Linking Resource Depletion to Economic Performance of the Coal-Mining Regions

Egor Sidorov, Iva Ritschelova
Faculty of Environment
Jan Evangelista Purkyně University in Usti nad Labem
13 Horeni St., Usti nad Labem, 400 96
CZECH REPUBLIC
egor.sidorov@ujep.cz, iva.ritschelova@ujep.cz, http://www.ujep.cz

Abstract: The system of national accounting is primarily focused at measuring economic performance at different levels. However, formal measures of economic activity may be quite misleading, since they don’t give a comprehensive idea of quality parameters of growth. One of the issues is relation between the economic activity and environment. The paper describes an approach to the calculation of coal depletion adjusted regional macroeconomic aggregates for the coal mining regions of the Czech Republic. Its first part introduces the methodological approach to resource rent and depletion modeling. In its second part the coal depletion adjusted macroeconomic aggregates at the level of the coal mining regions of the Czech Republic are presented.

Key-Words: depletion, coal, mining, regional GDP, Czech Republic

1 Introduction
One of the approaches to measure and therefore insure sustainable development is based on extending the conventional capital boundaries used in the conventional SNA. Treating natural assets in the same manner as conventional capital would enable accounting for degradation and depletion as part of social costs and calculation of environmentally adjusted economic performance macro-aggregates.

There is no general consensus on how the depletion adjusted aggregate economic measure should be calculated (see e.g. [1], [2], or [4]). One of the approaches consists in adjusting conventional GDP by a measure of natural resource depletion. Natural resource depletion in many respects has the same character as consumption of produced capital. That is why in order to calculate the net income, a measure of natural resources depletion should be subtracted (see e.g. [4]).

During the last few decades a lot of progress has been made both in theoretical and experimental spheres. The initial projects aimed at adjusting conventional macro-aggregates have been performed by a number of national and international organizations (see e.g. [5], [6]). Concerning developed countries, such projects have been performed more recently e.g. in Sweden (see [7]) or in the UK (see [8]).

Concerning the Czech Republic this study represents one of the initial steps in filling this gap and presents methodological approach to depletion adjusted regional macroeconomic aggregates calculation.

2 Depletion and Economic Activity

2.1 Regional Aspect of the Coal Mining
The Czech Republic (CR) has sizeable geological reserves of hard and brown coal (see eg. [14]). Domestic fossil fuels play a major role in the CR in providing primary energy sources and electricity generation. The share of indigenous fossil fuels in primary energy sources is over 50 percent.

Table 1 Physical Balance Sheet for Exploitable Coal Deposits in the CR (mt)

<table>
<thead>
<tr>
<th></th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening Stock</td>
<td>1,679</td>
<td>1,645</td>
<td>1,362</td>
<td>1,315</td>
<td>1,113</td>
</tr>
<tr>
<td>Extraction</td>
<td>-63</td>
<td>-62</td>
<td>-61</td>
<td>-62</td>
<td>-62</td>
</tr>
<tr>
<td>Other Changes in Volume</td>
<td>29</td>
<td>-220</td>
<td>14</td>
<td>-140</td>
<td>62</td>
</tr>
<tr>
<td>Closing Stock</td>
<td>1,645</td>
<td>1,362</td>
<td>1,315</td>
<td>1,113</td>
<td>1,114</td>
</tr>
</tbody>
</table>

Source: [9]

During 2003-2007 coal extraction in the CR was quite stable (see Table 1). However, the levels of exploitable stock deposits were rather volatile especially due to discoveries and revisions of the previous estimates. This is reflected as other changes in volume calculated as a residual.

The major brown coal reserves of the CR are concentrated in the North West of the country along the Ore Mountains in the North Bohemian, Sokolov,
and Cheb basins. Brown coal basin locations refer to NUTS II Severozápad (North-West) region situated along the Czech-German border. The Upper Silesian basin is in fact the only region where hard coal mining takes place at present. It is situated in the North-Eastern part of the CR in the Moravian-Silesian administrative region bordering Poland and the Slovak Republic. This single administrative region forms the Moravskoslezsko (Moravian-Silesian) NUTS II region at the same time.

By the beginning of 2008, the hard coal industry was represented by two firms and the brown coal mining market was divided between four companies. The share of mining and quarrying in total industry Gross Value Added (GVA) has been gradually declining since 1995 (when it was 2.2 percent). In 2008 the share was approximately 1.5 percent of which 83.5 percent referred to the mining of coal and lignite and extraction of peat industry. In this respect, the coal mining industry stands out among the rest of the mining and quarrying industry. This enables one to conclude that the biggest rent flows are generated in this branch of mining.

2.2 Coal Depletion Value Model

According to the SNA terminology, the term "depletion" means the decrease of the stock of non-produced assets due to extraction. A certain part of natural assets and their services is accounted for in the conventional accounting systems. Estimating the value of resource depletion can be realized based on different models and techniques.

In cases where resource stock value market data isn’t available (that is the case for CR), resource depletion can be estimated using the Net Present Value (NPV) model. The model assumes that the stock value is equal to the sum of expected flows of benefits (i.e., rents) flowing to resource owner during the assets’ expected lifetime (see e.g. [2]). The depletion is consequently estimated as the change of value of the resource stock due to extraction.

The modeling procedure involves several consequent steps. The net present value model uses the parameter of resource rent in order to calculate the stock value. In national accounting practice the so-called Perpetual Inventory Method (PIM) may be adapted for resource rent estimation. The procedure of the PIM-based approach to rent calculation is presented by the following model:

\[ R = O - IC - CE - CFC - \pi K, \] (1)

where \( O \) refers to output, \( IC \) - intermediate consumption, \( CE \) - to compensation of employees, \( CFC \) - consumption of fixed capital, \( \pi \) - normal rate of return on fixed capital, and \( K \) - fixed capital stock.

According to (1), one can define net operating surplus by subtracting consumption of fixed produced capital from gross operating surplus \((O - IC - CE)\). The next step is the estimation of the return on produced fixed capital \((\pi K)\) and its consequent subtraction from net operating surplus. The residual is considered to be the resource rent, which is consequently used for resource value, as well as estimation of the depletion and income elements.

The value of the natural resource stock may be derived as the Net Present Value of the expected benefits (i.e., rents) flowing to its owner:

\[ RV_{t-\epsilon} = \frac{R_t}{(1 + r)} + \frac{R_{t+1}}{(1 + r)^2} + \ldots + \frac{R_{t+\epsilon-1}}{(1 + r)\epsilon}, \] (2)

where \( R \) refers to resource rent, \( r \) - discount rate, and \( RV \) - value of an asset.

The yearly resource rent may be expressed as follows:

\[ R_t = (RV_{t-\epsilon} - RV_t) + rRV_{t-\epsilon}, \] (3)

i.e. the resource rent may be split between the depletion element (reflecting the decline in the value of the natural resource due to extraction \((RV_{t-\epsilon} - RV_t))\) and the return to natural resource asset element \((rRV_{t-\epsilon})\). Depletion is mathematically a difference between the value of resource stock at the end of the period (with discoveries being eliminated) and the value of the resource stock at the beginning of the period with a 1-year-longer expected life. See e.g. [2] for further details.

The strength of this method is that value modeling can be based mostly on conventional national statistics data. However, it also involves highly speculative assumptions about such model parameters as discount rate, rate of return, resource life expectancy, etc.

2.3 Setting Depletion Model Parameters

National accounts provide the majority of information for applying the PIM approach to resource rent estimation mentioned above except for rate of return to fixed capital.

Rate of return is a ratio of income flow divided by the value of capital stock that generated this
income. There are several possible approaches to rate of return calculations (see e.g. [2] or [10]). The return to fixed capital in our study was calculated by using a 3 percent rate. This rate is equal to average of rates of return to fixed capital in the mining of coal and extraction of peat industry, adjusted for inflation rate. This rate is also close to the average of the weighted averages of per annum interest rates on non-financial corporations' CZK credits also adjusted for inflation.

In order to develop the net present value model for stock value and depletion estimation, one needs to make a number of assumptions concerning extraction rates, resource life expectancy, and discount rate, among others.

While calculating the present values of rent flows, it has been assumed that rents and extraction rates remain constant at the level of the current period. Expected life length of deposits was calculated as exploitable (recoverable) reserves divided by current extraction rate.

Net present value method assumes using the discount rates reflecting the time preferences of asset owners as well as their risk aversion. The discount rate highly influences the estimation results: higher rates of time preference and higher risk aversion correspond to higher discount rates. Furthermore, the discounting is significantly complicated by the level of future uncertainty and by debates on whether low social rates (rates close to zero, assuming intergenerational equity) or, conversely, high discount rates (see e.g. [2] or [11]).

Use of lower rate is motivated by the fact that in Europe, the majority of reserves belong to the state (and the CR is not an exception). Since the rate of time preference and risk aversion of the government is assumed to be lower than in the private sphere, this lower “social discount rate” is more appropriately reflecting the average real rate of return on governmental bonds. The respective average real rate of return to medium- and long-term governmental bonds for the CR was around 3 percent for the period 1995 to 2007. This rate is used in our model.

3 Coal Depletion Modeling Results

3.1 Depletion Adjusted National Aggregates

The estimated resource rent indicators were used for national exploited coal deposit value estimation and consequent depletion assessment. Estimates were made in constant prices (or revalued into current prices) in order to provide comparability amongst indicators used (see Table 2).

Through the fact that extractions in physical units were stable during the analyzed period, depletion in monetary terms is significantly volatile. This may be explained by the fact that according to the described methodology, coal depletion (as well as stock value) is calculated based on the NPV of resource rent (i.e. part of the net operating surplus). In this respect the stock value volatility, as well as the increasing level of depletion over time, may be explained by the overall price volatility in international commodity markets influencing the expectations of the economic agents.

Table 2 Monetary Balance Sheet for Hard and Brown Coal (billion CZK, 2000 constant prices)

<table>
<thead>
<tr>
<th>Year</th>
<th>Opening Stock (1.1)</th>
<th>Depletion</th>
<th>Other Changes in Volume</th>
<th>Closing Stock (31.12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>17.3</td>
<td>-0.2</td>
<td>-7.3</td>
<td>9.8</td>
</tr>
<tr>
<td>2004</td>
<td>9.8</td>
<td>-0.8</td>
<td>20.5</td>
<td>29.5</td>
</tr>
<tr>
<td>2005</td>
<td>29.5</td>
<td>-1.1</td>
<td>6.5</td>
<td>35.2</td>
</tr>
<tr>
<td>2006</td>
<td>34.9</td>
<td>-1.3</td>
<td>1.6</td>
<td>35.2</td>
</tr>
<tr>
<td>2007</td>
<td>35.2</td>
<td>-1.6</td>
<td>6.2</td>
<td>39.8</td>
</tr>
</tbody>
</table>

Source: own calculations

The modeling also has confirmed that estimations are heavily dependent on assumed asset lives, depreciation patterns and the rate of return to assets. Changing either the discount rate or rate of return involves quite significant changes in stock value estimations. For instance given the 2007 closing stock value calculated for 3 percent discount rate and 3 percent rate of return is the reference level, a 1 percent change in discount rate results in at least a 5 percentage point change in stock value. Furthermore, a 1 percent change in the rate of return results in at least a 25 percent change in the stock value.

Estimated depletion (extraction) figures enable the calculation of coal depletion adjusted macroeconomic aggregates based on the previously described approach. Table 3 presents the extent of coal deposit depletion within the framework of the Czech coal mining industry.

Table 3 Coal Depletion Adjusted Net Value Added of Mining of Coal; Extraction of Peat Industry (billion CZK, at constant prices of 2000)

<table>
<thead>
<tr>
<th>Year</th>
<th>Gross Value Added</th>
<th>CFC</th>
<th>Net Value Added (NVA)</th>
<th>Depletion (dp)</th>
<th>Depletion Adjusted NVA</th>
<th>dpNVA/NVA (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>19.2</td>
<td>5.5</td>
<td>13.7</td>
<td>0.2</td>
<td>13.5</td>
<td>98 %</td>
</tr>
<tr>
<td>2004</td>
<td>22.4</td>
<td>5.5</td>
<td>16.9</td>
<td>0.8</td>
<td>16.1</td>
<td>95 %</td>
</tr>
<tr>
<td>2005</td>
<td>18.5</td>
<td>5.4</td>
<td>13.1</td>
<td>1.1</td>
<td>12.0</td>
<td>92 %</td>
</tr>
<tr>
<td>2006</td>
<td>18.2</td>
<td>5.4</td>
<td>12.8</td>
<td>1.3</td>
<td>11.5</td>
<td>90 %</td>
</tr>
<tr>
<td>2007</td>
<td>18.3</td>
<td>5.3</td>
<td>13.0</td>
<td>1.6</td>
<td>11.4</td>
<td>88 %</td>
</tr>
</tbody>
</table>

Source: Czech Statistical Office, own calculations

As one can see, depletion adjusted NVA for mining of coal; extraction of peat industry is
significantly lower than the conventional NVA. Starting from 2 percent of NVA of the industry in 2003, the coal depletion estimation has increased up to 12 percent of coal mining industry NVA at the end of the analyzed period. Adjusting NVA by the level of depletion, which is normally incorporated within this conventional indicator, leads to a significant decrease of what is being called an income from the national accounting viewpoint. This explicitly shows the environmentally misleading nature of conventional macro aggregates, which are purely focused at economic activity.

If the resource depletion was taken as costs similar to consumption of fixed capital the NVA would have been on average 7 percent lower during the analyzed period. The growing trend of this ratio may be explained on the one hand by the increasing scarcity of coal reserves reflected by decreasing physical stock and consequent increase of the unit value, and on the other hand by the increasing price of coal on the world commodity markets.

With a view to relatively high dependence of the analyzed Severozápad and Moravskoslezsko regions on coal mining, depletion adjusted NVA indicator is highly policy-relevant. It explicitly highlights the trade-off between the economic activities and their sustainability consequences. If this indicator was used on a scale the conventional macroeconomic aggregates are used at present, the policy makers would be more motivated to maintain the capital stock of these regions in order to ensure at least the same income generating capacity in future after resource stock is over or after coal loses its economic significance.

A similar trend may be seen while comparing the estimated depletion level (i.e. natural capital consumption) with the conventional Fixed Capital Consumption. In 2003 depletion was equal to 4.25 percent of the Fixed Capital Consumption indicator. However, this ratio has been consequently growing during the whole analyzed period, and has finally ended up at the 30 percent level. This enables one to say that in case of the coal mining industry the depletion of natural capital is significant compared to the consumption of produced capital.

### 3.2 Adjusting Regional Aggregates

As it has been shown in the first part of our study, during the whole analyzed period the hard and brown coal mining industry was located on the territory of two NUTS II regions of the CR: namely Severozápad and Moravskoslezsko. Since the coal mining geography coincides with these NUTS II regions, one can apply environmental adjustments to respective regional accounts. The obvious candidate for adjustment is regional Gross (or Net) Domestic Product.

The regional GDP indicator measures the economic performance of the chosen territory regardless if the product is generated by resident or non-resident workforce. Production of regional accounts in the Czech Republic is in fact a combination of top-down, bottom-up and pseudo bottom-up methods. Top-down method is applied in financial, government and non-profit sectors. In this case the aggregate GVA is allocated to a region and to an industry based on the chosen key that is close to value added. Bottom-up approach is used in case the data on local units are directly available. If the unit is represented in several localities, pseudo-bottom-up approach is applied. This method consists in assigning the regional weights to local units based on the defined keys. Regional GDP is available down to NUTS III level of the Czech Republic.

<table>
<thead>
<tr>
<th>Source: Czech Statistical Office, own estimations</th>
</tr>
</thead>
</table>

As one can see (Table 4), coal depletion has been showing a gradually growing share within both the aggregate regional GDP as well as regional Gross Fixed Capital Formation indicators during the whole analyzed period. The ratio of depletion to regional product has increased by 0.2 percentage points from 0.1 percent in 2003 to 0.3 percent in 2007. The same positive dynamics may be traced in the case of depletion to the Gross Fixed Capital Formation ratio. One should mention, however, that in the case of this relative indicator, the share of depletion has increased very significantly from 0.2 percent in 2003 to 1.3 percent in 2007.

One should mention, however, that the regional accounts are quite limited (see e.g. [12] or [13]). Basic price indicators are estimated based on the economy-wide price indexes. NACE-specific deflators however are applied to each single NACE divisions. Therefore the resulting regional deflator is to a certain extent region-specific.
While reflecting the level of product generated, the regional GDP indicator, however, does not characterize the product uses on this territory as in the case of GDP for the whole country.

Furthermore, compared to national level number of indicators are not available. The main reason for that is the lack of relevant data sources. For instance, the Czech Statistical Office doesn’t provide data about regional capital consumption. In this respect, it is impossible to estimate the net regional product indicator. That is why Table 4 presents the set of ratios rather than depletion adjusted indicators.

4 Discussion and Conclusion

The flexible approach discussed in the SEEA gives the possibility of accounting for high priority environmental issues, leaving behind those of little interest or those involving serious theoretical or methodological complications. This is the reason why coal mining regions may focus on coal reserves depletion covering their critical needs and meeting all the actual peculiarities.

Depletion adjusted regional macroeconomic aggregates are closer related to sustainable development philosophy. Conventional macroeconomic aggregates are aimed at reflecting purely economic performance. Depletion adjusted indicators additionally cover non-produced natural and environmental assets reflecting the changing capability of the region to generate income in the future. In this respect depletion adjusted indicators contribute to the evaluation of long-term growth potential of the regional economy in a more comprehensive manner.

Through the fact that the significance of the coal mining industry within the structure of the Czech economy is relatively small, it has a relatively significant share in the GVA on the level of coal mining regions. The mining and quarrying industry during the period analyzed (2003-2007) generated an average of 5.3 percent of GVA in the Moravskoslezsky and Severozápad coal mining regions. This share is comparable, e.g. to the electricity, gas and water supply or to the construction industries of these territorial units.

Since coal is a non-renewable natural resource (at least within the horizon of several centuries) mining activities are connected with natural capital depletion. From the economic viewpoint, current extraction reduces income generating capacity at the regional level in the future. Starting from 2 percent of NVA of the industry in 2003, the coal depletion estimation has increased to 12 percent of coal mining industry NVA by the end of the period analyzed. Furthermore, adjusting net additions to fixed capital stock of the mining of coal and extraction of peat industry by depletion estimation shows that Net Fixed Capital Formation is negative and is decreasing over time.

The ratio of depletion to regional product of the coal mining territories in our study was around 0.3 percent in 2007. The depletion to Gross Fixed Capital Formation ratio was equal to 1.3 percent in 2007.

Calculating depletion adjusted economic aggregates at regional level is capable of pointing out the unsustainability of the chosen development pattern of the territory. The constantly decreasing stock of the available capital would reduce the level of conventionally used income indicators and draw attention to the potential deepening of interregional disparities.

Concerning the interests of coal mining regions compensation the loss of natural capital stock due to extraction jeopardizes their potential to generate income flows in the future. Since the majority of rent remains in the private hands of mining companies, it is impossible to ensure that the consumption of resource stock is compensated by investment into other forms of capital assets of the analyzed mining regions. That means that local authorities have little power to compensate the loss of regional capital stock loss.

Under these circumstances the resource rent appropriation level should be increased. The extent of appropriation, however, should also consider such national interests as, e.g. energy security of the state, or influencing domestic prices of the resource. These two points seem to be quite critical in the Czech Republic. All these facts probably make partially appropriated rent the only politically acceptable solution.

Regional indicators of economic performance have number of shortcomings. One should name the above mentioned absence of regional deflators for basic price estimations, relation between supply and use sides, and general lack of regionally specific economic aggregates. Furthermore, regional GDP is partially based on the above mentioned top-down and pseudo bottom-up modeling methods that make estimations dependent on the chosen distribution keys.

In addition to depletion value modeling parameters, one can state, that resulting depletion-adjusted economic aggregates are to a significant extent speculative estimations dependent on the observers’ assumptions. Even through these shortcomings it may be useful to develop using environmentally adjusted economic aggregates in
regional management practice. If these indicators were used on a scale that the GDP is used at present, policy makers would be more motivated to sustain an economic, as well as natural wealth of the region. Welfare focused policies would be generally about finding compromises between the economic and environmental spheres of development.

Acknowledgement

This paper is a result of the project of Ministry of Environment of the Czech Republic No. SP/4i2/60/07 Indicators for Valuation and Modeling of Interactions among Environment, Economics and Social Relations. The support is gratefully acknowledged.

References:


