mt} - X_{Qt} - p_t^* E_{Xt} + (1+r)B_{t-1} . \tag{14}$$

The intertemporal welfare is given by

$$V = \sum_{s=t}^{\infty} \rho^{s-t} U_s \ , \rho = \frac{1}{1+\sigma} < 1 \ , \tag{15}$$

where σ is the rate of time preference and U is the same as in (6) above. We now insert (13) into the first constraint of the Lagrange function (7) and foreign borrowing (14) into its second constraint and note that the allocation of resources in period t also has an impact on the next period t+1 through (12) and (13). The current value Lagrange function is now analogous to that above, with λ_1 and λ_2 being the Lagrange multipliers of the constraints (1) and (14). Now we get the following optimality conditions for the export optimum of industrial goods and foreign borrowing,

$$\frac{\partial L}{\partial X_{Qt}} = \lambda_{1t} - \lambda_{2t} = 0 \text{ and} \tag{16}$$

$$\frac{\partial L}{\partial B_t} = -\lambda_{2t} + (1+r)\lambda_{2,t+1} = 0 \ . \tag{17}$$

Using these results we can further write for the resource allocation optimum,

$$\frac{\partial L}{\partial R_{Et}} = A_t^* a_0 f(Q_{t-1}^T)\left[1 + \frac{f'(Q_t^T)F_{t+1}}{(1+r)f(Q_{t-1}^T)}\right]\left[F_{1t} - F_{2t}G_{1t}\right] = 0 \tag{18}$$

and

[5] This initial level is due to the fact that then the level of TFP is a_0.

$$\frac{\partial L}{\partial X_{Et}} = A_t^* a_0 f(Q_{t-1}^T) F_{2t} \left[1 + \frac{f'(Q_t^T) F_{t+1}}{(1+r) f(Q_{t-1}^T)} \right] = p_t^* (1 - s_t \varepsilon^{-1}) \ . \tag{19}$$

The consumption optimum is determined by the following conditions,

$$\frac{\partial U_t}{\partial C_{Qt}} = \lambda_{1t}, \frac{\partial U_t}{\partial C_{Mt}} = \lambda_{1t} p_{Mt}, \frac{\partial U_t}{\partial E_{Ct}} = \lambda_{1t} \left[1 + \frac{f'(Q_t^T) F_{t+1}}{(1+r) f(Q_{t-1}^T)} \right] A_t^* a_0 f(Q_{t-1}^T) F_{2t} \, . \tag{20}$$

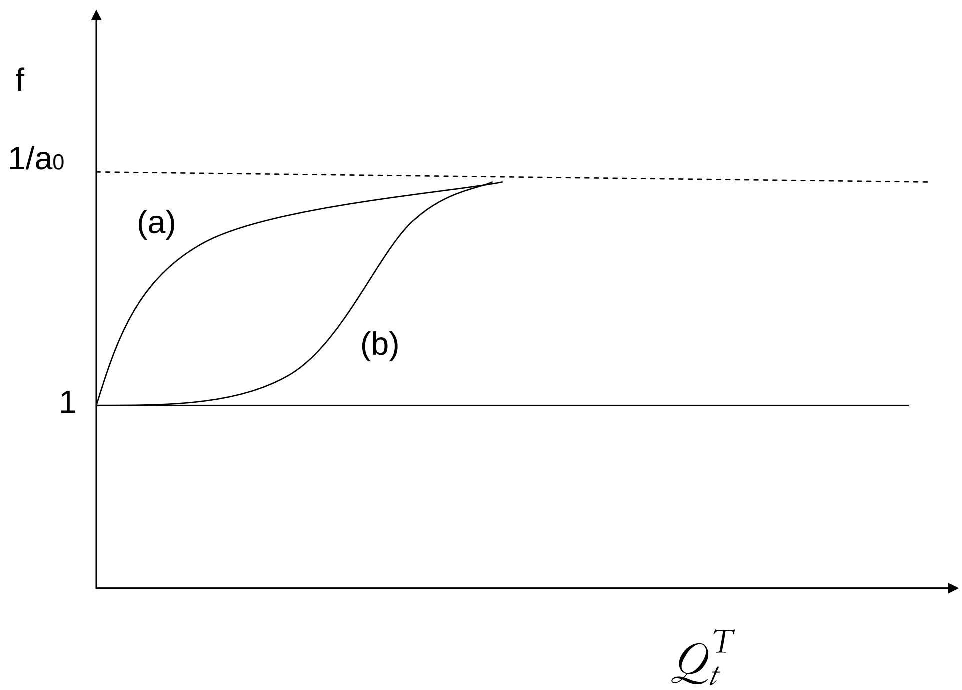
We shall discuss in the next section in more detail the magnitude of the term in square brackets on the left-hand side of Equations (18) and (19), but based on what was specified above (i.e. $f' \geq 0$) we see that it is higher than unity. As specified above, Russian manufacturing firms recognise the current level of TFP linked here to past production, i.e. the term $f(Q_{t-1}^T)$, and take it into account in their profit-maximising production decisions. But they do not take into account the social externality linked to the effect of current production on future level of the TFP, i.e., the term $f'(Q^T) > 0$. This means that the solution of $A_t^* a_0 f(Q_{t-1}^T) F_2$ from Equation (19) is the optimal domestic price p of energy extended to industrial companies, not internalising the social externality embedded in (12) and (13). So, we see now that the energy price is even less than the optimal pricing of energy based on the export optimum in Section 2, which is, of course, intuitively clear on the basis of introduction of the production externality above. If we have the case of no intertemporal spillover in industrial production, as will be the natural long-term outcome, we have $f' = 0$, and we return to the case in Section 2. Equation (18), similarly as Equation (9) above, gives the internal resource allocation between the two production sectors. The natural resource tax is determined similarly as in (11).

On the basis of (19) and (20) we can derive the optimal domestic consumer price and infer that the domestic consumers are not allocated the additional price reduction of energy based on learning-by-doing. They will enjoy only the gain derived above from a monopolistic position in the foreign market for energy. So, there is a dual domestic pricing of energy, i.e., the industrialists get energy at a lower subsidised price than the consumers.[6]

[6] The profile over time of the consumption items is derived in a standard way by combining (16), (17) and (20) with the specification of welfare in (15).

In principle, we can have two types of the learning-by-doing function, initially concave and convex, see Figure 3, and also Melitz (2005). The concave case (a) clearly implies the more plausible case of a uniformly rising optimal domestic price of energy, while the case (b) of a initially convex f-function would imply an U-shaped optimal price so that it first goes down and only later on starts to rise. Let us now turn to an empirical discussion of the findings reached in the paper.

Figure 3. Possible learning-by-doing functions



4. Empirical analysis

We first try to evaluate the practical meaning of the theoretical finding reached above related to the monopolistic position of Russia in the international market for energy. Tarr and Thomson (2004) go through a number of studies on energy demand which have produced quite different estimates of its price elasticity and which also differ between the short and long run, the former values being estimated to lie around 0.5, the latter ranging from values below unity to almost 5, the average being around 2.3. As our analysis is linked to long-run resource allocation, the latter estimates are the more relevant. Assuming that the market share of Russia in the EU energy (gas) markets is around 25%, we reach the estimate that the domestic price on energy in (9) and (10) should be around 90% of the international price. Starting from the unitary elasticity and going up to the value of 5 of price elasticity, gives the optimal domestic price to vary between 75% to almost par (95%). Above in Figures 1 and 2 we showed that the domestic price has been around a quarter of the international price of natural gas and in oil about a third (see also Kerkelä, 2004). So, we can preliminarily infer that the current domestic energy prices in Russia are clearly far below this optimal relationship.

Turn then to consider the infant-industry argument. As specified in (13), the learning-by-doing function f is a component of the total factor productivity (TFP) of industry. In order to increase the number of observations for estimation, we made an empirical evaluation of this function by studying the relationship between TFP and cumulated production in Russia and the following European countries being in transition coincidentally with Russia: the Czech Republic, Hungary, Poland and Slovakia. We had to take recourse to aggregate economy data, as there was no industry level data available, see Kaitila, Alho and Nikula (2007) for the construction of it. The estimation was done for the period 1997-2006. As in (13), we specified that the excess of the TFP growth over that in the international reference, i.e. the EU-15, with a trend TFP growth of around 1.5% p.a., depends on the accumulation of own production volumes, i.e. Q^T of the country. To produce a model consistent with the formulation (13) above we use a quadratic approximation for f (see Fig. 3), and specify it so that when the learning-by-doing comes to an end, the f-function reaches its maximum value of $1/a_0$ with $f' = 0$. So, we estimated the following specification:

$$TFP_{it} = f_{it} = A_0^* a_{0i} e^{0.015t} (1 + \beta_1 Q_{i,t-1}^T + \beta_2 (Q_{i,t-1}^T)^2) e^{u_{it}}, \qquad (21)$$

where u_i is the residual term and the just-mentioned constraint producing the tangency condition, is

$$\beta_2 = -\frac{1}{4(a_{0i}^{-1} - 1)}\beta_1^2 \ . \qquad (22)$$

Transforming (21) into logarithms, assuming that $a_0 = 0.5$, and using a first-order autoregressive specification for the residual, the estimation gave the following outcome, see Table 1.

Table 1. The estimation result of Equation (21)

Parameter	Estimate*	t-value* or p-value
β_1	0.035/0.039	8.254 / 19.597
β_2	−0.000/−0.0016	0.447 / .
Constraint $\beta_1 = 0$	.	0.0000
Constraint $\beta_2 = -\beta_1^2/4$	.	0.1862
R^2 for Russia	0.993	.

* The coefficient estimates and the t-values are denoted: without constraint / with constraint (22) imposed.

The empirical content of this estimation result is that learning-by-doing is clearly visible, but as the estimate of β_1 is small, it proceeds with a fair amount of sluggishness so that it will come to end only in the early 2020s. A sufficient condition for the convex learning-by-doing function f in Figure 3 (case b) is that the coefficient of the linear term in (21) is zero. This is clearly rejected by the data, while the constraint (22) is accepted. This implies that the solution for the optimal domestic price of energy cannot be markedly declining initially. Compare then our estimate in Table 1 in relation to that in the empirical learning literature, where the concept of the learning rate has been examined, defined as the cost reduction linked to doubling of experience. Our estimate for this rate is 8%, which is to some extent on the downside as compared to the normal range found in the literature, i.e. 11-21%, although not estimated at the level of the macro economy as here, see Ohashi (2005) and the references there to earlier estimates of this effect in the literature.

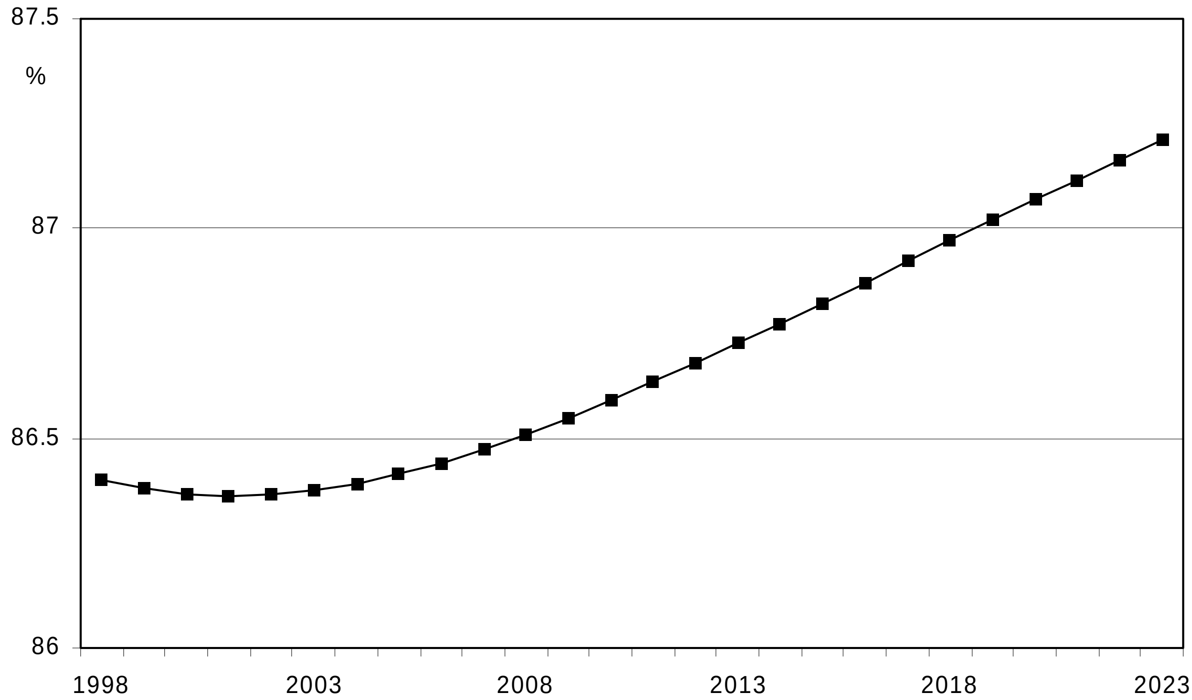
Let us use this specification of the f-function and now carry out a numerical solution of the model for the optimal pricing of energy as based on Equations (12), (18)-(20) and (11), and on the dependence of international energy price on changes in Russian supply, see the Appendix for more details. We compare the above optimal allocation with the case of regulated energy prices being 40% of those in the world market. Numerically, we solve the model over the time span 1998-2025.

Over time, as the learning-by-doing effect decreases at the margin, a consequence of it is the gradual rise in the energy price, see Fig. 4. However, from a practical policy point of view this deviation from the case, analysed above, of considering only the monopolistic pricing in the export market, is quite inessential and only marginal as the additional deviation in the price ratio between the domestic and foreign prices is initially on the order of 1 percentage point only on the basis of our estimation result in Table 1.[7] This is based on the fact that the estimated learning-by-doing function f rises only fairly slowly and, on the basis of what was stated above, this implies that the marginal effect related to the externality can only be fairly small.

The optimal price policy may also have a marked indirect effect on the level of the domestic energy price through its fairly large effect on the balance between the global demand for and supply of energy. In our calibration of a 10% global market share of Russia, the drop in the global energy price is initially around 5 percentage points between the optimal and regulated paths of energy prices. Over time this adverse impact will, however, be eliminated. The optimal resource allocation within the economy also initially shifts quite strongly towards the energy sector but then shifts towards industry. The export supply of energy is, consequently, clearly higher under the optimal than the regulated price set at the current level in Russia.

[7] The calibration adopted implies, using the framework of Section 2, that the optimal domestic price is 87.5% of the international price.

Figure 4. The optimal domestic energy input price in industry in relation to the international when the optimal price ratio based on Eq. (9) is 87.5%



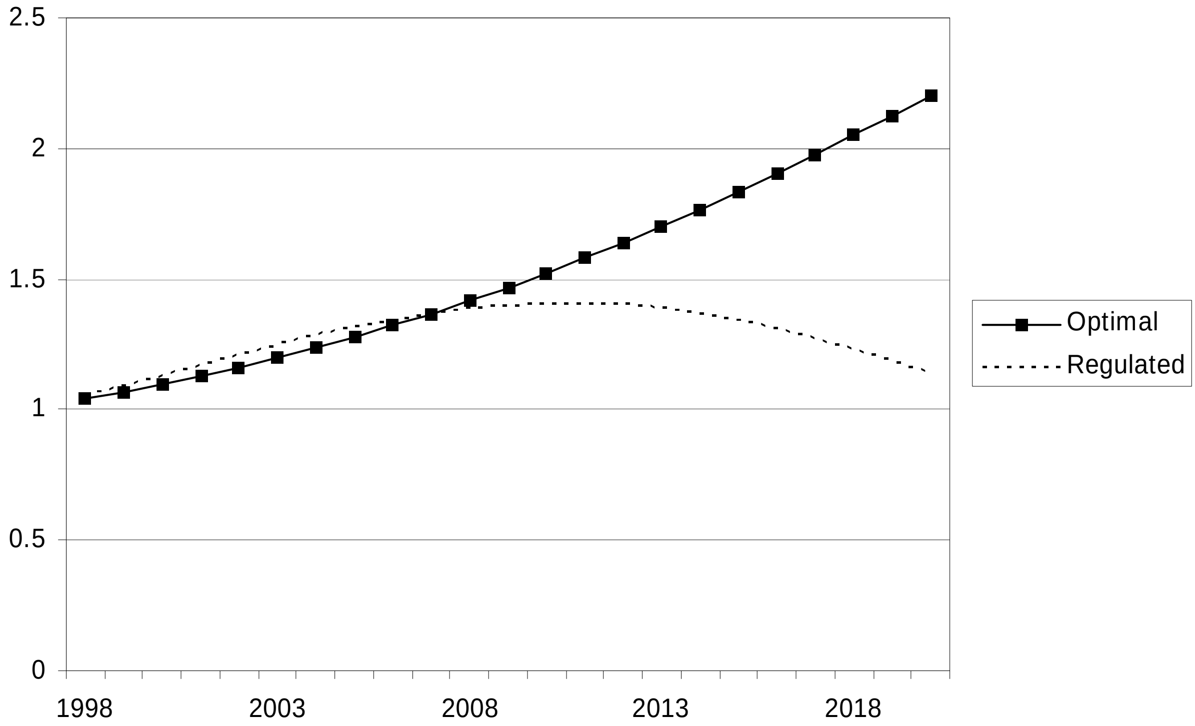
We can also solve for the optimal natural resource tax q. In relation to the international price p* of energy it is initially 14% and it gradually diminishes to 6% over the period. In relation to GDP, the tax revenues from energy are initially around 9% and decline rapidly. So, this suggests that Russia currently imposes too high a natural resource tax, say on oil.

The relation derived above that the domestic energy price for manufacturing should be less than that for consumers does not either seem to hold in practice because of cross-subsidisation, as reported by Kerkelä (2004), see also Figure 2 above. This shows that, in contrast to the policy outcome reached here, Russia seems to subsidise its domestic consumers more than industry with respect to the natural gas price.

On the basis of the above model we can also evaluate the welfare implications of the current policy of a low regulated domestic price in relation to the optimal. As mentioned, in the optimum allocation, there is a big difference with respect the resource allocation in energy production vs. industrial production as compared to the regulated case. It should be noted that we do not take here into account the adjustment costs related to this shift in resource allocation.

We also get the outcome that the aggregate production (GDP) is initially bigger with the regulated price than under the optimal time path, see Fig. 5. This is due to the fact that under the optimal path initially a lot more resources are allocated to energy production, and relatively little to manufacturing industry, while over time the growth of the latter is vigorous and it clearly surpasses the volume of manufacturing under a regulated energy price which stagnates. So, over time the optimal path produces a clearly higher overall output. This slow emergence of the benefits may be conceived to be one factor behind the reluctance of energy-rich governments to deregulate domestic prices on energy.

Figure 5. Volume of GDP under the optimal and regulated price path



5. Conclusions

Russia is rich in energy resources, which has a major bearing as to the management of its economy domestically and also as to the operation of the international market for energy. We have carried out a general equilibrium analysis of the optimal pricing in the domestic market for energy in Russia and have demonstrated that there may be some good theoretical grounds for deviating in a resource-based economy, like Russia, in the domestic pricing of the resource from that in the international markets. We have not considered here the domestic structure of the energy industry, on which Tarr and Thomsen (2004) suggest a deregulation of the local monopoly in gas.

We have also seen that the domestic prices of energy should be tied to the foreign, at least over time, so that the domestic subsidy should not be raised if the foreign price of energy rises. However, we did not consider the adjustment costs and macroeconomic considerations linked to, say inflation and equity considerations, of raising the current level of domestic prices on energy to their optimal level.

The effect of learning-by-doing, although statistically clearly visible, was found to be fairly inessential in empirical terms with respect to price regulation. To our knowledge there have not been similar efforts to empirically estimate the magnitude of this effect at the level of the macro economy in the transition economies. So, our results here can also have a wider application than just in the pricing of the energy resources.

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Appendix. Numerical calibration of the model

In the numerical solution we use a Cobb-Douglas specification for the production functions F and G in (1) and (3) with the share of the non-energy resource input in F being 0.9 and 0.5 in G so that the share of energy in industrial use is 0.1, a typical value, and the energy resource S contributes by 50% to the value of output in the energy sector. We leave for subsequent work analysis of alternative elasticities of substitution in the production functions. We calibrate the model so that initially, at regulated prices being 40% of the international, 90% of the total resources R_Q are in the non-energy sector. No productivity rise is assumed in the energy sector, while the TFP in industry has been specified above in Eq. (21) and the learning-by-doing function f is based on the estimation result in Table 1. For the other parameters we use 5% for the real interest rate in the discounting and accumulation of foreign debt. Domestic consumer demand for energy is taken to be in the regulated path initially 5% of GDP, and has a price elasticity of two. We also assume that the world market price of energy is affected by the difference between the alternatives of optimal and regulated energy price in Russia, with the Russian market share of the global supply being 10% and the price elasticity having the value two.

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