OPTIMAL TRADE AND INDUSTRIAL POLICY IN TRANSITION ECONOMIES : THE CASE OF UKRAINIAN IRON ORE INDUSTRY

by

Yuzefovych Oleh

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Abstract

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by Yuzefovych Oleh

Chairperson of the Supervisory Committee: Ms.Svitlana Budagovska
Economist, World Bank of Ukraine

The objective of the paper is to estimate the deadweight losses from the government industrial policy of regulating price for iron ore raw materials. The analysis is done with the help of partial equilibrium analysis for a "Large" country Case which Ukraine is on the world (Eastern European) market. The "Large" country case allows Ukraine to have some power on the market to change the world price.

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Chapter 1

INTRODUCTION

Iron ore mining and enrichment is a traditional sector and a key industry of Ukrainian economy. Ukraine possesses large iron ore reserves and accounts for 5% of the world iron ore production. The industry is of great importance to the country – iron ore is the state's premier mineral commodity, the industry employs thousands of people, supplies hard currency to the budget and is a provider of strategically important raw material, which is used in making steel products.

The mining industry is the base resource industry for Ukrainian metallurgical branch (iron ore is used to obtain steel products) and, itself, is very export oriented industry. Ukraine exports its iron ore to over 10 European countries satisfying about 40% of the demand from Eastern European metallurgical plants and almost completely fulfills the needs of the domestic metallurgical works in iron ore. Yet, no research has been done so far in terms of forecasting the demand and supply. Such negligence is explained by the fact that up to 1991 the mining industry was a part of the great Soviet planning economy in which manufacturing was done according to the plan. With the advent of the market economy the importance of such an analysis has greatly increased. Now that mining companies have to compete on the world iron ore market, they need the information on what factors the demand for their products depends on and what influence these factors have. Likewise, there was no attempt before to estimate the optimal trading policy.

As we will see later, there are distortions present in the Ukrainian iron ore industry due to the actions the government usually takes to keep the prices on the domestic market on the low level. The government does this to please the metallurgical producers who are widely represented in the highest government agencies. I will try to analyze if this policy of the government is indeed efficient at the national level and if not who the losers and winners are. Moreover, I will attempt to suggest an optimal policy the government should introduce to eliminate these distortions and maximize the value of the main players.

So far, the related research have been done by Y.Grygorenko(2001) and Y.Dubohryz (2003), yet their researches concentrated on the Ukrainian Ferrous Metal Industry, whereas I plan to look into the mining industry, which provides raw materials for the metallurgical industry.

The structure of the thesis is the following. In Chapter 2 literature review is presented. This review contains discussion about the current research of the modern iron ore market and the theory of international trade in commodities in oligopolistic market. Chapter 3 provides the basic overview of the Ukrainian ferrous metal and iron ore industry, the major players of the industry and the description of the economic links that affect the demand. Chapter 4 presents the econometric evaluation of the demand and supply for Ukrainian iron ore both on the Central European and domestic markets. In this chapter we estimate demand

and supply functions for the Ukrainian iron ore to define what factors are most likely to determine the dynamics of iron ore production in Ukraine. In Chapter 5 we apply the results obtained in the econometric analysis to build a trade model and calculate the optimal social welfare function. The paper concludes with the comments on the results and the possibilities for further discussions.

The data on monthly export volumes of each Ukrainian mining enterprise to each Eastern European country and each Ukrainian steelworks for the last 12 years are obtained in the transport company LTD *"Rudtranse"*. The State Statistical Committee provided monthly volumes of production of iron ore and steel in Ukraine (aggregate data) and price indexes on these commodities and on other important commodities necessary in analysis(electricity, wages) over the last 10 years.

Chapter 2.

LITERATURE REVIEW

The goals of the research is to determine the optimal trade policy for the Ukrainian mining industry after privatization and to calculate losses from the current government intervention in the industry (the government sets prices at which iron ore is to be shipped to domestic metallurgical plants). This will include tariffs, quotas or subsidies for Ukrainian producers of iron ore that may be levied on them to maximize industry's welfare after the privatization in mining enterprises. However, to carry out such an analysis one needs to determine the demand and supply elasticities for Ukrainian iron ore and analyze the iron ore market structure first.

J.Gaisford and W. Kerr (2001) present the theory of international trade as well as the techniques and tools that are widely employed in modeling trade policy analysis. The policy analysis is done through a partial equilibrium framework that is markets are analyzed in isolation. The partial equilibrium models are very convenient and flexible, because they are quite simple and do not require extensive data. First, the authors show what effect imposition of tariffs and subsidies have for importing and exporting countries accordingly. In a nutshell, both subsidies and tariffs increase prices on the domestic market thus creating producer surplus and consumer losses. The authors argue that the size of a country plays a role. If a country, engaged in world trade, is small it almost has no effect on the world price. However, a large country by introducing a tariff or a subsidy reduces the world price level thus decreasing the overall welfare. However, the effect of a subsidy is more transparent than that of a tariff as it allows government to keep track of its expenses.

Then the authors move on to show that opening markets to free trade creates losers and winners on domestic markets. In the exporting country producers are the winners and consumers are the losers, in the importing county – vice versa. Overall, however, the net result is that both countries benefit from free trade. Then, the analysis gets more complicated by introducing long-run considerations. In the long run all the qualitative changes the same yet the quantitative are somewhat different. In the long run, a tariff or a subsidy increases the price which means that producers get extra "super-normal profits". These extra profits invite new firms in the industry and they increase the supply of the good. As a result, efficiency loss in the long run is greater than in the short run. The authors conclude the theoretical part with an assertion that in the long run the benefits of changes in policy regime capitalize in the asset value and owners of assets will oppose the change in trade regime thus making further policy changes more difficult. The weakness of the partial equilibrium modeling is that it ignores the effect of the tariff (subsidy) removal in one industry on the related sector of economy.

Roningen (1997) extends partial equilibrium analysis to multi-market and multi-regional modeling because very often markets are linked. This mutual dependence of regions through trade means that nay change in one market, as shift in supply or a change in the terms of trade has an immediate impact on the variables in the other market – price, supply and demand. This model is especially important for analyzing the trade in iron ore because trade with the Central European countries affects domestic trade in ore. The simultaneous model includes two regions and two markets; each region has its own equilibrium prices that define demand and supply not only in that region but also in another. The model consists of several equations of domestic price, supply, demand and net trade at each region and is solved by using math software which allows investigating the effects of removal or imposition of tariffs and quotas. The advantage of using this multi-regional model is that it can analyze complex economic changes across markets.

Tarr and Morkre (1984) present methodology of estimating costs and benefits of tariffs and quotas elimination in general equilibrium framework since it takes into account interrelatedness of industries in the economy and terms-of-trade effects. The authors claim that the general equilibrium approach should be preferred when estimating the effects of a general cut in tariffs. The term-of-trade effect means either loss or gain in real income from a change in tariff, while terms-of-trade refers to the weighted average price of the country's exports divided by the price of its imports. However, the analysis of welfare effects from the tariff removal is supplemented with analysis of four important US sectors - automobile, sugar, textiles and steel industry in the partial equilibrium model. Then multilateral tariff reduction (i.e. all countries reduce tariffs) is assumed as one that encourages an increase in welfare, while if unilateral reduction occurs, it may lead to welfare losses for the country that introduce it. The net effect depends on the price elasticities of the country import demand and foreign demand for this country's exports. The authors then discuss the Brown-Whalley Model which estimated the benefits for the US from a 50% multilateral removal of tariff. They report that this led to an equal increase in the US exports and imports by $4.8 billion. It also had a negative net effect on employment – while increase in export increased domestic employment by 196000, increased imports decreased it by 218000 workers. The US real income is estimated to increase by $10.5 billion a year.

The two most widely used approaches to modeling trade policy are computable general equilibrium and partial equilibrium analyses. CGE models usually deal with two sectors of economy. Although they provide a significant insight into trade and explain many of the conventional facts, they have some shortcomings. First, CGE models employ very aggregated data, that is they lump together similar commodities in one group. As a result, an analysis of a country's accession to a custom union may be rendered useless because for some goods in this aggregate group tariffs will increase but for others decrease. Second, the CGE models often suffer from lack of transparency – it is difficult to trace the effect of a change on the economy. They do not logically link the input data with output results and are not clear about dynamic paths of adjustments (Gaisford). Therefore, an alternative comparative-static method, partial equilibrium approach, is used to account for changes in a market in isolation. This method is not perfect, it also ignores paths of adjustment and information on inter-market resource shifting, yet these drawbacks are not sufficient to cancel out its usefulness.

Frankois and Hall (1997) outline the basic techniques for a partial equilibrium approach to comparative static analysis of industrial policy. They consider two alternative approaches to conducting a partial equilibrium analysis - a perfect substitutes model with import goods considered as substitutes for domestic goods and the Amington models with similar but not identical products. The first model consists of four equations in log-log form: domestic demand and supply and import demand and supply equations. The price in the import equations is domestic price plus export tariff. Since the equations are in logarithmic form the obtained coefficients are elasticities with respect to price. The system is solved for price and welfare calculations are then performed. An alternative, more complicated Armington model assumes well behaved preferences over a weakly separable product category, that is not identical goods, and calculates not only own but also cross-price elasticities of demand.

There exists abundance of literature on analysis of different trade policies. One of such kind is *Protection for Sale* by Grossman and Helpman (1994), a seminal paper on trade protection in the presence of industrial lobbies. The authors present theory of government actions when it is affected by lobby behavior. Lobbies defend their industry interests and directly affect government. Government acts by choosing policies that maximize a weighted sum of social welfare and lobbies contribution to the trade policies. The authors limit their choice of instruments to trade taxes and subsidies and show how an optimal tax(subsidy) can be calculated at which the deadweight losses from restrictions of free trade are minimized. They found that large lobby groups in big sectors of the economy tend to raise the domestic price of goods they produce and lower the price of goods they consume.

Taking into account the oligopolistic market structure of the Ukrainian Iron Ore industry we look in the papers that deal with industrial and trade policy under oligopoly. Eaton and Grossman (1986) provide analysis of the welfare effects of trade and industrial policy for industries with different market structure. For an industry with domestic consumption (which is the case of Ukrainian iron ore industry) they argue that government intervention will be favorable because it would decrease the difference between the price of the product and its marginal cost, which characterizes oligopoly. The authors consider a duopoly industry producing homogeneous product with zero transportation good, thus, when production tax or a subsidy is levied consumers at home and abroad face the same price. The authors argue that the government should use production subsidy or a production tax depending on which instrument lowers the price for domestic consumers. Production subsidy is used if foreign marginal cost increase because subsidy increases world production and lowers world price. If marginal costs at home and abroad are constant, then the best industrial policy is laissez-faire. Then, the authors show that both trade tax or import subsidy can increase domestic welfare depending on the terms of trade. If the country is the net exporter, an export tax is used and vice versa.

A. Dixit (1994) provides a review of international trade policy in oligopolistic industries. He considers two countries that produce homogeneous product. The equilibrium in the industry is a Cournot one. The welfare effects of the home country are investigated when policy changes. He concludes that a home sales subsidy is needed when home firms have a cost advantage over those abroad. If there is no cost advantage over foreign firms, there is no point in limiting imports. Then, an import tariff should be used.

Cheng (1988) considers optimal trade and industrial policy for a home market that is supplied by both domestic and foreign firm. He studies what optimal policy is depending on the nature of oligopolistic competition.The author shows that if the industry's equilibrium is Cournot the optimal policy would be a domestic production tax and a tariff; when it is Bertrand then it is a production subsidy and free trade.

While useful in analyzing trade policy under oligopoly, these articles' conclusions should be taken with care. For, first, they emphasize the oligopolistic nature of international market rather than that of home (as it is in our case), second, imports of ore to Ukrainian home market are not great, domestic producers almost completely satisfy the needs of Ukrainian consumers, whereas, most models consider a market where foreign firm supply ore extensively to home market.

When considering an international trade model, one needs to take into consideration the share of production of the country in the world output. This defines the choice between the "small country" case and "large" country case – the difference between the two is that a "large" country can influence the world price of the good. Suranovic (2000) shows mathematical and graphically that when a small country impose a tax its effect is zero, while when a "large country" impose an export tax it can raise national welfare.

Literature on the theory of trade in iron ore is quite rare. It concerns basically econometric estimation of supply and demand. M.Tcha (1997) looks into trade in iron ore between the fast growing East Asia countries China, Japan and Korea and their primary iron ore supplier – Australia. The paper specifies the demand equation for Australian iron ore on the part of these countries and checks the coefficients statistical significance. The importance of the paper lies in the fact that the case of Australian iron ore import to these Asian countries is quite representative of the industry trade as they are important players on the world steel production and iron ore trade markets. Therefore, their case should be studied carefully to bring out the common trends that exist in the market and apply to the Eastern European market.

The article analyzes the factors that have a paramount influence on the demand for iron ore and then builds a model. The author includes the following factors in the model:

-last year demand as it is believed that this variable reflects the economic network built in Australia as well as cultural links;

-steel production of the importing country since the demand for iron ore is a derived demand from steel production;

-real GDP per capita of the country as the author argues that the demand for iron ore decreases as the GDP increases. This happens because as a country gets richer it begins to employ different production technologies that change the iron ore requirements. For example, more developed countries now adopt electric furnaces that use steel scrap instead of iron ore.

- the relative price is considered an important variable for demand as importers can change suppliers if the relative price is too high. It is calculated the ratio of average price of Australian iron ore to the average world price.

- the real exchange rate between a country's currency and the US dollar is suggested to reflect how a country structural changes impact the demand or iron ore;

-existence of labor disputes is included as an indication of how reliable a supplier is. Increasing labor disputes affect the country's production activity since hey increase instability and uncertainty.

Moreover, because spot trading in iron ore industry does not amount to much and prices are set yearly, some variables such as relative prices, labor disputes and exchange rates influence the demand for iron ore with time lags. The model is in log-log form and the first difference is used for demand, real GDP, steel production and exchange rate to eliminate the unit root problem. Besides, the author argues for using the GLS by SUR method because the three countries are closely linked with one another are main importers of iron ore from Australia and therefore it is reasonable to suggest that the disturbance are correlated across countries.

The results of estimation for each of the three importing countries shows that all variables but the relative price affect the demand for Australian iron ore. To conduct cross-country comparison of import patterns, the Wald Test is used and the result indicates that in general for Japan and Korea, the more developed countries, the patterns of demand are quite similar, while China's patterns are at variance with both countries.

Tcha and Wright' paper (1999) estimates the demand of only China for Australian iron ore. The model takes the same form with one exception only – instead of exchange rate now it incorporates a dummy for government direct intervention. This is because the period 1976-1981 in Chinese history was a time of a strong government intervention due to policy of rapid industrialization. Now that the demand of only one country was estimated, OLS was used. The model again was in a log-log from making it possible to interpret the coefficients as elasticities. Yet, in contrast to the model from the previous paper now variables GDP per capita and the previous trade volume are statistically insignificant.

Da Silva Neto(1993) investigates the effects caused by Carajas iron ore project, a large mining open pit in Brazil, which came into operation in 1989, on the world iron ore market. Although it deals with, primarily, price formation on the world iron ore market, it, however, provides some insights into how demand may be affected. The paper looks at the indirect effect of the projects on other producers' export level and on reduction of the world price level. One of the results of the introduction of the Carajas project was an increase in the Brazil's market share, although it did not reduce production volumes of other producers due to increased demand for iron ore in the late eighties. The author proposes a model of price level determination which includes Brazilian productive capacity to supply iron ore and the German consumption of iron ore. Brazil and Germany are chosen because price negotiations between these two largest supplier and importer set the reference price level. These factors affect the price next year – increased capacity exerts downward pressure on prices, while increased consumption exerts upward pressure. The econometric model showed that Carjas has a capability to affect prices downward. However, the author stresses that now that the full productive capacity has been reached, the capacity of Carajas to exert downward pressure are less.

The paper of Dubohryz 2003) presents an overview of the Ukrainian ferrous metal industry, part of which is iron ore industry. This is a huge industrial sector built in the Soviet times for the needs of the industrial and military base of the Soviet Union. It comprises 14 steel making, 6 pipe making enterprises, 11 coke plants, 5 iron ore enrichment plants, numerous iron ore and manganese mines. Today the Ukrainian steel industry which forms demand for iron ore is having a number of problems: steel- making technology is becoming all the more outdated, high costs pf production, oversized labor force, low quality of finished steel products. Another great problem is the question of ownership of steel enterprises. The steel plants are owned by three major oligarch groups which distorts the economic relations because the iron ore is often supplied to these plants on the base on belonging to these groups and not on market relations. To improve the situation in the ferrous industry in 1999 the Ukrainian parliament adopted the Law "On Conducting an Economic Experiment at the Enterprises in Mining and Metallurgical Complex of Ukraine". The rationale behind the Law was to exempt the enterprises from taxes to increase their working capital, to help them revamp their obsolete technology and increase the amount of high quality production and thus increase their profitability. The program lasted from 1999 to 2002. Dubohryz builds an econometric model which estimates demand and supply for Ukrainian steel and thus is related to the topic of our research. The finding of the paper is that the Economic Experiment did lead to increased profits and revenues, how ever its influence on the quantity of finished steel as negligible.

Shulha (2003) work is important in that it does empirical analysis of the imposition of export tax on seed flower products. She uses "small" and "large "country approach and the welfare gains or losses for each country are estimated. She estimates import demand and supply elasticities with respect to prices. Using these coefficients she then calculates non-constant elasticities for domestic supply curve and calibrate the parameters of the curves. The obtained coefficients are then used to measure potential changes in the world prices, consumer and producer surpluses. The author evaluates the impact of removing the export tax on the export seed market.

My work will be an attempt to investigate the welfare losses of the government policy and propose an optimal trade and industrial policy for the iron ore industry after the enterprises are privatized. I will consider a case of an oligopolistic market with domestic consumption and export, and low import. I will estimate internal supply, internal demand, export supply and export demand using a simultaneous equations approach. Then in a partial equilibrium framework the estimated coefficients of elasticities will be used to obtain deadweight losses and gains of the mining and metallurgical companies from the government policy.

Chapter 3

IRON ORE INDUSTRY OVERVIEW

Iron ore mining and enrichment industry is a strategically important industry of the Ukrainian economy. It provides raw materials for metallurgical industry, jobs to thousands of people, and is a town-making industry (the welfare of the cities of Krivoy Rog, Zaporozhie, Komsomolsk depends on the functioning of the many mining enterprises).

Mining of ore in Ukraine began in 1881 and the volume of iron mined has increased from 6,4 million ton in 1913 to the record 124 million ton in 1978. Ukrainian mining enterprises began to export ore in 1949 and in 1978 the export volume was 39 million ton.

The break up of the Soviet Union and the transition period that followed caused a great recession in the industry. During the 1990-2000 the volumes of production decreased twice as much.

Currently there are eight mining enterprises in the industry. Three of them mine ore by underground way – *Krivoy Rog State Mining Company*, *Sukha Balka GZK* and *Zaporozhie Mining Company* and five by open way – *Ingulets GZK*, *Southern GZK*, *Northern GZK*, *Central GZK* and *Poltava GZK*.

These companies produce a full range of iron ore products: lump ore, agglomerates, pellets and concentrates. The products of these enterprises sold both on domestic and foreign markets. On average 65% of production is consumed by domestic metallurgical works and the rest is exported to the Eastern European plants, whose production technology is oriented to consume and process relatively low quality iron ore from the former Soviet Union. The Ukrainian mining companies' share of home market is 80% and that of Eastern Europe - 40%. Currently there is no government regulation of the export activity of mining companies: no export taxes, tariffs or quotas exist. The only payment the companies incur are transportation costs.

The world production of iron ore amounts to 1 billion annually. Ukraine produces on average 50-55 million tons a year and thus is the seventh world's largest producer of iron ore with share of 5% of the world's production. However, its importance seems to increase in light of the fact that China, the largest producer of iron ore (21% of the world market), do not export ore to the world market at all due to its low quality, rather China itself is a large importer of ore. Australia and Brasilia, the two largest producers that export ore, hold approximately 70% of world ore export. However, the specific feature of the world market is the fact that it consists of several regional markets and each market has its own world price. For example, Australia dominates on the Asian market, Brazil on the Western European, Ukraine and Russia on the Eastern European market. Therefore, although Ukraine is small country in terms of volumes of production, it s a "Large" one in terms of market power that it exercises on the market of Eastern Europe.

Most iron ore companies have private investors, although the state has controlling stocks in many of them yet.

The table presents the share of stocks state controls of each company.

Iron Ore Company	Market Share, %	State's Stake	Owner
KRSMC	11,24	100%	State
Zaporozhie Mining Company	5,63	0%	Zaporozhstal
Sukha Balka GZK[1]	4,52	25%	PRIVAT group
Southern GZK	11,73	27,78%	PRIVAT group
Ingulets GZK	19,43	50%+1	PRIVAT group
Northern GZK	18,53	50%+1	UkrSIbBank
Central GZK	8,56	50%+1	System Capital Management
Poltava GZK	9,98	0%	Finance and Credit

NkGZK possess 10,98% of the market, yet it is a structural unit of *Krovorozhstal* and is not an independent player.

Source: News agency "Context"

The table shows that although the state has controlling and blocking states in most of the enterprises, they are owned by a few business groups.

The current problem of the domestic market is the shortage of iron ore experienced by Ukrainian metallurgical plants. A paradoxical situation has arisen: while Ukrainian iron ore export has grown by 8% in 2003, metallurgical plants increased import of ore (from Russia) by 52,8% in comparison with 2002. The reluctance of iron ore producers to sell ore on the domestic market is explained by the fact that Ukrainian metallurgical plants, unlike Eastern European importers, refuse to make advance payments. A more important reason is the government intervention that sets the quantities of iron ore that should be

[1] *GZK* stands for *gornozbagachuvalnyi kombinat*, that is *ore enrichment plant*.

shipped my mining companies to metallurgical plants. Such a situation has evolved as a result of a strong metallurgical lobby in the Ukrainian political circles. Naturally, in search of super normal profit they look for cheap raw material for their metallurgical plants. A manifestation of such activities was setting recommended levels of shipments at regular "balance meetings" in the Ministry of Industrial Policy.

Although, there are no government official directives, there exist latent enforcement – the mentioned above recommended level of shipments to the metallurgical works and recommended price that government use interchangeably. The latest manifestation of the government policy is the decision to fix the prices for iron ore products at the level of 2003. The outcome of such "enforcement" is a lower price level that exists on the domestic market than that on the Eastern European market since mining companies have to ship iron ore anyway. So, in effect, the metallurgical works are latently subsidized at the cost of mining companies. The consequence is that to work with domestic metallurgical plants is becoming all the more unattractive and Ukrainian mining companies prefer to export ore rather than sell on the home market. Finally, this forces metallurgical plants to import more expensive iron ore from Russia, which often negatively affect their profitability. The Russian Federation plans to eliminate the export tax for its exporting enterprises, which may decrease the price of its ore and enlarge the share of import ore. It bears mentioning that often mining enterprises do not fulfill their obligations or fulfill partially in terms of the necessary quantity that the state requires to ship to corresponding works.

The government made it clear that it will proceed with the privatization of the mining enterprises. The Ukrainian Parliament already decreed on privatization in the mining sector of the remaining stakes that belong to the state. Currently, the hottest debates take place in the parliament on how to privatize the enterprises. The two options are – to sell government stakes to one buyer or to allow the groups that hold shares in the companies to consolidate full control. The former implies that Ukraine will have an uncontrollable monopoly, the latter – oligopoly. The question remains what the policy of government will be under two scenarios now that it will no longer be able to use directives to regulate the industry.

In view of the above said, the current research will focus on evaluating the losses of the mining companies from the government planning and the formulation of the optimal trade policy.

Chapter 4

Theory

The government intervention that takes place in Ukrainian iron ore industry takes the form of setting "suggested" price for supplies to the domestic buyers. As result of this the price level in the industry is smaller than on the world market. Compliance with such a suggested price regime is clearly not in the interest of iron ore producers. Over time with further privatization we would expect the policy to become increasingly ineffective, but for the moment we assume full compliance. Therefore we analyze what effect the price difference will have on the producers and consumers of ore.

4.1. "Small" country case.

The critical assumptions for the small country are

- Perfectly competitive markets;
- The import demand function is perfectly elastic giving rise to a constant

world price.

Figure 1 depicts the small country case. Schedule ***S*** is the supply of the good on the home market, ***D*** is the demand. If no restrictions are in place the price of the commodity is equal in the exporting and importing countries. The amount of export is $X^1 = S^u - D^w$. When the price is decreased the export reduces to $X^2 = S^u - D^u$. However, the small country assumption implies that the change in the export volume is small in comparison with the world market and the world price is not changed.

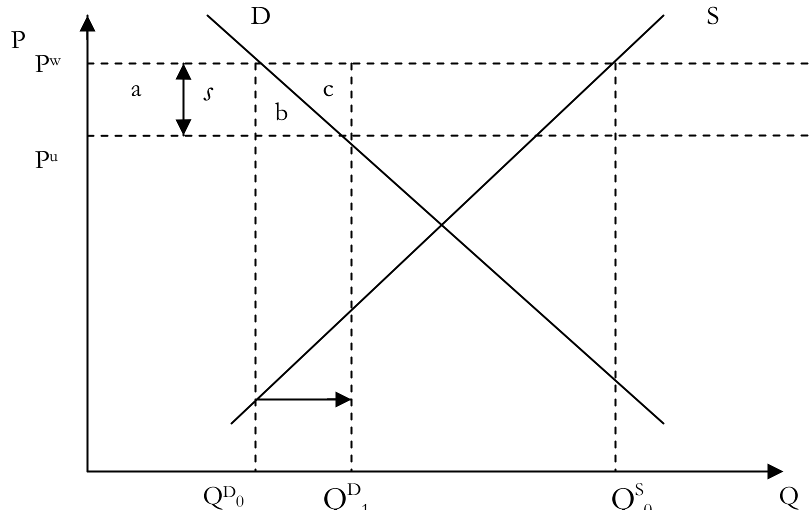


Figure1 . Effect of a price regulation for a "Small" country.

In considering the small country case we assume the following conditions hold.

1. $P^U = \overline{P}^U$

2. $ES=ES(P^w) = S(P^u) – D(P^u)$

3. $ID=ES(P^u, P^w)$

4. $P^w = P^u + s$

5. $\frac{P^w}{ID^w} * \frac{\partial ID^w}{\partial P^w} = -\infty$, where

ES is export supply of a commodity

ID is import demand of the commodity

S is supply on the domestic market

D is demand on the domestic market

P^d is the domestic price

P^w is the world price

s – the difference between the domestic and world prices, which has a role similar to a consumption subsidy.

The first equation indicates that the price on the domestic market is fixed at some level. This corresponds to a current situation on the iron ore market with "suggested" prices. The second equation requires that the export supply on the Ukraine's part is equal to the difference between the domestic supply and domestic supply and domestic demand, the equilibrium condition on the world market. The third equality says that what Ukraine exports is a function of both world and domestic prices and equal to the import demand. The fourth equation indicates that the world market exceeds the domestic price by certain amount *s,* a consumption subsidy to the metallurgical works. The last equation says that import demand is perfectly elastic.

Let us see who wins and who loses as a result of price regulation.

Exporting Country Producers. Since the price at which the good is sold on the domestic market is lower than that on the world's, producers experience a loss of producer's surplus equal to the sum of areas -(a+b+c). That is they sold output on the home market up to Q^u at lower, suggested, prices. The rest is sold at the world market price and therefore does not affect producer's surplus.

Exporting Country Buyers. Iron Ore Buyers gain is the sum of areas a+b from lower price on the home market.

Total welfare of the exporting country. The aggregate effect is obviously negative and equal -(a+b+c)+ (a+b)=-c, which is a distortionary loss.

4.2. "Large" Country Case.

The "large country" case refers to a situation where a country possesses a share of the world market large enough to change the world price. Therefore, price difference will affect supply and demand and influence the welfare both on the domestic and world markets. The assumptions of a large country are as follows:

- The markets are perfectly competitive.
- The schedule of import demand has a downward slope.

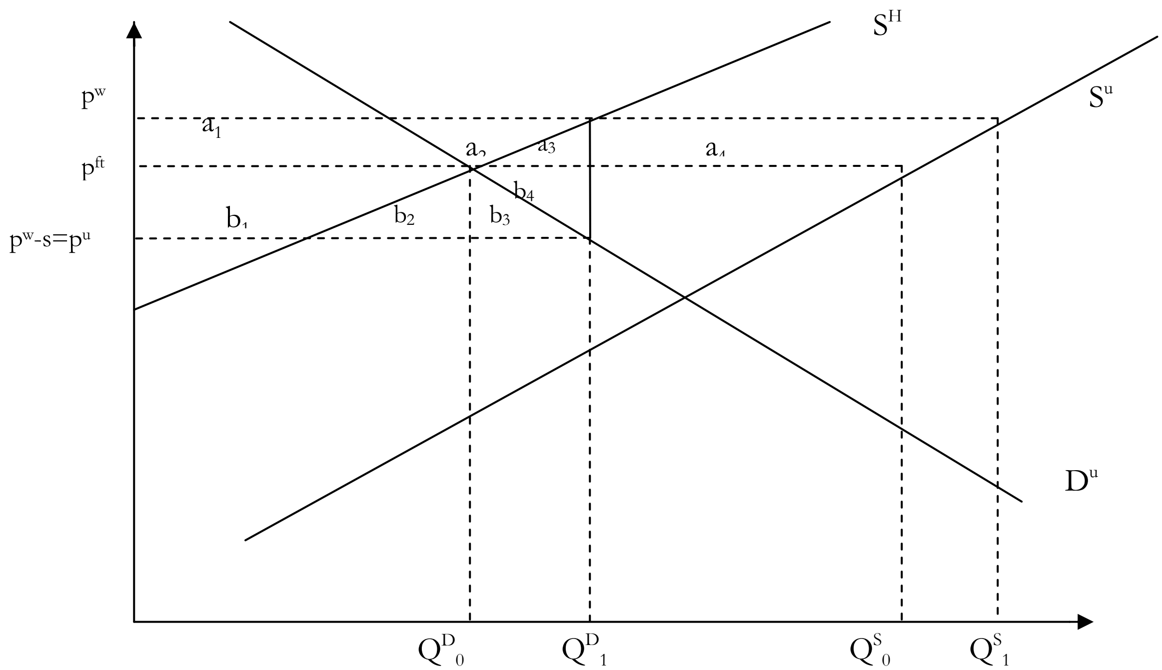
When the price difference exists in the large country case the following conditions must hold:

1) there are two countries – exporting and importing.
2) $P^w = P^u + s$
3) $ES^u = ES^u(P^u, P^w) = S(P^w) - D(P^u)$
4) $ID^w(P^w) = ES^u(P^w, P^u)$

5) $-\infty < \frac{P^w}{ID^w} * \frac{\partial ID^w}{\partial P^w} < 0$

The conditions are the same except for the last one which makes the difference between a large and small country cases – it requires price elasticity of demand to be negative and finite. That is, a country is large to change the world price.

The effect of the price difference is tantamount of analyzing the export subsidy and is depicted in Figure2.



The graph pictures the effect of a consumption subsidy (which is, in effect, a lower price for iron ore on the domestic market). The supply (S) and demand (D) curves are domestic demand and supply schedules.

S^H is the supply of iron ore to the home market, S^u is the total supply of iron ore by Ukrainian producers and the distance between them is the amount of iron ore imported by the rest of the world, such that $S(P^W)$-$ID(P^w)$. Thus at the free trade price p^{ft} , Q^S_0- Q^D_0 is the amount of iron ore imported by the rest of the world and thus Ukraine's imports.

As a result of government's setting the target price, the price on the domestic market goes down to p^u, while the price on the world market increases (we assume Ukraine to be a large country and able to change the world price). This causes exports to change to Q^S_1- $Q^D_{1,}$ which is exported at p^w, the now world price. Clearly, the government must be able to strongly influence iron ore producers if they are to comply with the target.

We can summarize the effect of the export subsidy as follows:

Ukraine's producers- producers gain from a higher price for the commodity on the world market. The producer surplus is increased by the amount of $(a_1+a_2+a_3+a_4)$. Accordingly, the increase in price causes output to rise. Producers also lose the amount of $(a_1+a_2+a_3+a_4+ b_1+b_2+b_3+ b_4)$ because they sell $Q^{suk}_{D\ on}$ the domestic market at the lower target price p^u . The net effect on the producer surplus is equal to

a_4-($b_1+b_2+b_3+ b_4$).

Ukraine's consumers. Obviously, a lower price benefits consumers in the exporting countries. The consumer surplus rises by the amount of $b_1+b_2+b_3$.

Total welfare of the exporting country. Total welfare is the sum of gains of consumer and producers and losses from the policy. It is easy to see that the aggregate welfare is $a_4-b_4=(a_3+a_4)-(a_3+b_4)$, where the first term in the brackets is terms of trade gain from higher prices and the second one is distortionary loss. Obviously, the end result can be either positive or negative depending on the amount the new world price exceeds the free trade price. If the difference between them is large area a_4 is greater than b_4 and the impact on overall welfare is positive. If world price exceeds the free trade price by a small margin, the welfare can be negative. If the price gap, *s*, is sufficiently small and the demand curve is less than infinitely elastic, the change in welfare will be positive.

4.3. Estimation of the optimal pricing policy.

The suggested pricing policy is similar to a consumption subsidy. The optimal pricing policy thus corresponds with the optimal consumption policy.

From Figure2 we inferred that the change in total welfare equals the sum of areas of consumer's surplus, producer's surplus and government loss. Here we present the main steps as we derive the optimal subsidy, although a more formal mathematical derivation can be found in Appendix.

First, we express the equilibrium condition of the market, which says that import demand as a function of the world price plus domestic demand, a function of restricted domestic price, equals the total supply. Totally differentiating the equation and factoring out $\frac{dp^w}{ds}$ we obtain:

$$Q^{md}(p^w) + Q^d(p^w - s) = Q^s(p^w)$$

$$\frac{dp^w}{ds} = \frac{\varepsilon^d}{\varepsilon^d + \frac{p^u Q^{md}}{p^w Q^d}\varepsilon^{md} - \frac{p^u Q^s}{p^w Q^d}\varepsilon^s}$$

We express consumer and producer surpluses as well as total change in welfare obtained above in mathematical terms.

Producer's surplus PS= a_4-(b_1+b_2+b_3+ b_4)=

$$= \int_{p^{ft}}^{p^w(s)} Q^S(p^w)dp^w - S * Q^D(p^w(s) - s)$$

Consumer's surplus CS= b_1+b_2+b_3= $\int_{p^w(s)-s}^{p^w} Q^D(p^{uk})dp^{uk}$

Change in total welfare then is

$\Delta TS =$

$$\int_{p^{ft}}^{p^w(s)} Q^S(p^w)dp^w - S * Q^D(p^w(s) - s) + \int_{p^w(s)-s}^{p^w} Q^D(p^{uk})dp^{uk}$$

Differentiating ΔTS with respect to s and setting the result equal to zero we derive the optimal subsidy as a ratio of subsidy to the domestic price.

$$\frac{\partial \Delta TS}{\partial s} = (\frac{Q^{md}}{Q^d} + \frac{s}{p^u}\varepsilon^d - \frac{s}{p^u}\varepsilon^d - \frac{s}{p^u}\frac{Q^{md}}{Q^d}\varepsilon^{md} + \frac{Q^s}{Q^d}\varepsilon^s)Q^d \frac{\partial p^w}{\partial s}$$

and we use the result that $\frac{dp^w}{ds} = \frac{\varepsilon^d}{\varepsilon^d + \frac{p^u Q^{md}}{p^w Q^d}\varepsilon^{md} - \frac{p^u Q^s}{p^w Q^d}\varepsilon^s}$ *to get*

$$\frac{\partial \Delta TS}{\partial s} = 0 \Rightarrow \frac{s}{p^u}(\frac{Q^{md}}{Q^d}\varepsilon^{md} - \frac{Q^s}{Q^d}\varepsilon^s) = -\frac{Q^{md}}{Q^d}$$

$$\frac{s}{p^w} = -\frac{Q^{md}}{\frac{Q^{md}}{Q^d}\varepsilon^{md} - \frac{Q^s}{Q^d}\varepsilon^s} = \frac{1}{\frac{Q^s}{Q^{md}}\varepsilon^s - \varepsilon^{md}}$$

$$\frac{s}{p^u} = \frac{Q^{md}}{Q^s\varepsilon^s - Q^{md}(1+\varepsilon^{md})} = \frac{1}{\left|\varepsilon^{md}\right| - 1 + \frac{Q^s}{Q^{md}}\varepsilon^s}.$$

We now consider an alternative policy where iron export are taxed. This policy also lowers the Ukrainian price in relation to the world price.

4.4. Determination of the Optimal Export Tariff.

To determine the optimal export tariff we follow the basic principle of microeconomics that marginal revenue of a good should equal marginal cost. First, we express $\boldsymbol{p^w = D_{ROW}(Q)}$ as indirect demand function,

Where $\boldsymbol{p^w}$ is the world price of a commodity

$\boldsymbol{D_{ROW}(Q)}$ – demand from the ret of the world for the commodity.

Next, we derive the marginal revenue function:

$$TR = Q^* \boldsymbol{p^w} = Q^* \boldsymbol{D_{ROW}(Q)}$$

$$(TR)' = MR = \boldsymbol{p^w} + Q^* \frac{\partial D_{ROW}}{\partial Q} = \boldsymbol{p^w}^*(1 - \frac{1}{\varepsilon^D})$$

Imposition of an export tax means implies that $P_{uk}(1+t)=P_w$

$$MC=P_{uk}=\frac{P_w}{1+t}$$

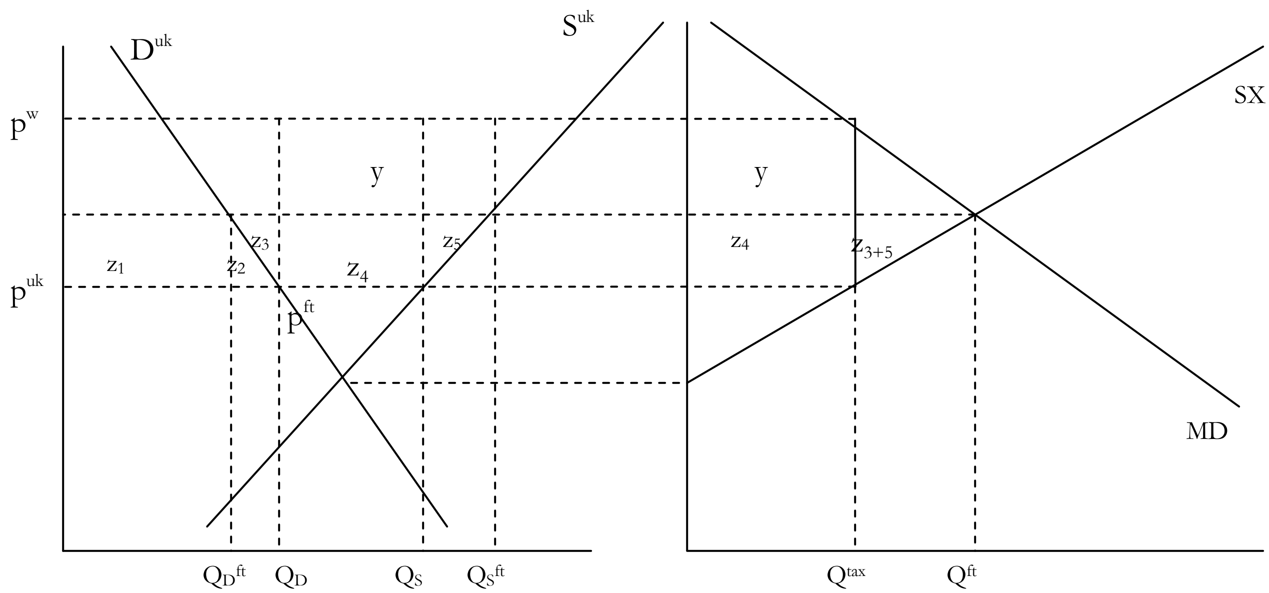
$$MC=MR$$

$$\frac{1}{1+t}=\frac{\varepsilon^D}{\varepsilon^D-1}$$

$$t=\frac{1}{\left|\varepsilon^D\right|}$$

While the optimal export tax may be higher or lower than the optimal consumption subsidy, the export tax is more restrictive on exports because iron production is reduced in addition to the increase in the domestic consumption of iron.

The Figure 3 .presents graphical analysis of export tax.



When a government introduces an export tariff, in effect, it lowers the price on the domestic market and raises the price on the world market. Producer lose the amount of $z_1 + z_2 + z_3 + z_4 + z_5$ while consumers gain $z_1 + z_2$. Thus, change in total welfare is $\Delta TS = -(z_3 + z_4 + z_5)$. Government gain is $(Q_S - Q_D)*(p^w - p^u)$, which is $\Delta GR = (y + z_4)$. Aggregate welfare then is $AS = y - (z_3 + z_5)$. The first term y presents terms of trade gains from better prices and $z_3 + z_5$ show efficiency loss from lower quantity. The resulting welfare can be of either sign and it depends on the size of the tariff imposed. If tariff is sufficiently small, the area y is larger than $z_3 + z_5$, which in extreme turns to a point and thus the welfare is positive, if tariff is large the welfare can be negative. The optimum export tax maximizes the welfare gain.

4.5. The Case of Ukraine's Iron Ore Industry.

Although Ukraine accounts only for 5 per cent of the world's production of iron ore, its share on the market of Eastern Europe is quite significant - 40%. Moreover, in each of the Eastern European country Ukraine is present among the three largest exporters of ore. It is one of the goals of the thesis to shed light on what case fits the Ukrainian iron ore industry.

Chapter 5.
METHODOLOGY AND DATA DESCRIPTION.

5.1. Methodology.

To conduct the analysis of effects of government intervention in the iron ore industry and develop optimal trade policy we use partial equilibrium framework, which allows considering the effect on a market taken in isolation.

First, I estimate elasticity coefficients of supply and demand on domestic and foreign market using constant elasticity assumptions. That is, I estimate equations in log-log form, which allows to obtain the elasticity coefficients.

Domestic market

$$\ln(Q_t^D)=a_0+ a_1\ln(p_{ore}^u)+ a_2\ln(p_{st}^u)+a_3\ln(GDP^{us})$$

$$\ln(Q_t^S)=\beta_0+ \beta_1\ln(p_{ore}^w)+ \beta_2\ln(S^u)$$

Foreign Market

$$\ln(p_{ore}^w) = \gamma_0+ \gamma_1 \ln(Q_t^{MD}) + \gamma_2\ln(p_{st}^w) + \gamma_3\ln(GDP^{US})+\gamma_4 D+ \gamma_5 D^* \ln(p_{st}^w),$$ where

Q_t^D, Q_t^S - quantities of iron ore demanded (supplied) at t;

p_{ore}^u – domestic price of iron ore;

p_{st}^u – domestic price of steel;

p_{st}^w – world price of steel;

p_{ore}^{w} – world price of iron ore;

p_{wage}^{u} - wage in iron ore and metallurgical industry of Ukraine;

GDP^{u} – Ukrainian GDP;

GDP^{US} – US GDP;

Q_t^{MD} – import demand from the rest of the world for Ukrainian ore;

D – a dummy variable that takes values of 0 from January 2000 to March 2002 and 1 thereafter and stands for the change in the US policy towards steel imports(US introduces safeguard measures restricting steel imports);

$D*ln(p_{st}^{w})$ – interaction term that captures how US price for steel changed after the new safeguard policy.

S – total change in stocks over the last 3 months

We specify the domestic demand equation as a function of domestic price, price for steel in Ukraine and US GDP. Price of steel enters the equation since iron ore is the basic input to the steel making process and thus steel prices are very likely to influence the demand for iron ore. We also have US GDP variable as a proxy for the purchasing power of the Ukrainian steel producers whose welfare is closely related to US GDP since a large share of steel is imported to either US or Western Europe.

The supply equation is specified as a function of the world price for iron ore and the wages in the Ukrainian iron ore and metallurgical sector.

The third equation is the inverse import demand equation, we include the dummy variable and the interaction effect to see how the change in the US policy affected the demand. The reason why this import demand equation is presented in the inverse form is that we are interested to know which "Country Case" Ukraine pertains to – "Large" or "Small" and the coefficient γ_1 next to quantity demanded can tells this outright. If it is insignificantly different from zero we deal with a "Small Country Case" and vice versa.

5.2 Simultaneous Equation Model.

We also can use the simultaneous equation methods since we estimate supply and demand that are linked through endogenous variables. Thus, the internal demand equation is a function of domestic price, while internal supply and import demand equations are the functions of the world (export) price. The import supply equation is specified as the difference between the internal demand and internal supply. The model can be estimated by several methods of SEM: two-stage least squares estimation(2SLS), weighted two-stage least squares(W2SLS), three-stage least squares(3SLS), full information maximum likelihood(FIML), seemingly unrelated regression(SUR) and generalized method of moments(GMM).

We use a White heteroscedacticity test to check if heterescedasticity is present, Hausmann test to see if residuals and regressors are correlated, to see the level of contemporaneous correlation in residuals we look at residual correlation matrix.

Our choice of the appropriate method is represented in the table:

Strategy for choosing the method of estimation of SEM

Statistical Problem			
Heteroscedasticity	Regressors and residuals are correlated	Contemporaneous correlation in residuals	Method for estimation
NO	YES	NO	2SLS
YES	NO	YES	SUR
YES	YES	YES	W2SLS
NO	YES	NO	3SLS
		Contemporaneous errors are distributed jointly normally	FILM
		Errors do not correlate with instrumental variable	GMM

Source. T Shulga Unpublished Masters Thesis. EERC, 2003.

5.3. Data Description.

The study uses monthly data for the period January 2000 – December 2003. The dataset includes: the export volumes of the main iron ore producers to each Eastern European country; the volumes of iron ore of all domestic producers supplied to domestic metallurgical plants; cumulative volumes of iron ore, cast iron and steel produced in Ukraine, Eastern Europe and world; the world volumes of iron ore production; the export price of the Ukrainian producers(FOB, Ukrainian border) to each country; the domestic price of iron ore shipped to each metallurgical works; aggregate price index on iron ore, steel, electricity and other industrial products produced in Ukraine; the nominal exchange rate of the US dollar to UAH.

Data on export volumes to Eastern Europe for the period of 1991-2003 were obtained at the transport company "Rudtrans" LTD. The data on prices of Ukrainian producers come from the State Holding company "Ukrrudprom"; the data on cumulative production of iron ore cast iron and steel were obtained at Derzhkomstat (Derzhavny Komitet Statistiki), data on the monthly production of steel by each country is obtained at the web cite of the International Iron and Steel Institute(www.worldsteel.org), basic monthly data on prices and production were provided by an analytic-consulting firm "Ukrpromzovhishexpertyza".

We have price and quantity series of four types of iron ore products supplied and consumed on both domestic and world market. These products – agglomerated ore, concentrate, pellets and sinter - are close substations in production; therefore we can aggregate them into one product. We use the following transformation to get aggregated quantity for domestic supply, domestic demand and import demand series.

$$Q_t^{ore} = Q_{1t} + \frac{P_{2t}}{P_{1t}} * Q_{2t} + \frac{P_{3t}}{P_{1t}} * Q_{3t} + \frac{P_{4t}}{P_{1t}} * Q_{4t},$$ where

Q_{it} - quantity of type *i* at period *t*

P_{it} – price of product *i* at period

The resulting quantity expresses iron ore in terms of one type of product (here, in agglomerated ore) using relative price of this product in terms of the others.

To get aggregated price series both for domestic and world market we weigh price for each type of ore by a share of that product in total production.

$$P_t = \sum_{j=1}^{4} w_j^p * P_{jt} \text{ ,}$$

$$w_j^p = \frac{\overline{Q_j}}{Q_j^T} * w_j^q$$

P_j – price of each product type

$\overline{Qj}$ - the average quantity of each product type(supplied to domestic or world market)

Q_T – total quantity supplied to domestic or world market.

Chapter6

Estimation Results

We use OLS method to estimate domestic demand, export supply and import demand equations. The estimation output results for aggregated series are given in the Appendices. The signs in the equations are in concordance with a priori economic theory expectations. The values of domestic demand and export supply elasticity coefficients -0,74 and 0,27 accordingly indicate that the domestic demand and export supply are inelastic, whereas the elasticity coefficient for import demand, when inverted, equals -6,57 and thus the import demand is obviously elastic. The coefficient of the quantity exported in the inverse demand function is significantly different from zero which is indicative of Ukraine being a "Large" country.

We also estimate demand, export supply and import demand equations for each individual commodity in order to check if the results for aggregated series are corroborated by the individual regressions.

The coefficients for concentrate and pellets in the domestic demand equation are negative and significant how we would expect them to be. However, the coefficient for ore is positive and insignificant. One of the possible reasons for the positive sign is an omitted variable, the likely one is quality, content of iron, which is quite difficult to get by. Then, agglomerated iron ore is less homogeneous than concentrate and pellets and thus the quality variable seems quite important.

-Domestic Demand coefficients------------------------

Variable	ore	conc	pellets
lph1	.18372322		
	0.6376		
lph2		-2.7920631	
		0.0000	
lph3			-.4198142
			0.0802
lukprst	-1.2101636	-1.1678366	1.2410863
	0.0289	0.3534	0.0188
lusgdp	6.5139779	15.89242	-3.3807397
	0.0591	0.0218	0.2353

In the export supply equations we again get expected positive signs for all but pellets variables. Yet, p-value indicates that this is not significantly different from zero.

---Supply coefficients----------------------

Variable	ore	conc	pellets
lp1	.60168065		
	0.0015		
lp2		.44328418	
		0.0059	
lp3			-.01203502
			0.9418
	0.0000	0.0015	0.0962
lqh1	.55189793		
	0.0000		
lqh2		.7442617	
		0.0000	
lqh3			.54383123
			0.0000
sttot	-2.911e-06	-1.058e-06	.00001969
	0.4735	0.8317	0.0000
lukwage	.41485577	.34744583	.13181353

Coefficients on the quantity variable in the inverse import demand equations are of negative sign and thus conform with economic theory.

----Import demand coefficient-----------------------

Variable	ore	conc	pellets
lq1	-.16054326		
	0.0047		
lq2		-.0862151	

		0.0408	
lq3			-.08348211
			0.0595
lusprst	1.0389635	4.2775345	.88344991
	0.2235	0.0002	0.2760
intstpr	-2.3593573	-6.6763105	-3.6776972
	0.0071	0.0000	0.0001
d	10.891305	30.967984	17.126449
	0.0076	0.0000	0.0001
lusgdp	1.0252131	5.6038677	-1.9506433
	0.5583	0.0107	0.2375

Therefore, we can say that the relationships on each commodity product make sense and support the results for the aggregated quantity of iron ore.

Using the estimated elasticity coefficients from the aggregated series and an Excel spreadsheet we design a number of scenarios and look for the one that maximizes national welfare, derived in the Chapter 4.

First, the current situation is presented in Appendix C1. We can see that the prices subsidy that Ukrainian consumers of iron get starts as high as 80 percent and with time gradually moves all he way down to zero. Its downward trend is explained by the fact that as time goes on the government has les leverage over the enterprises since these mining companies increase the share of stock that private investors hold and become al the more reluctant to comply with the government regulation. The average price subsidy over the 4 year period amounts to 32%, while the calculated optimal subsidy fluctuates around 15% and the optimal export tariff is exactly 15%. Obviously, the situation is far from optimal and we look at the possible scenarios of moving from current price regulation to free trade and from free trade to optimal export tax, consumption subsidy and pricing policy.

"Actual" Consumption subsidy – Free Trade.

In this scenario we analyze the move to free trade, that is a situation when a 32 % consumption subsidy is eliminated to zero. With a free trade the world price equals domestic and reduces from 84 hrv/ton to 79, 5 hrv/ton, which implies that Ukraine does not have much market power to influence the world price. Domestic producers gain from a higher price on the home market and the amount of the producer Surplus is 66 883 068 hryvnias, while consumers lose from higher prices and their loss is 66 516 566. On net, the change in the total surplus for Ukraine is negative and amounts to 2 633 497 hryvnias per month. Although this is not a huge sum, the situation supports the argument that Free Trade Policy may not be individually rational.

Free Trade - Actual Consumption subsidy.

Now we look at a situation when a government sets a consumption subsidy equal 32%. This is a mirror case of the above scenario and the gain in the national welfare is 2 633 497 hrv. per month. We use this case as reference point to compare with the optimal tariff and subsidy situations.

Free Trade – Optimum Pricing (consumption subsidy).

Ad valorem Consumption subsidy amounts to 16% and, when introduced, it benefits domestic consumers and hurts producers. The price on the domestic market goes down 70,9 hrv. per ton while on the world market it sets on the level of 82 hrv. per ton. As a result, consumer surplus is positive and is 34 432 725 hrv., while producers surplus is negative and equals 30 447 772 hrv.per ton. Thus, the change in total welfare is 3 984953 hrv. per month.

Free Trade – Optimum Export Tax.

The optimum export tax is calculated to be 15% and this leads to a price of 71,98 hrv. per ton on domestic market and 82,92 on the world market. Consumers gain since quantity supplied to the domestic market is larger than quantity exported. Thus consumer gain is 30 019514 hrv. per ton and producer loss is 50097089. The government gains 25795 017 in revenue. On net, the total gain in the national welfare is 5 717 442 hrv. a month, which a maximum out of all above mentioned policies.

Graphical presentation of the producer and consumer surpluses under different policies is as follows.

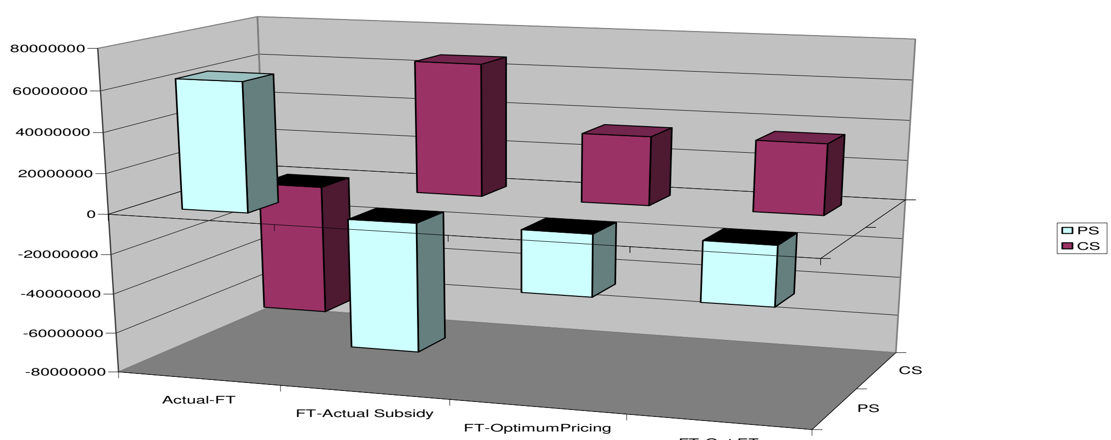


Figure 4. Producers and consumer surpluses under different policy regimes.

Accordingly, the change of total welfare is presented in the Figure 5.

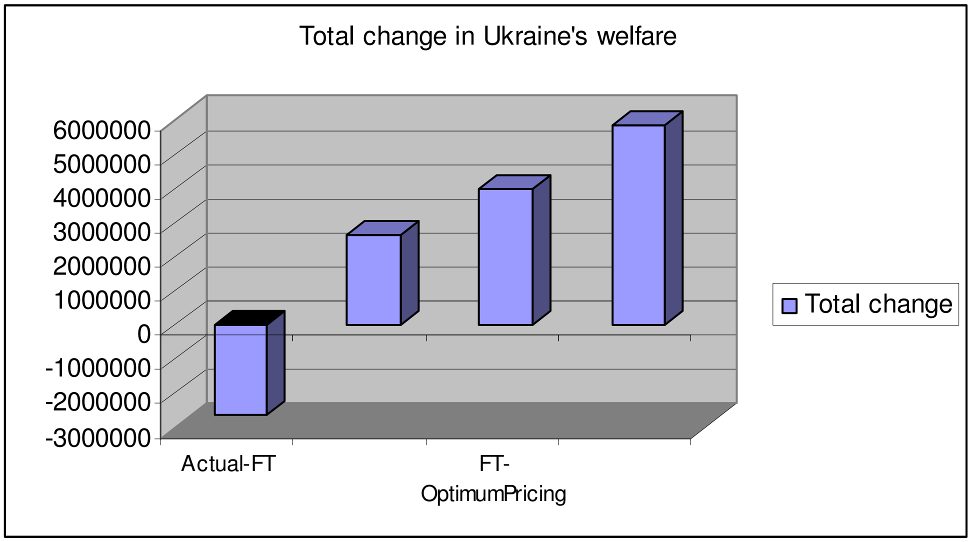


Figure 5. The total change in national welfare under different policies

We see from Figure 5 that national welfare is maximized when a country moves from free trade to setting an optimal export tariff. Free trade seems not to be the optimal choice for Ukraine.

Chapter 7

Conclusions.

The empirical estimation showed that Ukraine does have market power at least on regional iron ore market. Thus the large country case is relevant. Even so, Ukraine faces a foreign elasticity of demand that appears to be in the vicinity of 7 to 8 and may be as high as 14. This is sufficiently elastic that Ukraine has modest market power.

The analysis showed that regime of "suggesting" lower iron ore prices for domestic market restricts exports and raises the world price, which is beneficial to Ukraine. Since Ukraine has rather limited market power, the overall gain to Ukraine is modest in comparison with free trade. The market simulation suggests that Ukraine's pricing policy has been suboptimal and that, on average, for the past 4 years the gap between the world and the domestic price has been too large. Even with the optimum pricing strategy, Ukraine's gains relative to free trade would have been relatively small. The distributive effect of the pricing policy has been much larger. In comparison with free trade iron producers have experienced substantial losses as have, in effect, subsidized the buyers.

The "suggested" pricing policy is becoming increasingly untenable, with the passage of time and further privatization iron producers are increasingly unwilling to follow suggested pricing guidelines. While a true consumption subsidy with payment made by government could be imposed, greater welfare gain are available to Ukraine from an export tax and move to an optimal export tax would reduce the losses of iron producers in comparison with the current pricing regime and leave positive, but lower benefits to consumers. Even with the optimum export tax, however, the overall gains relative to free trade appear small. Consequently, moving to free trade in iron would not be a major concession in Ukraine's WTO accession negotiations.

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Appendix A

Estimation of the total welfare under the imposed subsidy.

Here we present a more formal mathematical derivation of the optimal subsidy.

First, we express the equilibrium condition of the market

$$Q^{md}(p^w) + Q^d(p^w - s) = Q^s(p^w)$$

$$\left(\frac{p^u Q^{md}}{p^w Q^d} * \frac{p^w}{Q^{md}} * \frac{\partial Q^{md}}{\partial p^w} + \frac{p^u}{Q^d} * \frac{\partial Q^d}{\partial p^u} - \frac{p^u Q^s}{p^w Q^d} * \frac{p^w}{Q^s} * \frac{\partial Q^s}{\partial p^w}\right) * dp^w = \frac{p^u}{Q^d} * \frac{\partial Q^d}{\partial p^u} ds$$

$$\frac{dp^w}{ds} = \frac{\varepsilon^d}{\varepsilon^d + \frac{p^u Q^{md}}{p^w Q^d}\varepsilon^{md} - \frac{p^u Q^s}{p^w Q^d}\varepsilon^s}$$

Producer's surplus PS= a_4-(b_1+b_2+b_3+ b_4)=

$$= \int_{p^{ft}}^{p^w(s)} Q^S(p^w)dp^w - S * Q^D(p^w(s) - s)$$

Consumer's surplus CS= b_1+b_2+b_3= $\int_{p^w(s)-s}^{p^w} Q^D(p^{uk})dp^{uk}$

Change in total welfare then is

$$\Delta TS = \int_{p^{ft}}^{p^w(s)} Q^S(p^w)dp^w - S * Q^D(p^w(s) - s) +$$

$$\int_{p^w(s)-s}^{p^w} Q^D(p^{uk})dp^{uk}$$

We differentiate change in the total surplus with respect to *s* and set the result equal to zero to find the optimal amount of s. We derive it as a ratio of the subsidy to the Ukrainian price.

$$\frac{\partial \Delta TS}{\partial s} = Q^s(p^w)\frac{\partial p^w}{\partial s} - Q^d(p^u) - s\frac{\partial Q^d}{\partial p^u} * \frac{\partial p^u}{\partial s} + Q^d(p^u) * \frac{\partial p^u}{\partial s} =$$

$$Q^s(p^w)\frac{\partial p^w}{\partial s} - Q^d(p^u) - s\frac{\partial Q^d}{\partial p^u} * (\frac{\partial p^w(s)}{\partial s} - 1) + Q^d(p^u) * (\frac{\partial p^w(s)}{\partial s} - 1) =$$

$$Q^s(p^w)\frac{\partial p^w}{\partial s} - Q^d(p^u) - s\frac{\partial Q^d}{\partial p^u}\frac{\partial p^w(s)}{\partial s} + s\frac{\partial Q^d}{\partial p^u} - Q^d(p^u)\frac{\partial p^w(s)}{\partial s} + Q^d(p^u) =$$

$$(\frac{Q^{md}}{Q^d}\frac{\partial p^w}{\partial s} + \frac{s}{p^u}(\frac{p^u}{Q^d}\frac{\partial Q^d}{\partial p^u})\frac{\partial p^w(s)}{\partial s} - \frac{s}{p^u}(\frac{p^u}{Q^d}\frac{\partial Q^d}{\partial p^u}))Q^d =$$

$$(\frac{Q^{md}}{Q^d} + \frac{s}{p^u}\varepsilon^d - \frac{s}{p^u}\varepsilon^d - \frac{s}{p^u}\frac{Q^{md}}{Q^d}\varepsilon^{md} + \frac{Q^s}{Q^d}\varepsilon^s)Q^d\frac{\partial p^w}{\partial s}$$

and we use the result that $\frac{dp^w}{ds} = \frac{\varepsilon^d}{\varepsilon^d + \frac{p^u Q^{md}}{p^w Q^d}\varepsilon^{md} - \frac{p^u Q^s}{p^w Q^d}\varepsilon^s}$ *toget*

$$\frac{\partial \Delta TS}{\partial s} = 0 \Rightarrow \frac{s}{p^u}(\frac{Q^{md}}{Q^d}\varepsilon^{md} - \frac{Q^s}{Q^d}\varepsilon^s) = -\frac{Q^{md}}{Q^d}$$

$$\frac{s}{p^w} = -\frac{Q^{md}}{\frac{Q^{md}}{Q^d}\varepsilon^{md} - \frac{Q^s}{Q^d}\varepsilon^s} = \frac{1}{\frac{Q^s}{Q^{md}}\varepsilon^s - \varepsilon^{md}}$$

$$\frac{s}{p^w} = \frac{s}{p^u + s} = \frac{\frac{s}{p^u}}{1 + \frac{s}{p^u}}$$

$$\frac{s}{p^u} = (\frac{Q^{md}}{Q^s\varepsilon^s - Q^{md}\varepsilon^{md}}) + \frac{s}{p^u}(\frac{Q^{md}}{Q^s\varepsilon^s - Q^{md}\varepsilon^{md}})$$

$$\frac{s}{p^u}(\frac{Q^s\varepsilon^s - Q^{md}\varepsilon^{md} - Q^{md}}{Q^s\varepsilon^s - Q^{md}\varepsilon^{md}}) = \frac{Q^{md}}{Q^s\varepsilon^s - Q^{md}\varepsilon^{md}}$$

$$\frac{s}{p^u} = \frac{Q^{md}}{Q^s\varepsilon^s - Q^{md}(1 + \varepsilon^{md})} = \frac{1}{\left|\varepsilon^{md}\right| - 1 + \frac{Q^s}{Q^{md}}\varepsilon^s}.$$

Appendix B
Estimation Output
Table B1
Domestic Demand Equation for aggregated quantity of iron ore

```
reg lQdom lp1 lukprst lusgdp  difs

      Source |       SS       df       MS              Number of obs =      47
-------------+------------------------------           F(  4,    42) =    2.73
       Model |  .313089532     4  .078272383           Prob > F      =  0.0415
    Residual |  1.20352878    42  .028655447           R-squared     =  0.2064
-------------+------------------------------           Adj R-squared =  0.1309
       Total |  1.51661832    46  .032969963           Root MSE      =  .16928

------------------------------------------------------------------------------
       lQdom |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         lp1 |  -.7364869   .4349857    -1.69   0.098    -1.614324    .1413498
     lukprst |  -1.880079   .6131042    -3.07   0.004    -3.117373   -.6427843
      lusgdp |   7.627952   3.757859     2.03   0.049     .0442855    15.21162
        difs |   .1896187   .2597329     0.73   0.469    -.3345435     .713781
       _cons |  -48.57617   32.03891    -1.52   0.137    -113.2333    16.08097
```

Table B2
Export Supply Equation for aggregated quantity of iron ore

```
reg lQs lpex sttot

      Source |       SS       df       MS              Number of obs =      48
-------------+------------------------------           F(  2,    45) =    6.20
       Model |  .131473006     2  .065736503           Prob > F      =  0.0042
    Residual |  .477257106    45  .010605713           R-squared     =  0.2160
-------------+------------------------------           Adj R-squared =  0.1811
       Total |  .608730112    47  .012951705           Root MSE      =  .10298

------------------------------------------------------------------------------
         lQs |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lpex |   .2691565    .101442     2.65   0.011      .064842    .4734711
       sttot |  -.0000195   5.86e-06    -3.33   0.002    -.0000313   -7.70e-06
       _cons |   7.223509   .6204649    11.64   0.000     5.973828    8.473189
```

Table B3
Import Demand Equation for aggregated quantity of iron ore

```
. reg lp11 lQex lusprst intstpr d lusgdp

      Source |       SS       df       MS              Number of obs =      48
-------------+------------------------------           F(  5,    42) =   10.91
       Model |  .187509541     5  .037501908           Prob > F      =  0.0000
    Residual |  .144364613    42  .003437253           R-squared     =  0.5650
-------------+------------------------------           Adj R-squared =  0.5132
       Total |  .331874154    47  .007061152           Root MSE      =  .05863

------------------------------------------------------------------------------
        lp11 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
```

lQex	-.1520349	.0681496	-2.23	0.031	-.2895664	-.0145035
lusprst	2.019984	.9227493	2.19	0.034	.1578002	3.882167
intstpr	-3.420254	1.042625	-3.28	0.002	-5.524356	-1.316152
d	15.85984	4.863766	3.26	0.002	6.044363	25.67532
lusgdp	2.563753	1.853847	1.38	0.174	-1.177463	6.304968
_cons	-27.51992	21.10191	-1.30	0.199	-70.10531	15.06546

Appendix C

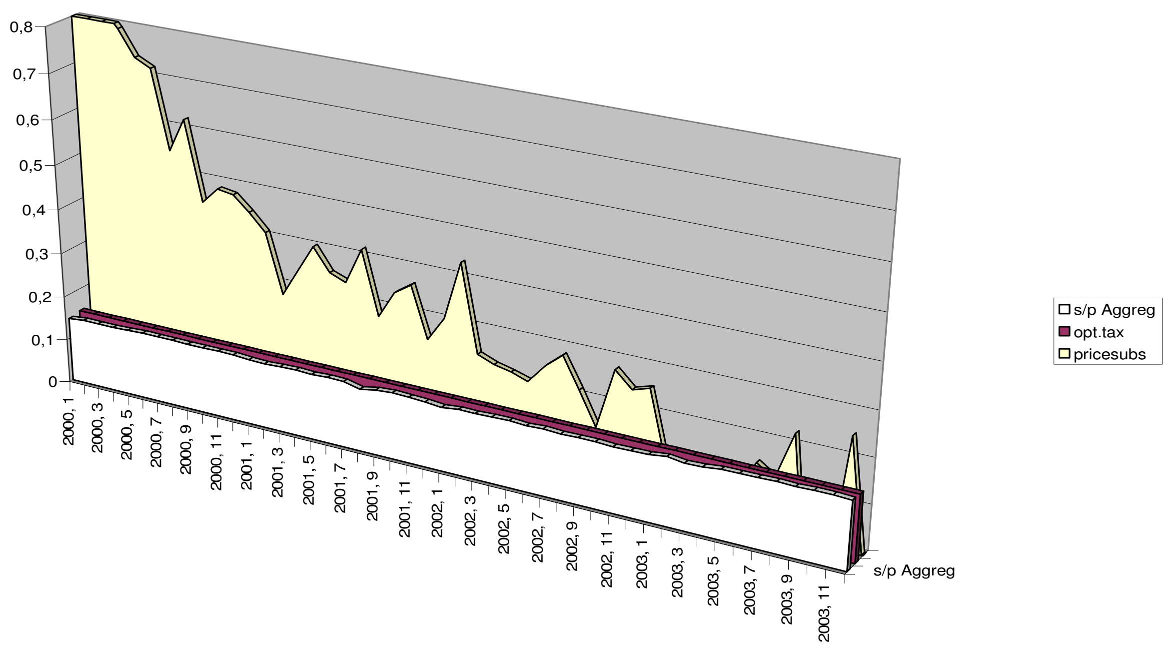

Figure C1. Comparison of the actual consumption subsidy, optimum export tax and price subsidy

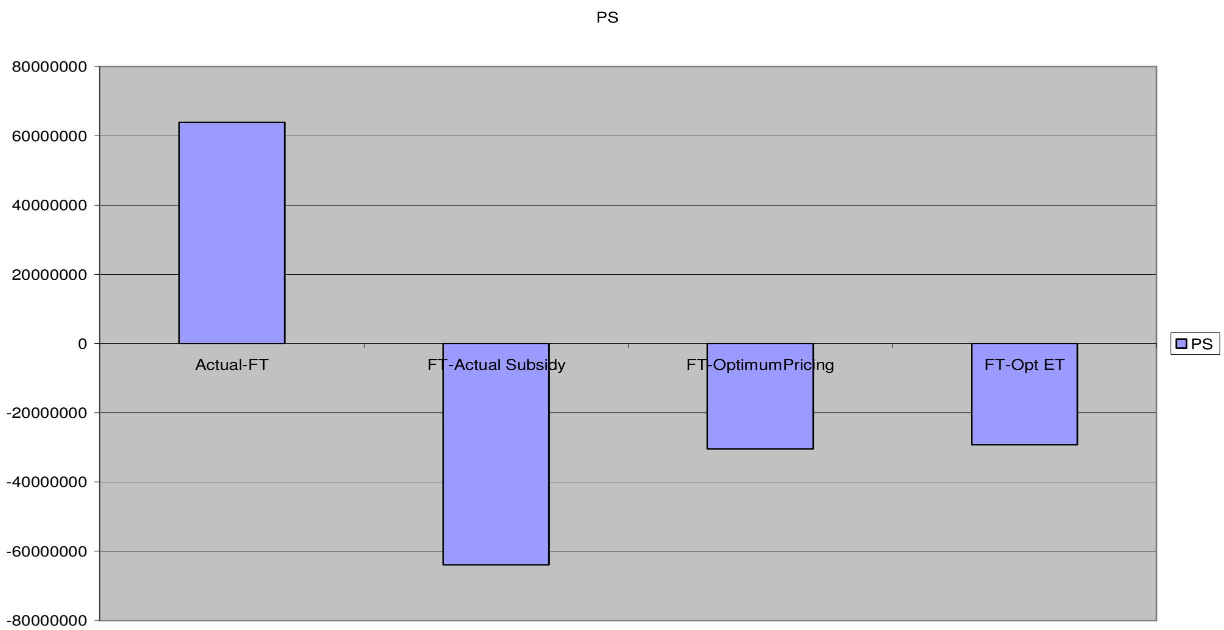

Figure C2. Comparison of the producer surplus under various scenarios.

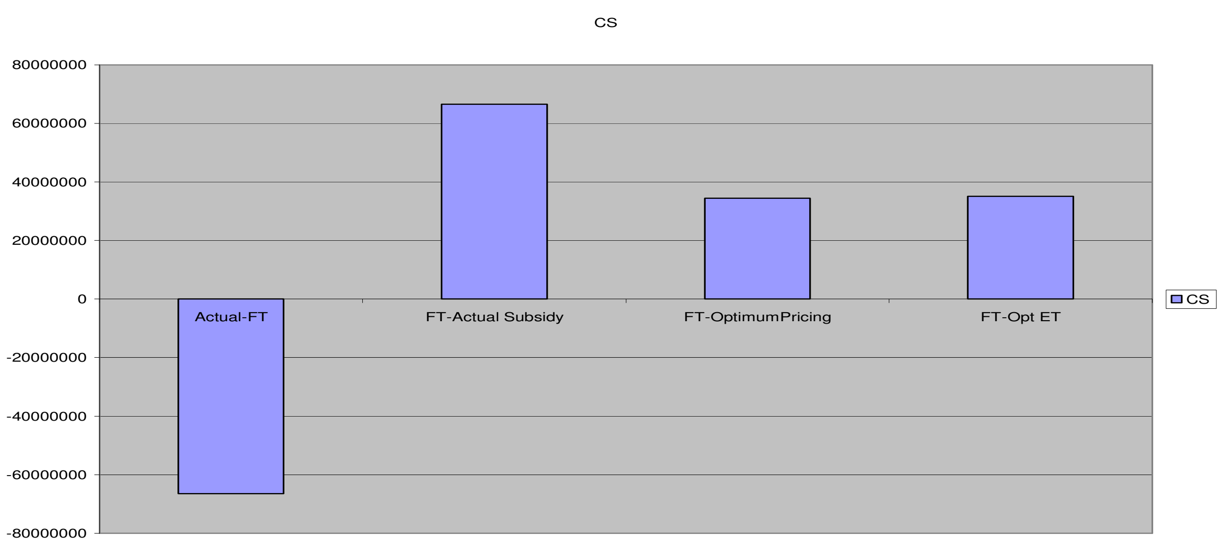

Figure C3. Comparison of consumer surplus under different scenarios

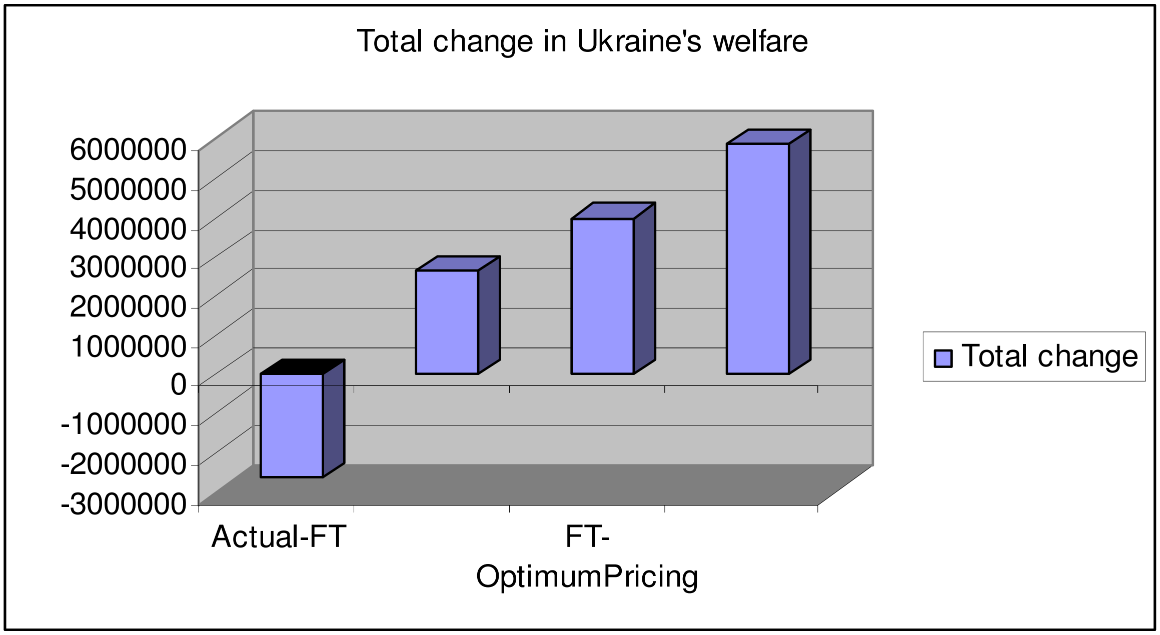

Figure C4. Change in the Total welfare under different scenarios