**Assessing the economic impacts of nuclear energy in Malaysia**

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Under the Economic Transformation Programs (ETP), the Malaysian government is planned to run a twin-unit of nuclear power plants with a total capacity of 2x1000 megawatt-electric by 2030. This paper assesses impacts of nuclear power plants (NPP) on the Malaysian economy by paying specific attention of the analysis during the construction periods. To achieve this objective, an econometric-input-output prototype model that developed by the International Atomic Energy Agency (IAEA) is applied. To execute the model, an input-output table for 2020 reference year and additional exogenous parameters are estimated. Results show that the contribution of NPP during the construction periods is satisfactory. Of the total Malaysian Ringgit (MYR) 31,295 million investment for the construction of NPP generates MYR1,443 million to GDP, MYR5,026 million to output, MYR426 million to disposable income and 9,431 employments.

*Keywords*: nuclear energy; economic impacts; input-output; Malaysia

**1. Introduction**

Electricity input is known to be as one of the driving forces of economic growth and development in a country. It provides a vital role in the production and consumption processes of goods and services. It is also well documented that studies on the consumption-growth nexus of electricity conclude that electricity consumption have a strong correlation with the level of economic growth and development (see for example, Ferguson et al., 2000). According to the International Energy Agency (IEA, 2014), the world total final consumption for electricity in 2012 is equivalent to 1,625.2 Mtoe (million tons of oil equivalent), which has increased by 270.1% from 1973 level of consumption. Rapid population growth is found to be the main driver for the growth of the world’s electricity consumption (Ozturk and Acaravci, 2010).

World electricity supplies are generated primarily from six major energy inputs which include hydropower, nuclear, petroleum, natural gas, coal and other renewable sources (geothermal, solar, tides, wind, biomass, and biofuels). The World Bank (2015c) database for electricity production shows that in 1990, world relies about 37.1% on coal to generate electricity, followed by hydropower (18.0%), nuclear (17.0%), natural gas (14.9%), petroleum (9.9%) and renewable energy (1.3%). In 2012, coal still topped the chart with 40.3% of input supplied. The percentage utilization of natural gas and renewable energy also increases to account for 22.4% and 4.7% of total input supplied, respectively. As a consequent, the use of petroleum energy has declined to record the lowest input supply of 4.1%. This situation can be explained by the shift in input used from petroleum to coal due to strong demand for electricity by the Chinese economy (Crompton and Wu, 2005; Adams and Shachmurove, 2008). The shift on the other hand, is induced by the large worldwide coal reserves which constitute 65.0% of the total world reserve for fossil fuel if compared to petroleum and natural gas that constitutes only 35.0% (Shafiee and Topal, 2009).

Is the pattern of population growth and electricity consumption in Malaysia similar to the rest of the world? Malaysia is well known to be an energy dependent country with electricity consumption closely related to the growth of population (see Tang, 2009; Ali et al., 2012). Tang (2008) indicates that the electricity consumption per capita does have a positive relationship with real income per capita which indirectly reflects the role of population growth. For the periods 2000-2012, the correlation coefficient between the population and electricity consumption in Malaysia is 0.99. The Malaysian population is projected to reach 33.4 million by 2020 and 37.4 million in 2030. This surely will increase demand for electricity to meet the direct consumption (i.e. housing and consumer utilities) and indirect consumption (i.e. consumption of goods and services).

Between the periods of 2000 and 2005, coal consumption in Malaysia has increased from 1.8 Mtoe to 5.5 Mtoe and most it is used for electricity generation (Economic Planning Unit, 2006; Malaysia Energy Information Hub, 2015). The increase in the consumption of coal is mainly driven by the government policy to shift towards coal and thus, reducing the dependency on petroleum and natural gas (Gan and Li, 2008). With the implementation of the Fuel Diversification Policy in 1980s, Malaysia is no longer dependent on petroleum for energy supply. Following the oil crisis in 1970s and 1980s, the policy has been enacted to diversify energy sources and this strategy brings to a substantial drop in the petroleum share to the energy mix from 87.9% in 1980 to 2.2% in 2005. The share of coal, natural gas and hydropower increased tremendously (Mohamed and Lee, 2006; Oh, 2010).

Equally important to be stressed here is that 90% of coal supplies in Malaysia are mainly imported from Australia, Indonesia, China and South Africa (Mohamed and Lee, 2006; Shafiee and Topal, 2009). As far as sustainable energy supply is concerned, heavy reliance on imported coals may not be a good strategy because fluctuations in the exchange rates affect the import costs which in turn affect the production costs for electricity. For instance, the Bank Negara Malaysia (2015) on January 02, 2015 recorded the exchange rate for 1 USD is equivalent to RM3.51 and this value has increased by 27.4% to record the highest rate of RM4.47 on September, 29 2015. Looking at this situation, coal seems not to be a sustainable choice for electricity generation due to uncertainty in the foreign currency exchange market (Ali et al., 2012). In this light, a new source of energy needs to be explored. With uncertain future supply and volatile coal prices, nuclear power is a promising option because it is cost effective and green. Thus, under the Economic Transformation Programs (ETP), the Malaysian government is planned to run a twin-unit of nuclear power plants with a total capacity of 2x1000 megawatt-electric by 2030.

This paper aims to measure the extent to which running the twin-unit of nuclear power plants affects the Malaysian economy. To achieve the objective, we apply the econometric-input-output prototype model that developed by the International Atomic Energy Agency (IAEA). To run the model, the estimated input-output table for 2020 along with exogenous parameters are prepared. This paper not only shows a significance contribution to the literature on economic-nuclear energy assessment, but also provides valuable information in formulating appropriate energy policy in Malaysia.

This paper is organized into five sections. Section 2 provides the methodological details of the econometric-input-output model that developed by the IAEA. Section 3 presents the technical procedures for the estimated input-output table for 2020 and for exogenous parameters. Section 4 discusses the main findings for the economic impacts of nuclear power plants. The impacts are analyzed only for the construction periods of the nuclear power plants while the impacts for the operational periods could not be performed due to data constraints. Finally, Section 5 provides concluding remarks.

**2. Econometric-input-output model for nuclear power plants**

The IAEA input-output prototype model was initially developed by Kratena (2014) and then further formalized by Voigt (2015). There are two main differences between the IAEA prototype model and the standard input-output model.

Firstly, the IAEA prototype model deals with the new industry in the impact analysis. Following Miller and Blair (2009, see Chapter 13), there are two options to deal with a new activity (new plant or new industry) in impact analysis: (i) the final demand approach, and (ii) the full inclusion in the input-output matrix. The differences between these two options are minor and the final demand approach is much more straightforward to be implemented and slightly less data demanding (the delivery structure of the new activity needs not to be known). Given that the focus in this paper is on deepening the macroeconomic feedback mechanisms of an input-output model by introducing additional model features, the decision for the simpler basic model framework, i.e. the final demand approach, was taken. IAEA (2009) provides in detail, how technical and commercial data from nuclear power plants can be used to inform a simple static input-output model for impact analysis.

 Secondly, the IAEA prototype model extends the static input-output analysis by endogenizing demand categories and taking into account price-quantity interactions. An impact of prices on quantities is usually part of a demand specification, whereas an impact of given quantities on (equilibrium) prices is usually part of the factor market clearing mechanism. In this respect, the IAEA model has several important features over the static models. First, the static input-output model may underestimate the short run effects of the introduction of a new industry as it does not take into account macroeconomic income multipliers. Given the fact that consumption does not simply follow a Keynesian income mechanism, but also has dynamic (life cycle) properties, these income multipliers will be applied very carefully. Second, the static input-output model is supposed to overestimate employment effects, as increased labor demand will not match perfectly with higher labor supply, therefore wage reactions will occur. Third, price-quantity reactions in both directions are captured for production and labor demand. In the case of labor demand, the nominal values increase half the magnitude of the wage rate, which roughly (depending on the underlying functional form of the demand function) corresponds to a price elasticity of -0.5.

 There are four different models are designed to measure the economic impacts of nuclear power plants during the construction periods. Let us define the four models as Models A, B, C and D.

* Model A – standard input-output model that decomposes the impacts into direct and indirect effects.
* Model B – extends Model A by capturing the induced effects that result from the endogenous private consumption.
* Model C – extends Model B by incorporating labor market response to the demand and supply.
* Model D – extends Model C by including feedback effects from the government through public-private investment financing scheme.

**Model A – direct and indirect effects**

The basic IO equation for the case of a symmetric input-output table is:

 (1)

In (1) **x** is the column vector of gross output, **c** is the column vector of private consumption (that is to be endogenized in Model B), **f**\* is the column vector of other (exogenous) final demand and **f**new is the column vector of demand from the new activity (the nuclear power plant), comprising intermediate demand (operation) as well as investment (construction). The matrix **A**d is derived by dividing the elements of domestic intermediate demand by the column sum of output, **x**. Another matrix **A**m can be derived for imported intermediate demand.

In the “baseline” case with the original input-output table, **f**new only contains zero elements. Equation (1) describes the solution for the production by inserting the basic data of the nuclear plant (construction or operation) into **f**new gives a new output vector **x**, which in turn is inserted into **A**d**x** to derive again a new output vector **x**, and so on. This methodology converges to the same solution for the output vector **x**, as the solution using the Leontief inverse matrix, [**I** - **A**d]-1. Therefore equation (1) serves to quantify the *direct* (**f**new) as well as the *indirect effects* via the input-output linkages.

In (1) all variables are defined in current prices. The general philosophy for price/quantity interactions in this model is that both models are solved independently without taking into account *additional* repercussions of simultaneous changes. The quantity model is solved with nominal values (= current prices) and it is assumed that nominal values stay constant when prices change. That involves demand reactions of unitary elasticity due to price changes. The impact on output volumes (= output by industry deflated by the corresponding output price) can be directly derived by dividing the nominal output values by the output prices determined below. All aggregate deflators (e.g. of total output) are calculated by applying the Divisia price index, assuming the concept of chained price indices over time. No specific accounting for the impact of structural change on relative prices is assumed, though.

**Model B – Model A and induced effects**

The first enlargement of this static input-output model is the treatment of private consumption as endogenous. The information about value added components in the input-output table which determine the income components of households have to be matched with data about households’ disposable income from National Accounts. The minimum disaggregation in the value added part of the input-output table comprises wages, operating surplus and taxes net subsidies which are linked to output by technical coefficients like in the case of intermediate demand: **l***w* is a row vector containing the employment per output coefficients (**l**) multiplied with the industry wage rates, *w*, and **s** is a row vector of operating surplus per unit of output.

There might be a difference between wages in the input-output table and that in National Accounts, so that an adjustment factor fw,hh is introduced. Only part of the operating surplus enters the disposable income of households and a large part stays in the firms, this is captured by the adjustment factor *f*s,hh. The household taxes and transfers are dealt with an average tax rate *t*hh on disposable income, *YD*. Besides that, there are other components of disposable household income *YDoth* (net income from abroad, profit and rent income) that shall be dealt with as exogenous in this model. The basic linkage to the input-output model is via wages and operating surplus. The definition of disposable income of households therefore is:

** (2)

In (2) represents gross wages minus corresponding net taxes and minus social security contributions) and  represents gross operating surplus accruing to households minus corresponding net taxes (including social security contributions). Once disposable income (*YD*) is determined, total private consumption is calibrated from a simple Keynesian consumption function with a fixed marginal propensity of consumption (*mpc*). The consumption vector **c** is determined by multiplying total consumption by a column vector of domestic budget shares, :

 (3)

Thus, the complete model now consists of the three equations:

 (1)

** (2)

 (3)

Once values for **f**new have been determined, the new output vector **x** gives new disposable income *YD* in (2), which in turn determines a new consumption vector **c** in (3) that is fed into (1), where the new output vector **x** also determines new intermediate demand. As in the simple quantity model above, the model solution converges to one stable new output vector **x**. The system of equations (1) to (3) therefore serves to quantify the *induced effects* including the input-output linkages as well as endogenous consumption.

**Model C – Models A, B and labor market feedback**

Total employment *L* is given by *L* = **lx**r, i.e. the matrix product of the row vector of employment coefficients with the new equilibrium vector of real output (in volumes), **x**r. The elements of **x**r are derived by dividing the elements of the output vector at current prices, *xi*, by the corresponding output price, *pi*, determined by the input-output price model (see equation (10)).

This static employment effect can only be realized, if labor force in the same region, qualification, etc. is available. In computable general equilibrium (CGE) models where full employment is assumed, all the potential employment effects materialize in higher wages in order to clear the labor market. The underlying labor market philosophy in this model corresponds to a wage bargaining or a wage curve model of the labor market. In these models a parameter value for the impact of the unemployment rate on wage formation exists (*ur*), relating both variables in an inverse relationship. In the case of full employment (e.g. 3% of unemployment rate) in the "baseline" situation, high repercussions from wage formation to an employment shock are expected. The opposite holds for a "baseline" situation with high unemployment.

Without specifying in detail all the wage setting mechanisms, a negative elasticity from log(unemployment rate) on log(*w*), i.e. the industry wage rate is assumed, where the unemployment rate is given as one minus the employment rate (with a given labor force, *LF*):

 (4)

The higher industry wage in turn has a repercussion on employment. Assuming the nominal wage coefficients **l***w* would stay constant with rising wage rates, this would imply a unitary elasticity. In this model it is assumed that the nominal wage coefficients **l***w* rise half as much as the wage increase would imply. The new value for total employment is therefore given with:

 (5)

The new coefficients for employment per output (**l**) also change disposable household income according to (2), which in turn has an impact on consumption (equation (3)).

A new aspect that is also linked to the wage feedback is a possible change in output prices. The basic equation of the input-output price model is:

 (6)

Similar to the case of the quantity model, this equation is not solved in the model context via the application of the Leontief inverse, [**I** - **A**d]-1, but in a loop. The new coefficients for employment per output (**l**) yield a new output price vector, which ceteris paribus gives a new vector of output at constant prices, **x**r and therefore changes employment again. The "employment loop" therefore comes very close to a simultaneous model with demand and supply (represented here by the price side) interactions. The full "employment loop" consists of the following equations:

 (7)

  (8)

** (9)

 (3)

 (1)

 (10)

A new vector of **x**r is calculated by dividing the solution for output at current prices from (1) by the new price vector from (6).

**Model D – Models A, B, C and public budget feedback**

In this model, the production and employment equilibriums are extended to incorporate a scenario with external financing of the nuclear power plant either via existing funds in the new industry or allowing for a higher public budget deficit. This is implemented by adjusting the households’ tax rate *thh* in an *ex ante* revenue-neutral manner. This scenario of public financing shall be assumed only relevant in the case, where the vector **f**new contains the expenditure for the construction of the nuclear plant. Once the share of public financing of total construction cost, *rpub*, is determined, the new tax rate  can be calculated for the value of disposable household income of the “baseline” case (***i*** in (11) is the unitary column vector):

 (11)

This methodology of determining the new tax rate corresponds to the assumption of *ex ante* revenue-neutral financing. As *YD* changes due to induced effects of the construction of the nuclear plant (equation (9)), the final result of the public budget is different.

**3. Data estimation**

There are two main datasets are utilized in this study: (i) input-output table and exogenous parameters such as marginal propensities to consume and annual growth rates of wages, employment and labour force. The latest input-output table for Malaysia is in 2010 reference year which consists of 124 sectors. This input-output table must be updated, taking into account that the construction period for the nuclear power plants (NPP) is planned to be started in 2021. In this study, we update the input-output table for 2020 reference year by using a non-survey technique. It is common procedures in updating input-output table that some transactions for output, final demand and primary input components are available for the updated year. In our case, final demand and primary input components for year 2020 had been estimated in the Eleventh Malaysia Plan (see Economic Planning Unit, 2015) and we take those figures as our baseline for the estimation of 2020 input-output table.

Estimation procedures for the 2020 input-output table are summarized in Table 1. In our estimation, the matrix of intermediate deliveries is adjusted biproportionally by means of the RAS method. There are two information are required before we RAS-ing the matrix of intermediate deliveries, $Z$. First, the total intermediate demand and the total intermediate input must be provided as the targeted column and row. The row sum of matrix $Z$**i** can be obtained by using the following accounting identity: $Zi=x-Fi$. The column sum of matrix of intermediate input ($i'Z)$ can be obtained by using the following accounting identity: $iZ=x'-v'-m'$.

 **Table 1**. Simplified structure of input-output table for Malaysia

|  |  |  |  |
| --- | --- | --- | --- |
| 　 | sectors | Final demand | Total output |
| 　 | *1* | *2* | *3* | *.* | *.* | *.* | *n* | *1* | *2* | *.* | *.* | *k* |
| Sectors | $$Z \left(n×n\right)$$**- RAS -** | $$F \left(n×k\right)$$ | $$x$$ |
| *1* |
| *2* |
| *3* |
| . |
| . |
| *n* |
| Imports | $$m (1×n)$$ |  |  |
| Value added | $$v (1×n)$$ |  |  |
| Total input | $$x'$$ | 　 | 　 |

where:

$Z$ = matrix of intermediate deliveries, $Z\_{ij}$represents the output of sector *i* used by sector *j*

$F$ = matrix of output deliveries to *k* categories of final demands (private consumption,

 government consumption, investment and exports)

$m$= vector of import

$v$ = vector of value added

$x=x'$ = vector of gross output = gross input

Data for final demand components, value added and import for 2020 are estimated at aggregated level by the Economic Planning Unit (2015). Total output for the whole economy is not available and we have estimated it for 2020 based on time-series estimation. Data for total final demand (for each final demand category), value added imports and output react as “control” values when detailing the transactions at detailed sectors. The main data source for the estimation of detailed sectors is time-series supply and use tables (SUTs) for periods 2000-2013. These SUTs consist of 67 sectors/industries that have been estimated by Saari et al. (2016), using the hybrid approach (combination of survey and non-survey techniques). Appendix 1 details the estimation procedures for the SUTs along with data sources. To be consistent with the structure of our input-output table (see Table 1), we have transformed the SUTs into symmetry input-output table by applying commodity technology (for overview see Chapter 5 in Miller and Blair, 2009).

Based on the time-series input-output tables, we calculate annual average growth rates for the sample periods 2000-2013 for each sector for final demand components, value added, imports and output. We use the annual average growth rates to estimate final demand components, value added, imports and output for each sector in 2020. Next, the total summation of final demand components, value added, imports and output across all the sectors must match exactly the “control” values. RAS-ing the matrix of intermediate deliveries for 2020 requires a benchmark matrix of intermediate deliveries. In our case, the benchmark matrix of intermediate deliveries is obtained by taking the average of matrix of intermediate deliveries for the periods 2000-2013.

 Next to the updated input-output table for 2020, additional exogenous parameters must be estimated to run the whole set of the model. These additional exogenous parameters are provided in Table 2. Annual growth rates for employment and labour force are estimated by taking average growth rates for the periods 1982-2014. Estimation of annual growth rates for wages is constrained by the limited number of observations. Alternatively, we assume the growth rates of wages are similar to the growth rates of GDP. This assumption seems to be reasonable given by the fact that the share of wages to GDP is almost “frozen”, which change only 1%-point for each two years. Marginal Propensities to consume (MPC) and parameter for wage reaction to unemployment rate are estimated econometrically. Finally, we need to determine the government allocation budget for the construction costs of NPP. Based on our consultation with the Malaysia Nuclear Power Corporation (MNPC), the government is expected to contribute only 10% of the total construction costs.

**Table 2**. Estimated parameters for exogenous variables

|  |  |
| --- | --- |
| Variables | Parameters |
| Annual growth rates of: |  |
|  Employment  | 2.29 |
|  Labor force | 2.50 |
|  Wages | 4.29 |
| Marginal propensities to consume | 0.48 |
| Wage reaction to unemployment rate | -0.17 |
| Government financing share | 0.10 |

**4. Results and Discussion**

Results that presented here only assess the impacts of nuclear power plants (NPP) during the construction periods. Specifically, we assess the impacts of MYR (Malaysian Ringgit) 31.3 billion of total construction costs which allocated for the whole construction periods from 2021 to 2028. These costs can be viewed as expenditures and used in our model as new final demand (**f**new) created by the economic activities associated with the construction of NPP.

The total construction costs are given by MNPC in total, without detailing the costs into specific construction materials and inputs. The detailed construction costs only can be determined once the decision regarding the contract has been finalized. However, to run our model, we need to distribute the total construction costs for each year according to the specific sectors in the input-output table. As an alternative to this constraint, we distribute the detailed construction materials and inputs based on the information that available in Lee et al. (2009). According to Lee et al. (2009), the following activities are directly impacted by the construction of NPP: basic chemical products; electric power plant construction; general machinery and equipment; electronic and other electric equipment; business services; finance and insurance; business services; furniture and other manufacturing; and finance and insurance. These construction cost components are considered as “generic” and they can always be changed once the actual cost components are made available.

Table 3 presents the summary of the results that obtained from Models A, B, C and D. For each model, results are detailed according to four main variables namely GDP, disposable income, output and employment. Recall that Model A is a standard input-output model. Model B extends Model A by endogenizing the private consumption. Model C further extends Model B by incorporating labor market response to the demand and supply. Model D extends Model C by including feedback effects from the government through public-private investment financing scheme.

**Table 3**. Impacts of NPP construction, 2021-2008 (MYR million)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
| Construction costs |  678  | 875  | 1,075  | 1,100  | 1,128  | 8,250  | 9,093  | 9,096  | 31,295  |
| **Model A** |  |  |  |  |  |  |  |  |  |
| Gross Domestic Products (GDP) | 186  | 186  | 186  | 186  | 186  | 186  | 186  | 186  | 1,485  |
| Output | 632  | 632  | 632  | 632  | 632  | 632  | 632  | 632  | 5,059  |
| Disposable income |  45  | 48  | 50  | 52  | 55  | 58  | 61  | 64  | 432  |
| Employment |  1,630  | 1,630  | 1,630  | 1,630  | 1,630  | 1,630  | 1,630  | 1,630  | 13,037  |
| **Model B** |  |  |  |  |  |  |  |  |  |
| Gross Domestic Products (GDP) | 203  | 203  | 203  | 203  | 203  | 203  | 203  | 203  | 1,621  |
| Output | 666  | 666  | 666  | 666  | 666  | 666  | 666  | 666  | 5,326  |
| Disposable income |  50  | 52  | 55  | 57  | 60  | 63  | 66  | 70  | 473  |
| Employment |  1,777  | 1,777  | 1,777  | 1,777  | 1,777  | 1,777  | 1,776  | 1,776  | 14,212  |
| **Model C** |  |  |  |  |  |  |  |  |  |
| Gross Domestic Products (GDP) | 183  | 184  | 185  | 186  | 187  | 187  | 188  | 188  | 1,488  |
| Output | 635  | 637  | 638  | 639  | 640  | 641  | 642  | 642  | 5,115  |
| Disposable income | 46  | 48  | 51  | 53  | 56  | 59  | 62  | 65  | 439  |
| Employment | 1,633  | 1,641  | 1,648  | 1,653  | 1,658  | 1,662  | 1,665  | 1,668  | 13,227  |
| **Model D** |  |  |  |  |  |  |  |  |  |
| Gross Domestic Products (GDP) | 177  | 178  | 179  | 180  | 181  | 182  | 183  | 183  | 1,443  |
| Output | 622  | 624  | 626  | 628  | 629  | 631  | 632  | 633  | 5,026  |
| Disposable income |  44  | 46  | 49  | 52  | 54  | 57  | 60  | 63  | 426  |
| Employment | 993  | 1,065  | 1,124  | 1,174  | 1,217  | 1,255  | 1,287  | 1,316  | 9,431  |

Notes: employments are measured in actual number.

 It is common to observe results that obtained in Model B are larger than Model A because the former involves additional economic cycles through private consumption feedback. Results derived in Model B however do not take into account the wage reaction that determines demand and supply of labor. Taking into account the labor market response in Model C resulted the impacts are relatively lower than Model B. Model C in addition does not impose tax on household income which will affect the consumption, production and employment. When tax on income is imposed in Model D, results are lower than the previous three models because of lower consumption which in turn lower the production and employment.

 Overall, the impacts of NPP during the construction periods are satisfactory. For the whole construction periods, the NPP is expected to contribute (Model D) MYR1, 443 million to GDP, MYR5, 026 million to output, MYR426 million to disposable income and 9,431 employments. On the other hand, the outcome of investment shows that for each Ringgit of investment (Model D) will result in the generation of GDP by 0.05, output by 0.16, disposable income by 0.01 and employments by 0.3. It is important to note that not all from the amounts of investment flow into the domestic economy because some of the materials have to be imported. We observe that about 22% of the total construction materials and inputs are supplied by imports. Our results may not comparable to other studies that measure the economic impacts of nuclear power plants during the construction periods. The results depend largely on the economic structures and the technology of nuclear energy. Fuhrmann (2012) shows that for each dollar of investment on the nuclear energy in 1990s generates 0.16 of GDP. Kennedy (2007) finds that for every pound of investment potentially generates 0.002 of output.

**5. Concluding Remarks**

This paper assesses the economic impacts of construction of nuclear power plants (NPP) in Malaysia for the periods 2021-2028. The impacts are run by applying the econometric-input-output prototype model that developed by the International Atomic Energy Agency (IAEA). To run the model, we have updated input-output table for Malaysia for 2020 reference year and estimated additional exogenous parameters to be fed into the model. Results show that of the total MYR31,295 million investment for the construction of NPP generates MYR1,443 million to GDP, MYR5,026 million to output, MYR426 million to disposable income and 9,431 employments.

In spite of the usefulness of analyses provided in this paper, results should be interpreted with caution particularly in relation to the policy implications. After considering all assumptions applied in this study, there are two main forces that may affect the results. First, results may vary depending on the distribution of cost components. In our analysis, the use “generic” distribution of cost components, which is Korean case and thus may not reflect the actual distribution cost components for the Malaysia case. Second, results may be highly sensitive to the estimated input-output table. Given the limited data, it is hardly to perform sensitivity analysis for the estimated input-output table.

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**Appendix 1. Estimation of time-series supply and use tables**

A symmetry input-output table (SIOT) assumes that each industry produces only one commodity and each commodity is produced by only one industry. Under this assumption, it is not necessary to make a distinction between commodities and industries (or activities). SUT, on the other hand, includes supply and use tables (or matrices). These were first introduced in System of National Accounts 1968 (United Nations, 1968) and does not requires that each industry produces one and only one commodity. They can be rectangular or symmetry and the supply table gives for each industry the output of all the different commodities it has produced. The use table gives for each industry the input of commodities. Structure of the benchmark SUT that is valued at basic prices for Malaysia is simplified in Table A1[[1]](#footnote-1).

 **Table A1**. Simplified structure of SUT for Malaysia

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 　 | Commodities | Industries | Final demand | Total output |
| 　 | *1* | *2* | *3* | *.* | *.* | *.* | *m* | *1* | *2* | *3* | *.* | *.* | *.* | *n* | *1* | *2* | *.* | *.* | *k* |
| Commodities |  | $$U (m×n)$$ | $$E \left(m×k\right)$$ | $$S$$ |
| *1* |
| *2* |
| *3* |
| . |
| . |
| *m* |
| Industries | $V (n×m)$ |  |  | $$G$$ |
| *1* |
| *2* |
| *3* |
| . |
| . |
| *n* |
| Imports |  | $$m (1×n)$$ |  |  |
| Value added |  | $$w (1×n)$$ |  |  |
| Total input | $$S'$$ | $$G'$$ | 　 | 　 |

Where:

$V$ = supply matrix, $V\_{ij}$represents the amount of commodity *j* produced by industry *i* (includes imports)

$U$ = matrix of intermediate demand, $U\_{ij}$represents the amount of commodity *i* used by industry *j*

$E$ = matrix of commodity deliveries to *k* categories of final demands

$m$= vector of industry import

$w$ = vector of industry value added

$S=S'$ = vector of commodity gross output

$G=G'$ = vector of industry total output

In Table A1, matrix $V$ represents the supply table while matrices/vectors $U$, $E$, $m$ and $w$ are components of use table. Table A1 shows that:

Total use by commodity is equal to total supply by commodity

$$U+E=V'$$

Total intermediate demand, imports and value added by industry is equal to total output

$$U'+m'+w'=V$$

For the Malaysian case, the use table already separated the total supply into domestically produced commodities and imported commodities. For analytical purposes, it is often necessary to know whether the goods and services used are produced domestically or imported.

***Estimation technique***

Estimation procedures for the compilation of the time-series SUTs for Malaysia are summarized in Table A2. Time-series components of final demand, imports, value added and total output are compiled from the survey data, provided by the Department of Statistics Malaysia (DOSM). Data coverage for the manufacturing industries are excellent and they serve as basis for the estimation of missing data for other industries (agriculture and services). The intermediate demand and the supply table are adjusted biproportionally by means of the RAS method.

 **Table A2**. Estimation procedures of SUT for Malaysia

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 　 | Commodities | Industries | Final demand | Total output |
| 　 | *1* | *2* | *3* | *.* | *.* | *.* | *m* | *1* | *2* | *3* | *.* | *.* | *.* | *n* | *1* | *2* | *.* | *.* | *k* |
| Commodities |  | $$U (m×n)$$**- RAS -** | $$E \left(m×k\right)$$ | $$S$$ |
| *1* |
| *2* |
| *3* |
| . |
| . |
| *m* |
| Industries | $V (n×m)$**- RAS -** |  |  | $$G$$ |
| *1* |
| *2* |
| *3* |
| . |
| . |
| *n* |
| Imports |  | $$m (1×n)$$ |  |  |
| Value added |  | $$w (1×n)$$ |  |  |
| Total input | $$S'$$ | $$G'$$ | 　 | 　 |

Recently, there are three main approaches that have been used to estimate time-series SUTs: (i) Euro method (see Eurostat, 2008), (ii) EUKLEMS (see Timmer et al., 2005), and (iii) SUT-RAS (see Temurshoev and Timmer, 2011). The Euro method relies on two assumptions: first, the shares of industries in the production of commodities remain constant and second, the fixed input coefficients determine the relations of all product inputs to production of industries. The working of the EUKLEMS method is more or less similar to the Euro method. In contrast, the SUT-RAS which has been applied for the estimation of world input-output database (WIOD), is a theory-based that minimizes the deviations of the projected SUT structure from the benchmark period. Temurshoev and Timmer (2011) show that the SUT-RAS method greatly improves the Euro and EUKLEMS methods in estimating Spanish SUTs. This provides a justification for our study to apply the RAS method. Thus, our method is in line with the international practices that estimate time-series SUTs for the purpose of KLEMS database (see for example, Avonds et al., 2007; Wu and Ito, 2015).

The major difference between our method and SUT-RAS method is that the former only RAS-ing the intermediate demand and supply table while the latter RAS-ing the whole SUT components. Our method relies mostly on the actual data compared to the SUT-RAS that requires limited information (due to unavailability of data). Our method is expected to produce a better approximation for the “true” SUTs because it was well documented in the literature that extra exogenous data produce better projections (see for example, de Mesnard and Miller, 2006; Temurshoev and Timmer, 2011).

The RAS technique iteratively adjusts a new matrix with the new information on the row and column sums. With the new or targeted row and targeted column sums, RAS generates a new matrix $x^{\*}$thatis balancedfrom the benchmark matrix $x$ by the means of ‘biproportional’ row and column operations. That is, $x^{\*}=\hat{r}x\hat{s}$, where $\hat{r}$ and $\hat{s}$ are diagonal matrices with positive entries on the main diagonal. Elements of $\hat{r}$ and $\hat{s}$ also can be termed as ‘scaling factor’ that ensure the new row and column sums match the targeted row and targeted column sums. Appendix A provides hypothetical example of how RAS method adjusts a matrix and provides the targeted row and column sums.

***Data Sources***

Total Malaysia production outputs are obtained from the National Accounts (NA) and annual manufacturing survey published by the Department of Statistics Malaysia (DOSM). The data covers for the periods 2000-2012. Then, data for 2013 are forecasted based on the historical data set. Three benchmark SUTs have been used, i.e. 2000, 2005, and 2010.

Annual manufacturing survey provides the basis for the construction of the Supply Use Table (SUTs) and the rest of the sectors are estimated using the available information in the benchmark SUTs and NA. Similar procedures are applied to gross fixed capital formation (GFCF), exports, government consumption, private consumption, value added, indirect tax and imports for the rest of the sectors.

Imports and exports data were obtained from two main sources; NA and Malaysia External Trade Statistics (METS) published by the DOSM. NA provides yearly control figures that have been finalized to reflect the correct amount of trade transaction in calculating the gross domestic product (GDP). Thus, from these control figures, we apply METS data to classify the details of exports and imports transactions according to commodities.

Exports and imports are classified according to the Standard International Trade Classification (SITC) following the classification system maintained by the United Nations to make it comparable with the other countries. Then, these data are required to be harmonized into Malaysia Standard Industrial Classification (MSIC), ensuring comparability of the data[[2]](#footnote-2). Although the trade data provide the detail transactions, exports and imports for services are unable to be captured because the available SITC only covers agricultural, mining and manufacturing commodities. Therefore, by using the available information in the SUTs and the total exports and imports for services from the balance of payment (BoP), we were able to estimate the exports and imports for services.

Furthermore, imports are further disintegrated into three type of final use; i) private consumption, ii) gross fixed capital formation, and iii) intermediate inputs used by industry. For this purpose, we follow the Broad Economic Categories (BEC) coding system for the classification of the final use[[3]](#footnote-3).

***Compilation***

The construction of SUTs begins with the compilation of final demand matrix which starts off at the most outer parts; total commodities output and total activities output. The values of the total output are derived from the values of the annual manufacturing survey alas the rest of the sectors are estimated residually from the control total of production output in NA and available information from the benchmark SUTs. These estimation procedures are applied to all variables except for the changes in inventories. The change in inventories vector is estimated residually by taking the difference between exports and domestic demand components[[4]](#footnote-4).

The intermediate demand of commodities is computed residually by taking the difference between the final demand components and the total output of production. Meanwhile, the intermediate demand of activities is measured residually from the total output and the total summation of value added, indirect tax, and imports. The difference of total output for commodities and activities captures the total consumption for direct purchase from abroad and direct purchase by non-resident.

Furthermore, value added vector is expanded to cover the compensation of employees and operating surpluses. Compensation of employees’ data comprises of salaries and wages, in-kind payment, gratuities and retirement, employee’s providence fund (EPF) and SOCSO, levy on labor, staff training cost, and other labor costs. Then, the operating surpluses data is quantified from the remaining values between value added and compensation of employees.

***Harmonization***

The available data as mentioned above is subjected to different classification frameworks. For the periods 2000 to 2008, the data are classified based on the Malaysia Standard Industrial Classification 2000 (MSIC 2000) while the consecutive years are classified based on MSIC 2008. Generally, the framework of MSIC 2000 and MSIC 2008 are broadly similar. Hence, the combination of MSIC with similar activities led to the classification of economic sector under the SUTs.

Economic sectors in the 2000 SUTs and 2005 SUTs are classified under MSIC 2000 while 2010 SUTs are classified under MSIC 2008. The harmonization of benchmark SUTs is needed to standardize the structure of the economic sectors throughout the study period for future use. Nonetheless, the standardization of the SUTs is not a straight-forward process because some areas under the upgraded version of MSIC 2008 are enriched through the expansion of certain type of industries. This expansion has resulted to the differences between these two classifications which led some of the MSIC to fall into different industries. For example, tea production activities in SUT 2000 stand independently. However, it has been classified under food crops sector alongside with other beverage crops in 2005 SUTs and 2010 SUTs. As a result, the industries are aggregated into 73 sectors in 2000 SUTs and 82 sectors in 2005 SUTs and 2010 SUTs. For the sake of comparison, these classifications are standardized into 67 sectors for all of these three benchmark SUTs. The standardized sectors are presented in Appendix B.

To harmonize the trade data that are recorded in SITC we follow the harmonization schemes published by the United Nations Statistics Division and Department of Statistics Malaysia, Malaysia Classification of Products by Activity 2009 Ver.1.0 (MCPA). In harmonizing the SITC trade data to MSIC, there are several stages that we have to follow. First, the SITC undergoes the conversion process to Harmonized System codes (HS codes). HS codes of tariff nomenclature is a standard international classification system of traded commodities developed by the World Customs Organization. Since the conversion intermediation, MCPA only provide the conversion of HS codes to MSIC 2008, it is essential to convert the SITC to HS codes before it can be converted to MSIC 2008. Then, MSIC 2008 will help us to classify the commodities that produce (exports) and use (the imported inputs) in the SUTs framework. The example of SITC and MSIC 2008 harmonization scheme is presented in Appendix C (the full harmonization schemes may be provided upon request).

As mentioned previously, imported commodities are disintegrated into private consumption, gross fixed capital formation and intermediate inputs. We apply Broad Economic Categories (BEC) coding system published by the United Nations Statistics Division for the classification to separate into these three components of final use.

In terms of data stability and validation, we test the correlation of our harmonized trade data with the benchmark SUTs. For the data from 2000 to 2004 we compare with 2000 SUTs, data for 2005 up to 2010 are compared with 2005 SUTs and the rest is tested with 2010 SUTs. The correlation results were found to be high for all of the data approximately 80.5% and above. This indicates that our data is reliable.

***Limitations***

In the estimation of time-series SUTs, there are several limitation that we have encountered. First, micro data is limited to the manufacturing industry, but the construction of time-series SUTs requires annual data for all industries. Thus, data for other industries have to be estimated based on the available information from benchmark SUTs and NA.

Second, the coverage of the data is constrained by time period. For instance, the provided annual manufacturing survey only covers the periods 2000-2010 and 2012. Data for the periods 2011 and 2013 are missing. For this reason, the data for the specified periods are forecasted based on the available dataset by using econometric regression.

Next, the utilization of data from different sources induces the possibility of inconsistencies. For example, the harmonized SITC data to MSIC 2008 has shown a slight deviation in the total amount of export and import figures for each sector when compared to the benchmark SUTs. However, the data is still reliable to be used because it still exhibit considerable correlation index of more than 80%.

1. The difference between the basic prices and purchases prices is the latter representing the prices that were actually paid by the purchaser for the commodity or product. It includes the basic prices *plus* any distribution margins and any net taxes on products. [↑](#footnote-ref-1)
2. To harmonize the trade data that are recorded in Standard International Trade Classification (SITC) we follow the harmonization scheme published by DOSM; Malaysia Classification of Products by Activity 2009 Ver.1.0 (MCPA). [↑](#footnote-ref-2)
3. BEC coding system is the standard procedures used by all national statistics office in separating imports into final and intermediate commodities. See United Nations Statistics Division, Classifications Broad Economic Categories. [↑](#footnote-ref-3)
4. Domestic demand components comprise of i) private consumption, ii) government consumption, and iii) GFCF [↑](#footnote-ref-4)