研　究　報　告

Is there a trade-off between Mining and Manufacturing? Empirical evidence from Mongolia

Enkhmaa Battogtvor[1] and Khaliun Dovchinsuren[2]
Department of Economics, National University of Mongolia.

Abstract

We argue that the extreme dependence on the natural resource sector has negatively affected a part of the Mongolian economy, thus causing the manufacturing sector to decline. The results support the argument. We found a long-run negative relationship between the growing resource sector and manufacturing: a 10% increase in the resource sector brings a 1-2% decrease in manufacturing in Mongolia. In addition, a structural break was found, indicating a change in the relationship from negative to positive, starting in 2010.

Keywords: Manufacturing, Natural resource abundance, Resource curse, Dutch disease, VECM, ARDL
JEL Classification: F14, F15, O13, O14, Q33

1 Introduction

The natural resource sector plays considerable role in Mongolian economy. In 2022, it accounts for 24 percent of the country's GDP and 95 percent of its exports. Although Mongolian economy enjoys high resource incomes, there are potential adverse effects of the booming resource sector on other sectors in the economy, in particular, manufacturing. In other words, there perhaps is a potential threat of de-industrialization in the economy. The negative effect, such as this, of the resource windfall on the economy is explained by the phenomenon so-called the Dutch disease.

The mechanism behind the Dutch disease is clear. A part of the resource revenues is spent on non-traded goods (services) which leads to a real appreciation, i.e., a rise in the relative price of non-traded goods in terms of traded goods. This in turn draws resources out of the non-resource traded sector (manufacturing) into the non-traded goods producing sector as Corden and Neary (1982) explained [1].

We conduct statistical analysis looking for evidence of Dutch disease in Mongolian economy. The vector error correction modeling (VECM) and Autoregressive distributed lag (ARDL) approaches are used. Findings suggest that a 10% increase in resource production is followed by 1-2% shrinkage in manufacturing.

In addition, we conducted a structural break test and found there is a breaking point in our data: March 2010 (henceforth 2010m3). We divided our sample into subsamples before 2010m3 and after 2010m3. Although the results are not statistically significant, we observed a shift in the long-run relationship between mineral resource production and manufacturing from negative to positive. This may be due to the development stages of the mining sector in Mongolia. Before 2010, the sector was under speedy start signing contracts with huge mining companies to build mines and exploit resources like coal and copper; however, after 2010, the sector had already reached its full potential to positively affect the whole economy.

Although the Mongolian economy is characterized by symptoms of the Dutch disease, no formal statistical work has been applied to this problem. The research fills this gap using monthly data from the National Statistical Office of Mongolia.

The rest of the paper is organized as follows. Section 2 reviews the theoretical and empirical literature on the effects of the natural resource boom on manufacturing. Section 3 explains

[1] Department of Economics, National University of Mongolia enkhmaab@num.edu.mn
[2] Department of Economics, National University of Mongolia khaliun.d@num.edu.mn

the Mongolian experience with natural resource discoveries and developments, along with the changes in the manufacturing sector using descriptive statistics. Section 4 presents the VECM and ARDL methodology and data and reports the empirical results. Section 5 summarizes the significant findings of the analysis and concludes.

2 Theoretical and Empirical Literature

Khan et al. (2022) [2], Ploeg (2011) [3], Sachs and Warner (1999) [4] and many recognize the opportunities natural resources provide for economic growth and development. Still, many countries are not doing well despite of the natural resource abun-dance such as African economies (Sachs and Warner, 1997) [5], Venezuela (Sachs and Rodriguez, 1999) [6], Brazil (Caselli and Michaels, 2013) [7], Azerbaijan (Zulfigarov and Neuenkirch, 2019) [8] etc. Therefore, according to Tovrik (2009) [9], the key question is why resource-rich economies such as Botswana or Norway are more successful while others perform poorly despite their immense natural wealth. Is it because resource booms induce an appreciation of the real exchange rate and make non-resource sectors less competitive? In other words, is it because of the Dutch disease? More generally, as Ploeg (2011) [3] put it, are natural resources a “curse” or a “blessing”?

Ploeg (2011) [3] argues that empirically either outcome is possible. He surveyed a variety of hypotheses and supporting evidence for why some countries benefit and others lose from the presence of natural resources. He summarized the negative effects of the natural resource boom as follows: A resource windfall induces appreciation of the real exchange rate, de-industrialization (Dutch disease) and bad growth prospects, and that these adverse effects are more severe in volatile countries with bad institutions and lack of rule of law, corruption, and underdeveloped financial systems.

There are supporting studies of such adverse effects of resource endowments. Narankhuu (2018) [10] found that the rapid development of the mining sector created significant fiscal and monetary imbalances in the macro economy, and moreover, the institutional quality and governance in Mongolia had deteriorated noticeably at the same time when Mongolia started experiencing favorable global commodity markets. Robinson et al (2006) [11] argue that the political incentives that resource endowments generate are the key to understanding whether they are a curse. They show that resource booms tend to cause over-extraction of natural resources, and increase resource misallocation in the rest of the economy by providing incentives for politicians to stay in power by influencing the elections. They conclude that the overall impact of resource booms on the economy depends critically on institutions since these determine the extent to which political incentives map into policy outcomes, and countries without institutions that promote accountability and state competence may suffer from a resource curse. Caselli and Michaels (2013) [7] found that oil-rich Brazilian municipalities experienced increases in revenues and reported corresponding increases in spending on public goods and services; however, social transfers, public good provision, infrastructure, and household income increased less (if at all) than one might expect, given the higher reported spending.

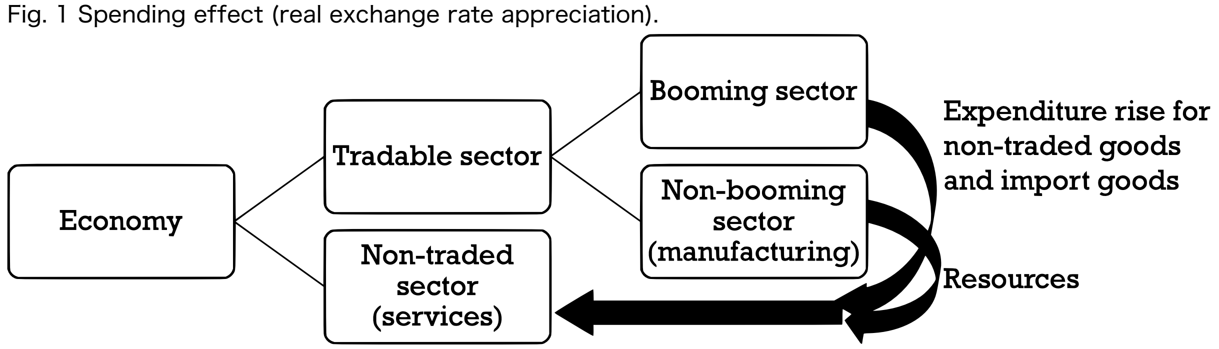
2.1 Theoretical explanations

Here, we discuss the theoretical support and evidence available for the effects of natural resources on the economy, particularly manufacturing.

The Dutch disease hypothesis predicts that natural resource windfalls cause de-industrialization [1]. According to the hypothesis, a resource windfall induces appreciation of the real exchange rate, contraction of the traded sector, and expansion of the non-traded sectors.

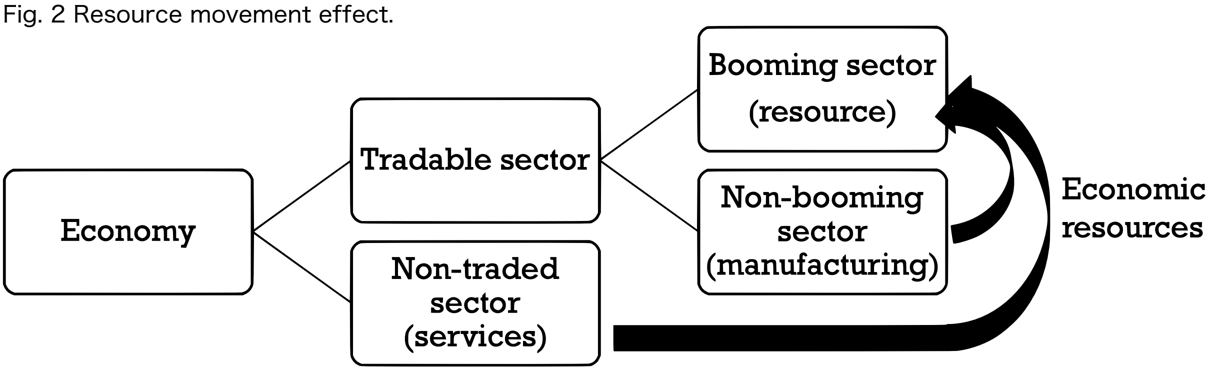
In the short-run, resource revenue increases national income and demand. Figure 1 summarizes the spending effect. rewrite: The spending effect works as the extra income from the booming resource sector is spent on the non-traded sector, raising its price and leading to real exchange rate appreciation. In Figure 1, we can see that more resources from manufacturing is drawn to the non-traded sector, which results in indirect de-industrialization. In addition, because of the real exchange rate appreciation, manufacturing is less competitive compared to the cheap imports [1].

Fig. 1 Spending effect (real exchange rate appreciation).



Note: This is the author’s imaging based on Corden and Neary (1982) [1]

Fig. 2 Resource movement effect.



Note: This is the author's imaging based on Corden and Neary (1982) [1]

For the longer run effects, one must allow capital and labor to be mobile across sectors and move beyond the specific factors framework. In an open economy the Heckscher-Ohlin framework with competitive labor, capital, and product markets, and constant returns to scale in the production of traded and non-traded goods, a natural resource windfall induces a higher wage-rental ratio if the non-traded sector is more labor-intensive than the traded sector. In any case, there is a rise in the relative price of non-traded goods, leading to an expansion of the non-traded sector and a contraction of the traded sector. Labor and capital shift from the traded to the non-traded sectors.

Morshed and Turnovsky (2004) [12] studied the effects of a resource boom in a dynamic dependent economy with adjustment costs for investment and allowed for costly sectoral reallocation of capital between non-traded and traded sectors. Turnovsky (1996) [13] used a model of endogenous growth in the dependent economy to explore the implications of a resource boom on economic growth.

What happens if the resource exploitation sector uses labor and capital as factor inputs? According to Corden and Neary (1982) [1], apart from the previously discussed spending effects of a resource boom, there is also a resource movement effect which is summarized in Figure 2. The resource movement effect explains that due to resource revenue increase, the labor movement from the non-traded and traded sectors towards the resource sector causes direct de-industrialization.

Looking at the longer run, where both factors of production (labor and capital) are mobile between the traded and non-traded sectors and the resource sector only uses labor, it helps to consider a mini-Heckscher-Ohlin economy for the traded and non-traded sectors. The Rybczynski theorem states that the movement of labor out of the non-resource towards the resource sectors causes the output of the capital-intensive non-resource sector to expand. This may lead to the paradoxical result of pro-industrialization if capital-intensive manufacturing constitutes the traded sector, despite some offsetting effects arising from the de-industrialization (Corden and Neary, 1982) [1]. If the non-traded sector is more capital-intensive, the real exchange rate depreciates if labor is needed to secure the resource windfall; the Rybczynski theorem then states that the non-traded sector expands and the traded sector contracts. This increase in the relative supply of non-traded goods fuels the depreciation of the real exchange rate. Real exchange depreciation may also result from a boost to natural resource exports if the traded sector is relatively capital-intensive and capital is needed for the exploitation of natural resources. Since less capital is available for the traded sector, less labor is needed, and thus, more labor is available for the non-traded sector. This may lead to a depreciation of the real exchange rate. This also occurs if the income distribution is shifted to consumers with a low propensity to consume non-traded goods (Corden, 1984) [14].

2.2 Empirical evidence of natural resource abundance on manufacturing

Although early evidence for a shrinking manufacturing sector in response to terms of trade shocks and real appreciation has been mixed, more recent evidence by Harding and Venables (2016) [15] based on averages across 1970-2006 for 41 resource net-exporters indicates that the response to a resource windfall is to decrease non-resource exports by 74 percent, and increase imports by 23 percent, implying a negligible effect on foreign savings. The negative impact on exports is larger for manufacturing than for other sectors. Thus, on average, resource exports reduce exports of manufactures by 46 percent, service exports by 17 percent, and agriculture and food exports by 6 percent.

Another study uses detailed, disaggregated sectoral data for manufacturing and obtains similar results: a 10 percent oil windfall is on average associated with a 3.6 percent fall in value-added across manufacturing, but less so in countries that have restrictions on capital flows and for sectors that are more capital intensive (Ismail, 2010) [16]. Using as a counterfactual the Chenery-Syrquin (1975) norm for the size of tradables (manufacturing and agriculture), countries in which the resource sector accounts for more than 30 percent of the GDP have a tradables sector 15 percentage points lower than the norm

(Brahmbhatt, et al., 2010) [17]. The macroeconomic and sectoral evidence thus seems to offer support for Dutch disease effects.

Interestingly, macro cross-country and micro U.S. county-level evidence suggest that resource-rich countries experience de-specialization as the least skilled employees move from manufacturing to the non-traded sectors, thus leading their traded sectors to be much more productive than resource-poor countries (Kuralbayeva and Stefanski, 2013) [18].

Within-country, quasi-experimental evidence on the Dutch disease in Brazil is also notable (Caselli and Michaels, 2013) [7]. The study exploits a dataset on oil dependence for Brazilian municipalities, which is useful as oil fields are highly concentrated geographically and local resource dependence is more likely to be exogenous as it is decided by the national oil company, Petrobras.It turns out that oil discoveries and exploitation do not affect non-oil GDP very much, although in line with the Dutch disease hypothesis, services expand, and industry shrinks somewhat. However, they boost local public revenue, 20-25 percent (rather than 10 percent) going to housing and urban development, 15 percent to education, 10 percent to health, and 5 percent to welfare. Interestingly, household income only rises by 10 percent, mostly through higher government wages. The lack of migration to oil-rich communities also suggests that oil does not really benefit local communities much. The evidence for Brazil thus offers support for the Dutch disease hypothesis.

There is also a wide range of hypotheses about the effects of natural resources on the economy and society. These include economic growth, institutions, corruption, rent-seeking, conflict and policy. Frederik van der Ploeg (2011) [3] provides systematic explanations in this context. The hypothesis regarding the effect of natural resources on economic growth say that if the traded sector is the engine of growth, a resource bonanza will lead to a temporary fall in growth. Early cross-country evidence indeed indicates a negative link between resources and growth. There is the hypothesis that the resource curse can be turned into a blessing for countries with good institutions. Ploeg (2011) [3] provides some evidence in support thereof. In addition, the hypothesis that presidential democracies are more likely to suffer a negative effect of resources on growth; econometric and quasi-experimental evidence for the hypothesis that resource windfalls increase corruption, especially in countries with non-democratic regimes, are discussed in his seminal paper. Econometric support for the hypothesis that the negative effect on growth is less in countries with well-developed financial systems and the hypothesis that resources induce voracious rent-seeking and armed conflict are also explained. There is also a discussion of the hypothesis that resource windfalls encourage unsustainable and unwise policies.

Why are many resource-rich developing countries unable to fully transform their large stocks of natural wealth into other forms of wealth? Ploeg (2011) [3] explains this with two hypotheses. First, the “anticipation of better times” hypothesis suggests that resource-rich countries should borrow in anticipation of higher world prices for resources and improvements in extraction technology in the future. Second, the “rapacious extraction” hypothesis explains how, in the absence of effective government intervention, conflict among rival factions induces excessive resource extraction and investment and negative genuine saving when there are wasteful rent-seeking and short-sighted politicians. There are no studies available yet that attempt to apply these political economy insights to a formal model addressing the optimal depletion of natural resources.

3 Mongolian Experience: Stylized Facts

Mongolia is abundant in natural resource minerals, such as coal, copper, gold, crude oil, iron, molybdenum, and zinc. The natural resource sector plays a large role in the economy, reaching 24 percent of the GDP and more than 90 percent of the exports in 2022. Clearly, the economy is heavily dependent on natural resources. In contrast to this, however, the manufacturing sector is underdeveloped and stagnant.

The very first step towards becoming a resource exporter was taken in 1978 by building and utilizing the Erdenet copper mine. The Erdenet mine is one of the largest factories in Asia with annual production of 530 thousand tons of copper concentrate and around 4.5 thousand tons of molybdenum concentrates.[3]

In 2009, the Oyutolgoi mine entered the industry with estimated deposits of 30 million tons of copper and 1.7 million ounces of gold, meaning that it is operable for more than 50 years. This makes Oyutolgoi one of the biggest mines in the world. Mine construction began in 2010, and the first exports were made in mid-2013. In 2021, Oyutolgoi earned sales revenue of 1,971 million U.S. dollars from sales of 669 thousand dry metric tons of concentrate with a metal content of 139 thousand tons of copper, 435 thousand ounces of gold, 783 thousand ounces of silver.[4]

Thus, the Mongolian economy is vulnerable to the volatility of world market resource prices due to heavy resource dependence. For instance, starting from July 2003, the copper price constantly

[3] Details can be found in the official webpage of the Erdenet mine at www.erdenetmc.mn

[4] See details in www.ot.mn

increased from 1700 to 8045 U.S. dollars in May 2006, almost five times higher than the initial level. During these three years, the Mongolian economy has enjoyed fast growth of 9 percent and a dramatic export increase from 0.5 billion U.S. dollars in 2003 to 1.5 billion in 2006.

The facts associated with the Mongolian experience are in many ways consistent with the Dutch Disease argument. The real mineral resources production grew rapidly over the years following the mineral resource booms. Mineral production was close to 7 million tons in 1989 following the resource boom of the Erdenet mine in the 1980s, and the number was more than 35 million tons in 2014, resulting from the Oyutolgoi mine resource boom, which is more than a five-fold increase.

Productivity increases in the mining sector worked to raise labor incomes. For example, from 2009 the Oyutolgoi's mine resource boom, along with its investments, was followed by an average 55 percent increase in the wages of the mining sector over five years. During the period, productivity in the mining sector jumped almost five-fold compared to the national level. During the period, productivity in mining sector jumped almost five-fold compared to the national level.[5] These observations, in fact, are consistent with the effect of resource movement in Corden and Neary's (1982) framework. In Figure 3, the share of in exports grew dramatically and it reached 90 percent on average for the last five years. This clearly shows that the economy is heavily dependent on the resource sector, and thus, more importantly, this is the indication that the booming resource sector is crowding out the other tradable sector, manufacturing.

The government budget is dependent on the mineral resource revenue as well. For instance, in 2006, a windfall tax was introduced in the mining sector, and as a result, the mineral resource tax revenues represented almost 45 percent of the total government budget. In 2010, the windfall tax was replaced by a royalty tax and the share decreased to 28 percent. However, starting from 2011, 3-year average tax revenue from the mining sector accounted for one-third of the total budget revenue. This rise in the government budget allowed the government sector expansion and was a major reason for aggregate demand and wage increases. Consequently, the expenditures on non-traded goods and imports rose, which in turn caused a currency appreciation. Furthermore, an increased foreign direct investment (FDI) aimed at Mongolia’s mining sector also strengthened Mongolia’s currency (Wei and Kinnucan, 2017) [20]. Thus, these facts imply that the spending effect of the Corden and Neary (1982) framework is in action.

The developments made by the government policies following the budget increase from the resource export are explicitly shifting the economy towards a generous welfare state. As a response to their electoral campaign promises, the government started to distribute money in 2008. Government spending and private consumption increased dramatically.

The theory by Corden and Neary (1982) [1] predicts that a resource windfall induces appreciation of the real exchange rate and, thus, deindustrialization. The mechanism behind this is clear. Part of the resource revenue is spent on non-traded goods, which leads to a real appreciation, i.e., a rise in the relative price of non-traded goods in terms of traded goods. This, in turn, draws resources out of the non-resource traded sector into the non-traded goods-producing sector (Corden and Neary, 1982). This simply means that for example, if the extra income from the resource sector is spent by government spending or private consumption, and not saved, our export price relative to foreign prices increases, making our exports not competitive on foreign market. If this continues in the long run, with the resource movement effect, our already small non-resource export sector or the manufacturing sector vanishes.

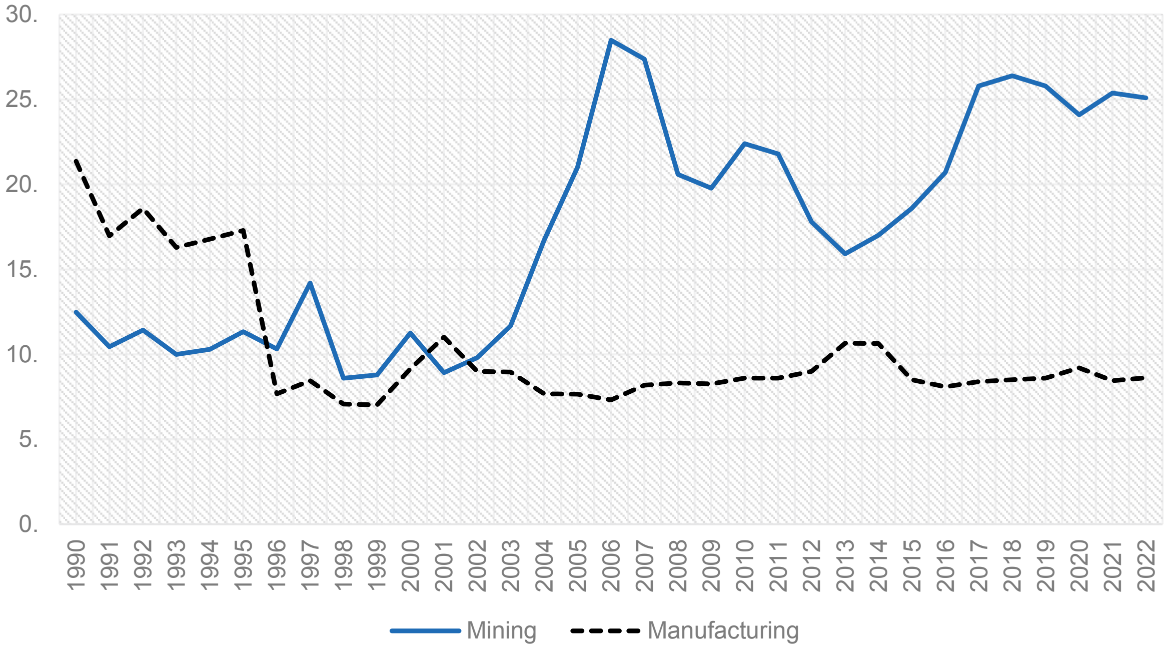
Consequently, the main concern of the natural resource dependent economies is the de-industrialization issue or declining of the manufacturing sector.

It is important to recognize, however, the fact that the economy is negatively affected by the natural resource windfall. Once it is recognized, learning from the abundant experiences of the other countries, we would be able to contribute to providing policy implications to avoid further worsening of the de-industrialization process.

Therefore, to see if the resource windfall has a negative effect on the economy, i.e., to see if there is a Dutch disease in the Mongolian economy, we should examine the manufacturing sector since it is the “victim” of the “disease”. Let us see how the manufacturing sector changed from 1990 to 2022. Figure 3 shows the GDP share of manufacturing and mining. We can see and contrast the sectors. As expected, we see that Mongolian manufacturing has been declining or growing slower than the GDP. In contrast to this, the Mongolian mining industry grew rapidly from 2001 or grew faster than the GDP. In 2022, the mining to GDP ratio reached 25 percent, while the manufacturing to GDP ratio is not more than 7 percent. Using descriptive analysis, we, thus, have seen the symptoms of the Dutch disease in Mongolia. We now empirically test for evidence.

[5] National Statistical Office of Mongolia (NSO) [19]

Fig. 3 Mining and manufacturing output (percentage of GDP).



Note: This is the author's calculation based on NSO [19] data.

4 Methodology and Data

Before explaining our methodology, it is important to note that most of the studies in the literature use cross-section analysis with many countries (for example, Harding and Venables (2016) [15]) or many industries (for example, Ismail (2010) [16]) in certain point of times. Therefore, it is quite rare to find one country case with time series analysis.

It is quite complicated to examine the dynamics of manufacturing sector adjustment due to the natural resource discovery and exploitation. Thus, the underlying structural parameters, the adjustment speeds of the goods and asset markets, as well as the expectations and anticipations will differ from country to country and are difficult to obtain empirically in a structural econometric model. Therefore, we use the vector error correction modeling (VECM) strategy to decompose the variance of manufacturing output fluctuations into different time horizons with corresponding natural resource booms and world resource prices.

This methodology is particularly appropriate in cases such as this with potentially complicated dynamic relationships. The VECM gives us the possibility to create a short-run model with a given long run relationship. The model has a special explanatory variable – the error-correction term – which represents the long-run equilibrium equation. By means of this term, the restricted dynamic short-run model converges to the imposed long-run model.

Furthermore, we also adopt a relatively new cointegration technique, the Autoregressive Distributed Lag (ARDL) model, which gives us the advantage of testing the existence of a long-term relationship between the manufacturing sector and natural resource production, irrespective of whether the variables are mutually cointegrated.

4.1 The VECM Approach

Following Hutchison (1994) [21], we examine a multivariate system (Y_t) that includes real manufacturing output (y_t^m), natural resource production (y_t^r), the money supply (m_t) and real copper price (p_t^{cu}). This is referred to as the basic model. In an extension, the real effective exchange rate (e_t) is also included in Y_t. The only nominal variable here is the money supply, and the inclusion of the variable to the model makes possible the consideration of the expansionary government policy effects mentioned earlier to capture the essence of the spending effect.

Y_t is assumed to have vector autoregressive (VAR) representation with errors, u_t:

$$Y_t=A_0+A_1Y_{t-1}+A_2Y_{t-2}+\cdots+A_\rho Y_{t-\rho}+u_t \quad (1)$$

where Y_t is a ρ x 1 (ρ represents the number of variables, it is four in basic model and five in the extended model) vector of time series, $A_1,\ldots,A_\rho$ are ρ x ρ coefficient matrices and u_t is a ρ x 1 unobservable zero mean white noise process.

In general, economic time series are non-stationary processes and it is useful to take the first difference by subtracting Y_{t-1} from both sides of (1). It can be written as:

$$\Delta Y_t=A_0+\Gamma_1\Delta Y_{t-1}+\cdots+\Gamma_{\rho-1}\Delta Y_{t-\rho+1}+\Pi Y_{t-\rho}+u_t \quad (2)$$

where Γ_i=-(I-A_1-⋯-A_i), i=1,2,…,ρ-1, and Π=-(I-A_1-⋯-A_ρ).

Except for the long-run equilibrium term or error correction term $\Pi Y_{t-\rho}$, equation (2) is nothing else but the traditional first difference VAR model.

The coefficient matrix Π contains information about the long-run equilibrium.[6] The rank (r) of Π matrix, is the cointegration rank, i.e., it shows how many long-run relationships exist between the variables of Y_t. Π can be expressed as $\Pi=\alpha\beta'$ where α and β are $\rho\times r$ matrices containing the loading coefficients and the cointegration vectors respectively (Johansen 1991) [22]. The $\beta' Y_t$ is stationary even though Y_t itself is non-stationary. Therefore, equation (2) can be interpreted as a vector error correction model (VECM).

Both trace and maximum eigenvalue tests are employed to determine the number of cointegrating vectors. The approach is to test the null hypothesis that there is no cointegration among the elements of vector Y_t; rejection of the null is then taken as evidence of cointegration. The long-run constraints expressed by the estimated cointegrating vectors ($\hat{\beta}' Y_t$) are then imposed to the differenced VAR model via error correction terms.

After estimating the VECM, impulse response functions and variance decompositions are calculated with the variables ordered as: manufacturing output, mineral production, money supply and real copper price. This ordering allows the three potential explanatory variables to exert the largest possible influence on manufacturing output movements.

The VECM is more appropriate for impulse-response analysis or dynamic forecasts as it models the feedback from the dependent variable to the weakly exogenous variables. However, VECM concentrates on cases where the underlying variables are integrated of order one. Hence, the method requires pre-testing to identify the long-run relationship among the variables.

4.2 The ARDL approach

The Autoregressive Distributed Lag (ARDL) model, a relatively new cointegration technique, tests the relationship between variables irrespective of whether the independent variables are integrated of order one, order zero, or mutually cointegrated (Pesaran and Shin, 1998) [23]. The ARDL model can be transformed into an error-correction (EC) form, which separates the long-run relationship from the short- run dynamics (Hassler and Wolters, 2006) [24]. Furthermore, the bounds procedure is implemented to test the existence of a long-run relationship based on the EC representation of the ARDL model (Pesaran *et al*. 2001) [25].

Using the advantages of the ARDL approach over the other cointegration techniques, we also test the existence of a long-run relationship between the levels of variables irrespective of whether they are a mixture of stationary and nonstationary variables.

Suppose we expect an equilibrium relationship between a variable y_t and a set of K explanatory variables $\boldsymbol{x}_t=(x_{1t},x_{2t},\ldots,x_{Kt})'$. Estimating the relationship among the variables in a simple static model by ordinary least squares will result in spuriously large coefficient estimates. Adding enough lags of dependent and independent variables in the regression equation, the regression error term is serially uncorrelated, and contemporaneous feedback from y_t to $\boldsymbol{x}_t$ will be ruled out. As a result, the problem can be prevented, and therefore, the following general ARDL ($p,q,\ldots,q$) model with intercept c_0 and lag orders $p\in[1,p^*]$ and $q\in[1,p^*]$ is derived:

$$y_t = c_0 + \sum_{i=1}^{p}\phi_i y_{t-i} + \sum_{i=0}^{q}\boldsymbol{\beta}_i'\boldsymbol{x}_{t-i} + u_t \qquad (3)$$

Hassler and Wolters (2006) [24] transforms the ARDL model in EC representation, which makes it possible to have a better interpretation of the regression coefficients:

$$\Delta y_t = c_0 - \alpha(y_{t-1} - \boldsymbol{\theta}\boldsymbol{x}_{t-1}) + \sum_{i=1}^{p-1}\psi_{yi}\Delta y_{t-i} + \boldsymbol{\omega}'\boldsymbol{\Delta x}_t + \sum_{i=1}^{q-1}\boldsymbol{\psi}_{xi}'\boldsymbol{\Delta x}_{t-i} + u_t \qquad (4)$$

The coefficients in model (3) and model (4) are mapped together as follows:

$$\alpha = 1 - \sum_{i=1}^{p}\phi_i, \boldsymbol{v} = \frac{\sum_{j=0}^{q}\boldsymbol{\beta}_j}{\alpha}, \psi_{yi} = -\sum_{j=i+1}^{p}\phi_j, \boldsymbol{\omega} = \boldsymbol{\beta}_0, \psi_{xi} = -\sum_{j=i+1}^{q}\beta_j \qquad (5)$$

The above model is not directly used for computation due to the nonlinear interaction between the parameters α and θ. Instead, it is slightly modified to get a computationally more convenient approach. Long-run coefficients θ and speed-of-adjustment coefficient α are derived from the transformed model.[7]

4.3 Data

Monthly data is used covering the period of 2003M1-2024M4. The variables are measured in natural logarithms. The data consists of real manufacturing output, actual physical production of mineral resources, nominal M2 as money supply, the real dollar price of copper, and the real effective exchange rate (REER)[8]. The main sources of data are the National Statistics Office of Mongolia (NSO) [19] and the Bank of Mongolia [27]. Complete definitions, units, and sources of the data are provided in appendix A.

[6] For more detailed explanation see Johansen (1991) [22].
[7] Refer to Kripfganz and Schneider (2023) [26] for the detailed procedure and estimations.
[8] The real effective exchange rate index represents the price compared to the weighted average of the exchange rate index of the Mongolian currency against the currency of foreign trade partner countries.

5 Results

5.1 VECM results

We start by following the standard steps to conduct a time series analysis, starting with unit root tests and cointegration tests.

The Augmented Dickey-Fuller (ADF) and Phillips and Perron (PP) unit root tests suggest that all five variables appear to be integrated of order one or I(1), i.e., non-stationary in levels and stationary in first-differences[9]. A linear combination of two or more non-stationary series may be stationary as shown by Engle and Granger (1987) [28]. This stationary linear combination is called the cointegrating equation and can be interpreted as a long-run equilibrium relationship among the variables.

Johansen tests for the model indicate cointegrating relationships between real manufacturing output, mineral production, and other variables. One cointegrating vector is suggested in both the four-variable and five-variable models by maximum eigenvalue and trace statistics at the 1 percent significance level.[10]

The estimate of cointegrating vector β′ is reported in Table 1. The restriction for β′ matrix is imposed as a negative unity on the variable of primary interest, real manufacturing output (y_t^m). A negative coefficient on mineral production (y_t^r) would indicate a long-run tradeoff, or crowding out, between outputs in the manufacturing and natural resource sectors. Thus, Table 1 shows that in the long run, 10 percent growth in mineral resource production is estimated to bring almost a 2 percent contraction in the manufacturing output. This suggests that there is a long-run negative relationship between the resource output and manufacturing in Mongolia.

The variance decomposition results derived from the VECM estimates in Table 1 suggest, as expected, that natural resource sector innovations cause a major role in generating manufacturing output fluctuations.[11] However, surprisingly, the real copper price shocks seem to play a very small role as we were expecting that since the economy is heavily dependent on natural resource exports, particularly copper, the copper price shocks might be affecting all sectors, including manufacturing. The variance decomposition results also suggest that monetary factors play a relatively small, but not negligible, role in this context.

In summary, there is statistically significant evidence for the negative impact of the resource abundance on the manufacturing in Mongolia.

5.2 ARDL results

We can directly proceed to ARDL estimation and bounds testing without any conventional unit-root test, which is an advantage of the model, as it can deal with mixtures of I(0) and I(1) variables. The results are given as follows.

The test involves three steps, and rejecting all three null hypotheses leads to statistical evidence of a cointegrating relationship. The F and t statistics are sufficiently larger than the corresponding critical values, suggesting long-run relationships in both basic and extended models.[12]

The magnitude of coefficients on minerals output is about 0.1 percentage points lower than that of Johansen estimation, and it is not statistically significant (the p-value is 12.2% for the basic model and 13.3% for the extended model). However, the obtained coefficient signs are consistent and support the result of Johansen's estimation. A 1% increase in mineral output will lead

Table 1 Cointegration Coefficients in Johansen Estimation

	Basic model	Extended model
Real manufacturing output	-1.000	-1.000
Minerals output	-0.156***	-0.178***
Money supply	0.432***	0.447***
Real copper price	0.135**	0.111*
REER		0.147
Constant	8.211	7.771

Note: The coefficients are normalized with a negative unity on the manufacturing output. A negative coefficient indicates a long-run offset. ***, ** and * denotes statistical significance at 1%, 5% and 10% level respectively.

[9] Detailed results of the unit root tests can be found in Appendix B.1.
[10] Detailed results of the cointegration tests can be found in Appendix B.2
[11] Detailed results of VECM variance decompositions can be found in Appendix B.3
[12] The test statistic has a nonstandard distribution that depends on various model characteristics and the data, including the integration order of the variables. Pesaran, Shin, and Smith (2001) [25] propose a "bounds test," which involves comparing the values of conventional F and t statistics with pairs of critical values.

Table 2 ARDL long-run estimation results in EC representation

	Basic model	Extended model
Real manufacturing output	1.000	1.000
Minerals output	-0.099	-0.101
Money supply	0.407***	0.408***
Real copper price	0.160**	0.158**
REER		0.028
Constant	4.115	4.054
F◦	26.294***	20.949***
t◦	-10.096***	-9.996***

Note: The coefficients are normalized with a negative unity on the manufacturing output. A negative coefficient indicates a long-run offset. ***, ** and * denotes statistical significance at 1%, 5%, and10% level respectively. ◦ denotes the results of Pesaran, Shin, and Smith (2001) bounds test.

to a 0.1% and 0.11% decrease in real manufacturing output in basic and extended models, respectively.

5.3 Structural break analysis

In addition, we applied the extended VEC and ARDL models in different periods, setting 2010m3 as thresholds, which is found to be the structural break point of the data period from the Gregory-Hansen test. The test's null hypothesis is that there is no cointegration against the alternative of cointegration with a single shift at an unknown point in time. 2010m3 is found to be a breakpoint in both tests where there is a break in the constant and a break in the constant and the trend.

Although we must be careful about interpreting the estimates of the minerals output as they are not statistically significant when we divide the sample, we find interesting results from the subsample results. For both the VEC and ARDL models, minerals output has a negative long-run impact on the real manufacturing output before 2010m3. After 2010m3, the reverse sign is obtained so that the minerals output has a positive long-term impact on the minerals output.

The negative sign, as expected, can be explained by the resource movement effect, as the mining sector was at its early stage of development until 2010. This means resources were drawn from other sectors, such as manufacturing, causing contraction in the former sectors. However, the reverse sign since 2010 might be due to a huge expansion in mineral production, which may have had a positive effect on the whole economy.

Table 3 Results of Gregory-Hansen test, Break in the constant

	Test statistic	Date	Asymptotic critical values 1%
ADF	-9.33	2010m3	-6.05
Zt	-10.04	2010m3	-6.05
Za	-140.53	2010m3	-70.18

Table 4 Results of Gregory-Hansen test, Break in the constant and the trend

	Test statistic	Date	Asymptotic critical values 1%
ADF	-9.32	2010m3	-6.36
Zt	-10.03	2010m3	-6.36
Za	-140.38	2010m3	-76.95

Table 5 Results of VECM Extended model with full year, before 2010m3, and after 2010m3

	All period	Before 2010m3	After 2010m3
Real manufacturing output	1.00	1.00	1.00
Minerals output	-0.178***	-0.152	0.071
Money supply	0.447***	0.55***	0.379***
Real copper price	0.111*	0.04	0.24***
REER	0.147	1.426	0.52*
Constant	7.771	14.692	3.477

Note: The coefficients are normalized with a negative unity on the manufacturing output. A negative coefficient indicates a long-run offset. ***, ** and * denotes statistical significance at 1%, 5%, and 10% level respectively.

Table 6 Results of ARDL Extended model full year, before 2010m3, and after 2010m3

	Full period	Before 2010m3	After 2010m3
Real manufacturing output	1.00	1.00	1.00
Minerals output	-0.101	-0.011	0.052
Money supply	0.408***	0.438***	0.408***
Real copper price	0.158**	0.081	0.243**
REER	0.028	-0.011	0.478
Constant	4.054	6.021	1.911

Note: The coefficients are normalized with a negative unity on the manufacturing output. A negative coefficient indicates a long-run offset. ***, ** and * denotes statistical significance at 1%, 5%, and 10% level respectively.

6 Conclusion

The paper reviews the theoretical and empirical explanations of the effects of natural resource windfalls on the manufacturing sector of the economy. Within this context, we examined the experience of Mongolia. Thus, the main hypothesis examined is the argument that natural resource booms cause de-industrialization following Corden and Neary (1982) [1].

The descriptive statistics show that the Mongolian economy is already natural resource-dependent, with the natural resource share of exports exceeding 90 percent in 2022. In contrast, the manufacturing sector stayed stagnant at around 7 percent of the GDP. We used VECM and ARDL models to test for a long-run trade-off between the mineral production output and the manufacturing sector. Thus, our results suggest a long-run trade-off: a 10% increase in resource production is followed by a 1-2% contraction in manufacturing.

The structural break test suggests 2010m3 to be a breaking point in our data. Unfortunately, when we divide our data into two subsamples before and after 2010m3, the results of VECM and ARDL models are statistically insignificant in both sub-samples. However, interestingly, we saw a shift in the long-run relationship between mineral production and manufacturing, which was negative before 2010 and positive after 2010. This might be due to the resources drawn from the other sectors causing contraction in manufacturing before 2010 and due to a huge expansion in mineral production, causing an overall expansion of the economy.

References

[1] Corden, W.M., Neary, J.P.: Booming sector and de-industrialisation in a small open economy. The Economic Journal 92, 825–848 (1982) https://doi.org/10. 2307/2232670

[2] Khan, S.A.R., Ponce, P., Yu, Z., Ponce, K.: Investigating economic growth and natural resource dependence: An asymmetric approach in developed and devel-oping economies. Resources Policy 77, 102672 (2022) https://doi.org/10.1016/j. resourpol.2022.102672

[3] Ploeg, F.v.d.: Natural resources: Curse or blessing? Journal of Economic Litera-ture 49, 366–420 (2011) https://doi.org/10.1257/jel.49.2.366

[4] Sachs, J.D., Warner, A.M.: The big push, natural resource booms and growth. Journal of Development Economics 59, 43–76 (1999) https://doi.org/10.1016/ s0304-3878(99)00005-x

[5] Sachs, J.D., Warner, A.M.: Sources of slow growth in african economies. Journal of African Economies 6, 335–376 (1997) https://doi.org/10.1093/oxfordjournals. jae.a020932

[6] Sachs, J.D., Rodriguez, F.: Why do resource-abundant economies grow more slowly? Journal of Economic Growth 4, 277–303 (1999)

[7] Caselli, F., Michaels, G.: Do oil windfalls improve living standards? evidence from brazil. American Economic Journal: Applied Economics 5, 208–238 (2013) https://doi.org/10.1257/app.5.1.208

[8] Zulfigarov, F., Neuenkirch, M.: Azerbaijan and its oil resources: Curse or blessing? SSRN Electronic Journal (2019) https://doi.org/10.2139/ssrn.3391732

[9] Torvik, R.: Why do some resource-abundant countries succeed while others do not? Oxford Review of Economic Policy 25, 241–256 (2009) https://doi.org/10. 1093/oxrep/grp015

[10] Narankhuu, B.: Are natural resources a curse or a blessing for mongolia? Mineral Economics 31, 171–177 (2018) https://doi.org/10.1007/s13563-018-0144-0

[11] Robinson, J.A., Torvik, R., Verdier, T.: Political foundations of the resource curse. Journal of Development Economics 79, 447–468 (2006) https://doi.org/10.1016/ j.jdeveco.2006.01.008

[12] Mahbub Morshed, A.K.M., Turnovsky, S.J.: Sectoral adjustment costs and real exchange rate dynamics in a two-sector dependent economy. Journal of International Economics 63(1), 147–177 (2004)

[13] Turnovsky, S.J.: Fiscal policy, adjustment costs, and endogenous growth. Oxford Economic Papers 48(3), 361–381 (1996)

[14] Corden, W.M.: Booming sector and dutch disease economics: survey and consol-idation. Oxford Economic Papers 36, 359–380 (1984) https://doi.org/10.1093/ oxfordjournals.oep.a041643

[15] Harding, T., Venables, A.J.: The implications of natural resource exports for nonresource trade. IMF Economic Review 64(2), 268–302 (2016)

[16] Ismail, K.: The structural manifestation of the 'dutch disease': The case of oil exporting countries. International Monetary Fund, IMF Working Papers 10 (2010) https://doi.org/10.5089/9781455200627.001

[17] Brahmbhatt, M., Canuto, O., Vostroknutova, E.: Dealing with dutch disease. World Bank - Economic Premise, 1–7 (2010)

[18] Kuralbayeva, K., Stefanski, R.: Windfalls, structural transformation and spe-cialization. Journal of International Economics 90(2), 273–301 (2013) https: //doi.org/10.1016/j.jinteco.2013.02.003

[19] www.1212.mn/en/ Accessed 2023-05-15

[20] Ge, W., Kinnucan, H.W.: The effects of mongolia's booming mining industry on its agricultural sector: A test for dutch disease. Agricultural Economics 48, 781–791 (2017) https://doi.org/10.1111/agec.12374

[21] Hutchison, M.M.: Manufacturing sector resiliency to energy booms: Empirical evidence from norway, the netherlands, and the united kingdom. Oxford Economic Papers 46, 311–328 (1994) https://doi.org/10.1093/oxfordjournals.oep.a042131

[22] Johansen, S.: Estimation and hypothesis testing of cointegration vectors in gaus-sian vector autoregressive models. Econometrica 59, 1551–1580 (1991) https: //doi.org/10.2307/2938278

[23] Pesaran, H., Shin, Y.: In Econometrics and Economic Theory in the Twentieth Century: The Ragner Frisch Centennial Symposium, pp. 371–413. Cambridge University Press, (1998). https://doi.org/10.1017/CCOL521633230.011

[24] Hassler, U., Wolters, J.: Autoregressive distributed lag models and cointegration. Allgemeines Statistisches Archiv 90, 59–74 (2006)

[25] Pesaran, H., Shin, Y., Smith, J.R.: Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics 16, 289–326 (2001) https: //doi.org/10.1002/jae.616

[26] Kripfganz, S., Schneider, D.C.: ardl: Estimating autoregressive distributed lag and equilibrium correction models. Stata Journal 23, 983–1019 (2023)

[27] NEER, REER /monthly/. https://www.mongolbank.mn/en/neer-reer Accessed 2023-05-15

[28] Engle, R.F., Granger, C.W.J.: Co-integration and error correction: Representa-tion, estimation, and testing. Econometrica 55, 251–276 (1987) https://doi.org/ 10.2307/1913236

[29] https://www.lme.com/en/ Accessed 2023-05

[30] Stock, J.H., Watson, M.W.: Introduction to Econometrics. Pearson Education Limited, (2020)

Appendix A Data table and explanation

We summarized our variables with respective measure units and sources in Table A1.

Manufacturing output is deflated by national Consumer Price Index with base year 2015. Mineral production is the total monthly physical production of coal, crude oil, copper concentrate, molybdenum concentrate, gold, iron ore, iron ore concentrate, flour spar, flour spar concentrate and zinc concentrate.

Appendix B Some results tables and explanations

B.1 Unit Root Tests

The t-statistics for the Augmented Dickey-Fuller (ADF) unit root tests are reported in Table B1. The tests were conducted both in log levels (x) and log first-differences (dx) and each time series includes a constant and both constant and time trend. The null hypothesis states that there exists a unit root in the time series, and failure to reject the null indicates that the variable may be non-stationary. The ADF statistics were estimated using Akaike Information Criterion (AIC) since it is recommended to use AIC instead of the Schwarz Information Criterion to determine lag length of the autoregressive process for the ADF statistic.[13]

The ADF tests are consistent in failing to reject the null in log levels (x) at 1% significance level, meaning the series are likely non-stationary in levels. ADF tests are consistent in rejecting the unit root hypothesis for all of the variables in log first-difference form (dx). Only the ADF test with trend for money supply is rejecting the null at 5% level, but the rest of the test statistics are sufficient to reject the null at 1% level. Consequently, we can say that all five variables appear to be integrated of order one or I(1), i.e., non-stationary in levels and stationary in first-differences.

B.2 Cointegration tests

Table B2 shows the Johansen cointegration tests consisting of trace and maximum eigenvalue test statistics as well as the critical values at 1% significance level for the number of maximum cointegrating vectors. We assumed a linear trend in data and allowed the cointegrating equation to have both intercept term and trend. The null hypothesis for each test is also included in Table B2.

We see that there are at most 2 cointegrating vectors in the basic model and at most 1 in the extended version.

Table A1 Data

Variables	Measurements	Source
Manufacturing output	Log of real manufacturing output (Million tugrugs)	National Statistical Office of Mongolia (NSO)
Mineral production	Log of physical mineral production (Thousand tons)	NSO
Money supply	Log of M2 money supply (Billion tugrugs)	NSO
Real copper price	Log of real copper price (US dollar per ton)	London Metal Exchange [29]
Real effective exchange rate (REER)	Log of REER (weighted average of exchange rate indices)	Bank of Mongolia

[13] See Stock and Watson (2011, Chapter 14)[30] for lag length selection in time series regression with multiple predictors.

Table B1 Augmented Dickey-Fuller Unit Root Tests

	Real manufacturing output	Mineral production	Money supply	Real copper price	Real effective exchange rate
ADF intercept (x)	-1.262	-1.034	-1.715	-3.086**	-2.359
ADF intercept + trend (x)	-3.198*	-2.581	-1.791	-3.186*	-2.398
ADF intercept (dx)	-4.076***	-4.216***	-3.564***	-4.651***	-5.359***
ADF intercept + trend (dx)	-4.081***	-4.205***	-3.823**	-4.685***	-5.353***

Note: x and dx refer to the variable listed in log level and log first-difference form respectively. *, ** and *** denote the individual test statistic statistically significant at the 10%, 5% and 1% levels respectively.
Source: Monthly data from 2003M1 to 2024M4 were used from the NSO.

Table B2 Johansen Cointegration Tests

Null hypothesis	Critical value at 1%		Test statistics	
	Trace	Max-Eigen	Trace	Max-Eigen
Basic model				
None	54.46	32.24	151.49***	103.33***
At most 1	36.65	25.52	48.17***	29.05***
At most 2	20.04	18.63	19.12	13.4
At most 3	6.65	6.65	5.72	5.72
Extended model				
None	76.07	38.77	77.31***	36.82***
At most 1	54.46	32.24	40.49	18.6
At most 2	35.65	25.52	21.89	10.76
At most 3	20.04	18.63	11.12	9.07
At most 4	6.65	6.65	2.06	2.06

Note: *** denotes the rejection of the null hypothesis at the 1% significance level. The critical values were taken from the Stata Software edition 17.

B.3 VECM variance decompositions and impulse responses

Table B3 reports the manufacturing output variance decompositions derived from the estimates of the VECM for basic and extended models. The VECM was estimated using the estimated cointegrating vector shown in Table 1. The estimation results suggest that natural resource sector innovations cause a major role in generating manufacturing output fluctuations. The estimated percentage impact of natural resource sector on manufacturing output error variance after a year is as high as 19 percent in the basic model and 21 percent in the extended model. The real copper price shocks seem to play small role. Monetary factors play relatively small, however, not negligible role in this context.

Figure B3 shows the accumulated impulse response functions of manufacturing output to a one-unit positive shock in real copper price, mineral sector and REER. Mineral sector shocks have significant and sustainable negative effects on manufacturing output. Thus, the result is supportive of our hypothesis that the natural resource production innovation has a long run negative effect on manufacturing production in Mongolia.

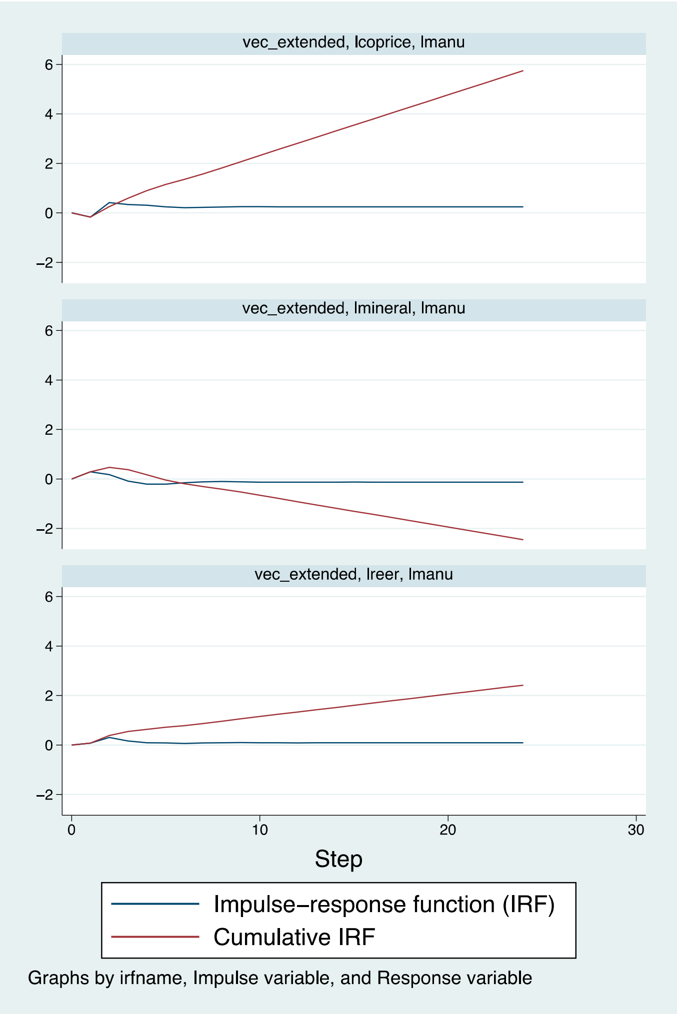
Table B3 Manufacturing variance decompositions (24-month time span)

Months	Four-variable Basic Model			
	Manufacturing	Mineral sector	Money supply	Real copper price
1	100	0	0	0
6	78	16	3	3
12	66	19	10	5
18	58	21	14	7
24	51	23	18	8

Months	Five-variable Extended Model			
	Manufacturing	Mineral sector	Money supply	Real copper price
1	100	0	0	0
6	76	17	3	1
12	64	21	4	1
18	56	24	5	1
24	49	26	6	1

Note: Variance decompositions report the percentage impact of the n months ahead manufacturing forecast error variance from corresponding variable listed in the column. VECM is ordered as real manufacturing output, mineral production, money supply and real copper price in basic model. REER is the last in order in extended model.

Figure B3 Impulse responses of manufacturing sector.



Note: Figure shows the impulse response func-tions of manufacturing output to a one-unit positive shock in mineral sector, real copper price and REER, respectively.