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Natural Resources, Tradable and Non-tradable Sector: An Exemplification with Bolivia, a Boom - Tradable and Non-tradable Model

Roger Alejandro Banegas Rivero[1]*, Marco Alberto Núñez Ramírez[2], Luis Fernando Escobar Caba[3]

[1]Institute of Economic and Social Research "José Ortiz Mercado", Universidad Autónoma Gabriel René Moreno, Bolivia, [2]Department of Management, Instituto Tecnológico de Sonora, México, [3]Institute of Economic and Social Research "José Ortiz Mercado", Universidad Autónoma Gabriel René Moreno, Bolivia. *Email: rogerbanegas@uagrm.edu.bo

ABSTRACT

In this document the transmission channel between natural resource dependence and its dynamic effects on growth is evaluated (Dutch disease hypothesis). An exemplification is done through a small open economy (Bolivia case) according to representative characteristics of high concentration in exports of hydrocarbon and minerals, and their implications in the productive sectors: Boom (B), tradable (T), and non-tradable (NT) (Boom TNT model), plus the addition of domestic demand and relative prices (foreign and domestic) in alternative econometric specifications by structural restrictions for quarterly period from 2000 to 2015. The results show statistical predominance of long-term responses over short-term specifications, and different magnitudes between positive and negative shocks.

Keywords: Dutch Disease, Growth, Resource Booms, Dependence, Tradable, Non-tradable
JEL Classifications: O13, Q33, O41

1. INTRODUCTION

In this paper two research questions are pursued: How is the channel transmission between natural resource dependence (NRD) and growth for one open and small economy? How is the response of real growth to negative shocks in boom sector (B), tradable (T) and non-tradable sectors (NT)?

To answer these questions, a dependent country in natural resources (Bolivia) is used as an example, considering its high share of hydrocarbon and mineral exports (70% in monetary terms and 86% in relation to weight exports). It is covered quarterly periods from 2000 to 2015 that it is characterized by rising in oil prices[1]. Consequently, NRD is conceptualized as a measure of export concentration of natural resources (Sachs and Warner, 1995; 1997).

Also, the issue of Dutch disease (DD) is designated as a phenomenon of high export concentration of natural resource (boom sector), since the discovery of volumes of oil, gas or mineral potentates with windfalls in external prices (positive shocks)[2].

Initially, a large amount of external resources inflow the economy that leads to increase domestic demand (effect of the demand side) in NT goods; Domestic prices increase more rapidly than external

1 The discovery of significant gas reserves in Bolivia was in 2000. In late 1999, Bolivia had 8.58 trillion cubic feet (TCF); for 2000, the level of reserves reached at 32.2 TCF, it also began to export natural gas to Brazil (80% of exports) (Banegas and Vergara, 2014: 95-96).

2 The Dutch disease is based in the Netherlands, whose country great discoveries of natural gas in the North Sea by the early 1960s, not only by increasing domestic demand and appreciating the real exchange rate, but also by reducing tradable manufacturing and deindustrialization: The competitiveness of tradable goods fell, in addition to negative growth in the long term, especially against implications *shocks* negative in natural resource prices. Alternatively, the Dutch disease can also occur by the flow of remittances, foreign aid and capital inflows.

prices and therefore the real exchange rate gets appreciated (Neary and van Winjbergen, 1986). On the other hand, it is argued that deviations from the real exchange rate relative to their medium and long-term value (gap) would affect negatively on real growth (Washington consensus approach).

By the side of producers, having an expectation of higher domestic prices, they decide to change tradable production in foreign markets by domestic production, meaning that there are shifts between factors of production with negative impacts on industrialization. The final channel continues with contraction in the tradable goods sector relative to NT goods (Corden and Neary, 1982; Krugman, 1987; Van Wijnbergen, 1984), this is the effect of Natural resources on the supply side (Lopez et al., 2016).

The discussion at both theoretical and empirical levels are based on whether or not DD symptoms have effected on economic growth with divided and unproven conclusions (Sala-i-Martin and Subramanian, 2003). On the one hand, there are results with negative explanations on growth (Gylfason et al., 1999; Sachs and Warner, 1995; 1997). In contrast, there is evidence suggesting no impact on growth (Magud and Sosa, 2013). Even with positive implications for economic growth by considering the natural resource stock (Brunnschweiler and Bulte, 2008).

It has also been shown that there is an optimal level of DD, so it could not be a serious problem if the fraction of the natural wealth is destined for consumption by the adjusted decreasing tendency (Matsen and Torvik, 2003). Similarly, there is a misunderstanding about the meaning of abundance in natural resources as a measure of capital stock or natural reserves that is mistaken with the measure of dependence on the natural resource (concentration of natural resource exports) (Banegas, 2015). Additionally, growth may depend of its rents of natural resources (another confused term), some examples show that growth depends on the period of analysis: 1970-1980 with positive effects of prices and 1980-1990 with declines in prices of natural resources (Brunnschweiler and Bulte, 2008; James, 2015).

Added to previous misunderstanding topics, there is some empirical controversy for the Bolivian experience. For example, Cerezo (2014) did not find symptoms of DD in Bolivia for the quarterly period from 1990 to 2010; while Borja and Zavaleta (2016) have evidenced implications of DD and the natural resource curse for the mining sector. Additionally, their estimates show that negative shocks in the oil and natural gas sector may show negative effects on the Bolivian growth by using a social accounting matrix (SAM with 2006 as base year) and a computable general equilibrium model.

By this paper, three specifications of econometric models help to appreciate the differences in the economic behavior system by using structural analysis such as vector autoregression (SVAR) with short and long-term restrictions, as well as responses in context of negative innovations.

Consequently, the document is structured by four sections: The first deals with the theoretical framework, TNT model and the proposed transmission channels; the second section describes the used data and econometric methodologies; the third section shows, there are offered the results of the estimates; in the fourth section, the discussion and the implications for public policies are discussed. The main conclusions of the research are given at the end of the document.

1.1. Theoretical Framework TNT Model

In this section the theoretical framework is explained by considering the aggregate supply of the TNT model: Tradable (T) and NT sectors, as also the relationship with the real effective exchange rate (Reer); The balance in the TNT goods market is also explained by the proposed boom-TNT model. In fact, three sectors are considered with two exportable or importable sectors (boom and tradable sector) and one sector with domestic production and consumption (NT sector).

1.2. TNT Aggregate Supply and the Real Exchange Rate (Reer)

We begin explaining a widely used theoretical model in macroeconomics, under the main assumption of two types of the aggregate goods in one open and small economy: Marketable with the rest of the world, called tradable goods (Q_T); and the other just tradable domestically or NT goods (Q_{NT}) (Larrai'n and Sachs, 2002. p. 633-649).

Consequently, in the economy, there are two types of production functions, for each type of goods according to two factors of production: The capital stock (K) and labor (L), denoted by the respective sub-indices in tradable (T) and non-tradable (NT):

$$QT=f(LT, KT) \quad (1)$$

$$QNT=f(LNT, KNT) \quad (2)$$

In this model, it is assumed that capital is a constant; so the level of production depends only on the level of labor:

$$Q_T=a_T*L_T \quad (3)$$

$$Q_{NT}=a_{NT}*L_{NT} \quad (4)$$

Likewise, the labor factor is the sum of the employment used in the tradable and non-tradable sector:

$$L=L_T+L_{NT} \quad (5)$$

Similarly, from (3) and (4), the sectoral productivities of the tradable and non-tradable sector can be deducted, respectively:

$$aT=QT/LT \quad (6)$$

$$aNT=QT/LNT \quad (7)$$

By solving (6) and (7), it may get:

$$LT=QT/aT \quad (8)$$

$$LNT=QNT/aNT \quad (9)$$

Replacing in (5):

$$L=Q_T/a_T+Q_{NT}/a_{NT} \quad (10)$$

Solving for Q_{NT}:

$$Q_{NT}+a_{NT}L-(a_{NT}/a_T)Q_T \quad (11)$$

On the other hand, assuming optimum conditions for the benefits of firms, the level of wages (w) depends on the price of each good, in addition to their level of productivity:

$$w=P_T*a_T \quad (12)$$

$$w=P_{NT}*a_{NT} \quad (13)$$

Solving (12) and (13) for the wage level:

$$P_T/P_{NT}=a_{NT}/a_T \quad (14)$$

Consequently, the equivalence of the real effective exchange rate (R), either through relative prices (external or tradable prices in terms of domestic prices or non-tradable) and it is shown to be equivalent to the relative productivity between non-tradable and tradable goods.

$$R=P_T/P_{NT}=a_{NT}/a_T \quad (15)$$

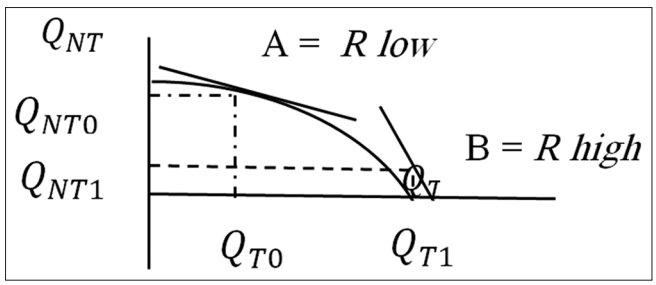
According to the expression (15), it can be explained that the appreciation of the exchange rate (R) may be attributed to the fact that prices of non-tradable goods P_{NT} increase more than the prices of tradable goods (P_T); Alternatively, productivity in tradable goods (a_T) is greater than productivity in non-tradable goods (a_{NT}); Consequently, in order to get equilibrium at wage levels, the price of non-tradable goods must increase at higher levels.

In Figure 1, we can see the combination of tradable (Q_T) and non-tradable (Q_{NT}) depends on the state of low real exchange rate (a) or high real exchange rate (b) in the first case, there is strong incentives for non-tradable production and for the second case the greater slope by tradable goods, in both cases the slope is negative and the combination is directly linked to the state of real exchange rate.

1.3. The Equilibrium of the TNT Model

The TNT aggregate supply figure incorporates aggregate demand composed of domestic demand and external demand, as an alternative to non-tradable and tradable consumption (Figuers 1 and 2):

Figure 1: Production possibilities frontier and real exchange rate



At point A (appreciated real exchange rate), non-tradable goods are equivalent to domestic demand (Q_{NT0}=*dom. Demd*$_0$), where the level of tradable consumption (C_T) is higher than the level of tradable goods (Q_T). Therefore, there is a deficit in the trade balance. Conversely, for point B, tradable goods exceeds tradable consumption, with a surplus in the trade balance, implying lower level of non-tradable goods equivalent to the level of domestic demand (non-tradable consumption).

1.4. Boom-TNT Model

It also referred in Figure 3 (Boom-TNT model), that endogenous system respond to the behavior of three control variables (exogenous variables): Prices of natural resources, the degree of trade liberalization and external demand; therefore, it is offered the following transmission channel:

1.4.1. Shock of NRD and boom sector

It is assumed that the discovery of natural resources (reserves) impulses the economy to direct specialization in the natural resource by extracting type (natural gas, minerals, petroleum, among others); definitely, there is a growth in the sectoral growth of the boom sector (Corden, 1984; Corden and Neary, 1982).

1.4.2. Shock boom sector, domestic demand and the real exchange rate

As the share of boom sector increases, it stimulates domestic demand equivalent to the real growth of aggregate supply by non-tradable sector; as a result, domestic prices growth faster than external prices by the demand side; therefore, the real exchange rate is appreciated (ibid).

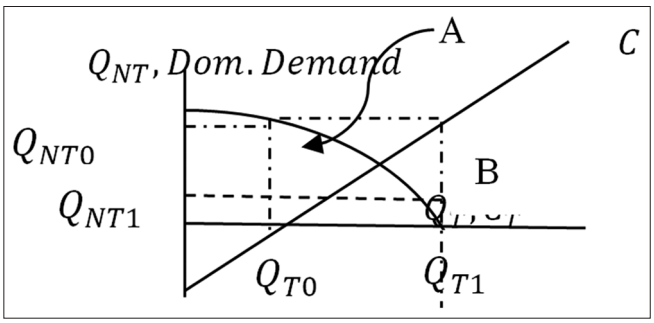
1.4.3. Shock of real exchange rate and tradable sector

Depreciating the real exchange rate leads to movements and internal changes within the production possibilities frontier. As a result, the tradable sector gets contracted in terms of the non-tradable sector (Bruno and Sachs, 1982; Corden and Neary, 1982; Krugman, 1987; Van Wijnbergen, 1984), by appreciating the real exchange rate.

1.4.4. Shock of natural resources, the TNT sectors and real growth

During positive shocks under dependence of natural resources and by considering the context of positive shocks in prices, there are contractions on the tradable sector; even though there are positive impacts on real growth in economic activity (Brunnschweiler and Bulte, 2008); however, in the presence of negative shocks, dependence on natural resources and the natural resource sector negative impact on economic activity with the need of structural

Figure 2: The equilibrium of tradable and non-tradable Model



adjustments and increase over the tradable sector relative to the size of the non-tradable sector.

2. MACROECONOMICS DATA AND STRUCTURAL MODELS

2.1. Data

The information considered is quarterly from 2000 (Q1) to 2015 (Q4) based on official information on Bolivian sources (INE, UDAPE). In Appendix 1, it describes the number of variables used detailed as the respectively operationalization and sources of information. It should be mentioned that all variables were seasonally adjusted by using ARIMA-CENSUS X-12 in multiplicative version.

The aggregation and categorization of three sectors: Boom (B), tradable (T) and non-tradable (NT) corresponds to a standard industrial classification that is commonly used in macroeconomics (Larrai'n and Sachs, 2002. p. 637).

Similarly, when dealing with descriptive statistics for the variables (Appendix 2a), Bolivia was used as a symbolic example of NRD, given its high concentration in natural gas and mineral exports (86% of total exports). On the other hand, the boom sector represents 11% of gross domestic product (GDP), domestic demand equals once total value of GDP and the level of trade liberalization is equivalent to 63% of GDP.

By addressing statistics in difference variables (measure as growth rates), there was growth in NRD, growth in the booming industry (natural gas, oil and minerals). In an opposite sense, there was contraction of the tradable sector (manufacturing, trade and agriculture)[3], relative to non-tradable sector[4] (on average), as well as negative changes in the real exchange rate (appreciation) (Appendix 2b).

Looking at the associations between variables (Appendix 3), on NRD is directly and significantly related to the variation of natural resource prices, as the variation of the real exchange rate and the relative variation of the TNT sector. Similarly, for every positive variation of 1% in external demand, it is linked to + 0.49% of the variation of the boom sector. Conversely, there is no evidence of a significant association between NRD, the boom sector, domestic demand, and growth in real economic activity; however, simple correlations do not imply causality.

2.2. Structural Macroeconomic Models

Under the theoretical model presented (Figure 3), two vectors were estimated: One of endogenous variables and the other that belongs to exogenous variables.

Also, the vector of endogenous variables is composed of six variables:

$$Y_t=\{ldepen_t, lboom_t, ldomestic_t, lreer_t, lTNT_t, lgdp_t\} \quad (16)$$

All variables are expressed in logarithmic terms denoted by the initial letter (l). At the same time, for the vector designated, export concentration in natural gas and mine is incorporated ($ldepen_t$); the relative share of industry boom (A, hydrocarbons and minerals) ($lboom_t$) domestic demand ($ldomestic_t$); the real effective exchange rate ($lreer_t$) and sectoral output in the tradable sector in relative terms the non-tradable sector (NT); Finally, the real GDP is considered ($lgdp_t$).

For control purposes, three exogenous variables are considered:

$$X_t=\{loilp_t, lopen_t, lfordem_t\} \quad (17)$$

Where $loilp_t$ represents the logarithm of oil price index (base year 2005); $lopen_t$ denotes the logarithm of trade liberalization (Exports plus imports in terms of GDP); $lfordem_t$ is an external demand index represented by the physical volume of exports with base year 1990.

2.2.1. Unrestricted autoregressive vectors (VAR)

Consequently, by considering the vector of endogenous variables (16), as well as exogenous variables (17), we get a model of unrestricted autoregressive vectors (VAR) with stationary variables (expressed in differences):

$$\Delta Y_t = \sum_{i=1}^{k} \Delta Y_{t-i} + \beta_j \Delta X_t + \varepsilon_t \quad (18)$$

2.2.2. Structural constraints

Restrictions are compared with short and long-term specifications according to the theoretical model (Figure 3) from the traditional triangular mechanism of identification:

1. The NRD is structural and strictly exogenous.
2. The variability in NRD influence on the size of the boom industry (boom) (B) in the economy.
3. Domestic demand responds to changes in the size boom sector (B) sector as also from the variability of NRD.
4. The Reer is affected by variability in the factors (1), (2) and (3).
5. The magnitude of the tradable sector (T) in terms of non-tradable sector (NT) depends on changes in external and internal relative prices and from changes of the variables included in the previous form.
6. The real growth of the economy is structurally endogenous to all system disturbances from (1) to (5).

2.3. Specification A: Short-term Structural Response (SVAR CP)

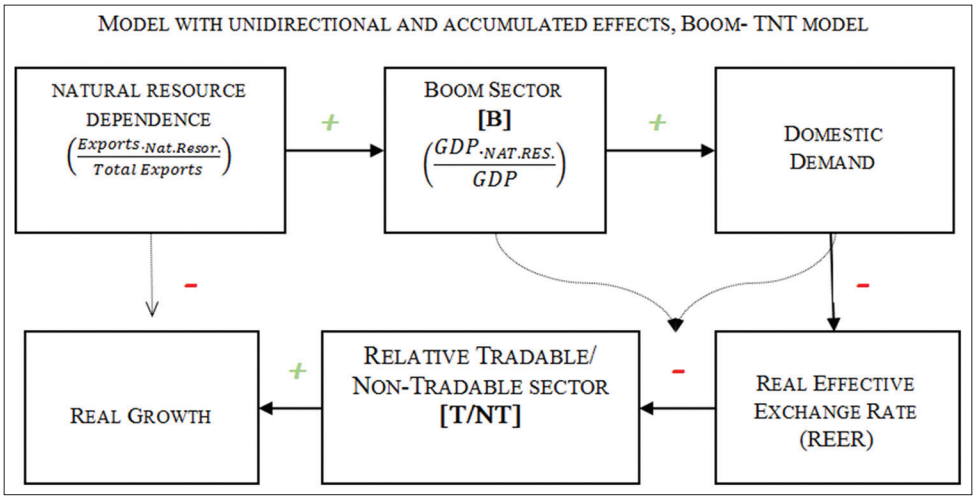
Since expression (3) does not incorporate any restrictions on the behavior of the variables, the specification linked to the theoretical Figure 3 is provided. The central purpose of the specification of structural autoregressive vectors (SVAR) is to explain the determinant shocks on the actual product in two contexts: (1) in a contemporary way and (2) with dynamic effects.

It is also necessary to define non-observable and structural exogenous innovations. The representation of a moving average vector (ΔY_t) follows the next structural representation:

3 In general, these are the most tradable sectors (ibid).

4 This measure is made by sectoral participation as a proportion of total GDP for Construction, financial establishments, electricity, gas and water services, public administration, transport and communications, plus indirect taxes.

Figure 3: Boom-TNT Model



$$\Delta Y_t = C(L)\mu_t^{Y_t} \tag{19}$$

Where L is a lag operator for six endogenous variables $\mu_t^{\Delta Y_t} = \left[\mu_t^{depend.}\ \mu_t^{boom}\ \mu_t^{domdem}\ \mu_t^{rel.prices.}\ \mu_t^{TNT}\ \mu_t^{growth}\right]$ indicating the vector of exogenous unobservable structural innovations.

$$A\varepsilon_t^{\Delta Y_t} = C\mu_t^{Y_t} \tag{20}$$

In (20), A contains short-term effects with contemporary responses and C is a lower triangular matrix with structural shocks. Therefore, expressing (20) with short-term constraints for the specification as stationary components, we obtain:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ -\alpha_{21} & 1 & 0 & 0 & 0 & 0 \\ -\alpha_{31} & -\alpha_{32} & 1 & 0 & 0 & 0 \\ -\alpha_{41} & -\alpha_{42} & -\alpha_{43} & 1 & 0 & 0 \\ -\alpha_{51} & -\alpha_{52} & -\alpha_{53} & -\alpha_{54} & 1 & 0 \\ -\alpha_{61} & -\alpha_{62} & -\alpha_{63} & -\alpha_{64} & -\alpha_{65} & 1 \end{bmatrix} * \begin{bmatrix} \varepsilon_t^{\Delta depen.} \\ \varepsilon_t^{\Delta boom} \\ \varepsilon_t^{\Delta Domdem} \\ \varepsilon_t^{\Delta Reer} \\ \varepsilon_t^{\Delta T/NT} \\ \varepsilon_t^{\Delta growth} \end{bmatrix} = \begin{bmatrix} \mu_t^{depend.} \\ \mu_t^{boom} \\ \mu_t^{dom.dem.} \\ \mu_t^{Rel.Pric.} \\ \mu_t^{T/NT} \\ \mu_t^{growth} \end{bmatrix} \tag{21}$$

For expression (21) is necessary to impose some restrictions for the short-term; That is, fifteen coefficients equal to zero are required (depending on economic theory) in order to get exact identification.

2.4. Specification B: Long-term Structural Response (SVAR LP)

The SVAR proposal proposes to recover the innovations of structural vectors $(\mu_t^{y_i})$ not directly observable, from the estimation of an unrestricted VAR. This VAR is invertible and generates the following moving average representation:

$$\Delta Y_t = A(L)\varepsilon_t^{Y_t} \tag{22}$$

Where A(L) represents a parameter operator; $\varepsilon_t^{\Delta y_t}$ indicates the vector of the residuals in reduced form with the covariance matrix Σ. The expression (23) establishes a linear relationship between the reduced form of the residuals $\left\{\varepsilon_t^{\Delta y_t}\right\}$ and the structural shocks in the model, in the long-term:

$$\varepsilon_t^{\Delta y_t} = C_0\,\mu_t^{\Delta y_t} \tag{23}$$

In a complementary way, if (23) is expressed in a matrix and unrestricted way, we obtain:

$$\begin{bmatrix} \varepsilon_t^{\Delta depen.} \\ \varepsilon_t^{\Delta Boom\ sector} \\ \varepsilon_t^{\Delta Dom.\ dem.} \\ \varepsilon_t^{Aprec.\ RER} \\ \varepsilon_t^{\Delta TNT\ sector} \\ \varepsilon_t^{Growth} \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} & C_{13} & C_{14} & C_{15} & C_{16} \\ C_{21} & C_{22} & C_{23} & C_{24} & C_{25} & C_{26} \\ C_{31} & C_{32} & C_{33} & C_{34} & C_{35} & C_{36} \\ C_{41} & C_{42} & C_{43} & C_{44} & C_{45} & C_{46} \\ C_{51} & C_{52} & C_{53} & C_{54} & C_{55} & C_{56} \\ C_{61} & C_{62} & C_{63} & C_{64} & C_{65} & C_{66} \end{bmatrix} * \begin{bmatrix} \mu_t^{depen.} \\ \mu_t^{Boom} \\ \mu_t^{dom.dem.} \\ \mu_t^{Rel.\ Prices} \\ \mu_t^{TNT} \\ \mu_t^{Growth} \end{bmatrix} \tag{24}$$

Likewise, in (24) additional constraints n (n -1)/2 are required to identify the model; that is fifteen coefficients equal to zero imposed through economic theory are required.

On the other hand, for a long-term design, Blanchard and Quah (1989) proposed (accumulated) responses from structural innovations, which are presented in the impulse-response properties and take the form:

$$C = \hat{\psi}_{\infty} A^{-1} B \tag{25}$$

In this way, it would be necessary to identify the matrix $C_0(6\times6)$ in order to recover the vector of structurals hocks $(\mu_t^{y_t})$, from the vector of estimated errors $(\varepsilon_t^{\Delta y_t})$. Then the restrictions built into the model, assuming that there are some automatic effects of variables on others, while the dynamics of economic sectors (T/NT) and growth delay some time against various shocks including exposed.

In a reduced form, we obtain:

$$\begin{bmatrix} \varepsilon_t^{\Delta depen.} \\ \varepsilon_t^{\Delta Boom\ sector} \\ \varepsilon_t^{\Delta Dom.\ dem.} \\ \varepsilon_t^{Aprec.\ RER} \\ \varepsilon_t^{\Delta TNT\ sector} \\ \varepsilon_t^{Growth} \end{bmatrix} = \begin{bmatrix} C_{11} & 0 & 0 & 0 & 0 & 0 \\ C_{21} & 0 & 0 & 0 & 0 & 0 \\ C_{31} & C_{32} & 0 & 0 & 0 & 0 \\ C_{41} & C_{42} & C_{43} & 0 & 0 & 0 \\ C_{51} & C_{52} & C_{53} & C_{54} & C_{55} & 0 \\ C_{61} & C_{62} & C_{63} & C_{64} & C_{65} & C_{66} \end{bmatrix} * \begin{bmatrix} \mu_t^{depen.} \\ \mu_t^{Boom} \\ \mu_t^{dom.dem.} \\ \mu_t^{Rel.\ Prices} \\ \mu_t^{TNT} \\ \mu_t^{Growth} \end{bmatrix} \tag{26}$$

In (26) the accumulated responses are obtained from observed shocks in their reduced form: $\hat{\psi}_{\infty} = (I - \hat{A}_1 - \cdots - \hat{A}p)^{-1}$. The identification of the constraints is specified in terms of the Matrix (basically they are coefficients zeroes). The restriction $C_{i,j}=0$ symbolizes that the (cumulative) response of the variable does not respond to structural shocks in the long run (although there may be short-term effects). Conversely, $C_{i,j}\neq0$ (in [1]) implies a response to one structural shock in the long run. In this way, we determined the structural shocks that influence on the real growth of the economy.

2.5. Specification C: Negative Shock Response with Triangular Impulse

Finally, as further exercise, there were considered negative shocks of one standard deviation for every endogenous variable. It was considered cholesky triangular arrangement of response, in order to evaluate the response of variables against contractions or negative shocks are simulated: What happens to negative impulses in NRD or in the face of a contraction in the boom sector?

3. RESULTS

In this section the results are described according to the theoretical approach indicated in the Boom-TNT model (Figure 3). Consequently, this section is organized by three sub-sections: The first deals with the transmission channel of contemporary innovations between NRD and real growth of economic activity; the second and third sub-sections address the results from a comparative specification results between short and long-term implications respectively. As a final exercise, in fourth sub-section, the results are approached from the perspective of negative shocks in the variables incorporated in the system.

3.1. Transmission Channel by Contemporary Innovations

According to Appendix 4, the long-term estimates have superiority over short-term inferences based on the degree of statistical significance (at 0.01 level). In response, it is noted that positive innovations in NRD generate direct interference on the boom sector variation **{+},** as domestic demand and real growth in economic activity **{+}**; so contrary, positive innovations in natural resource generate contemporary negative shocks on the real exchange rate fluctuations (appreciation) and contraction innovations on tradable sector in terms of non-tradable sector **}** (0.01 statistical significance) (Appendix 4, Specification B).

In the presence of positive innovations for boom sector, there are major positive perturbations in the relative sector T/NT and real economic activity {+}; There are no significant impacts on domestic demand shocks; finally, there is evidence of negative impact on the real exchange rate (appreciation) **{-}** (at 0.01 statistical significance).

Positive innovations in domestic demand generate negative shocks, both real exchange rates (appreciation) as the tradable sector in terms of non-tradable sector {-}; so contrary, positive shocks are evident in the real growth of economic activity **{+}**. Finally, disturbances of real economic activity respond negatively against positive shocks in the real exchange rate, as the relative size of the tradable/non-tradable sectors (T/NT) **{-}** [at 0.01 significance statistics].

3.2. Specification A: Responses by Short-term Restrictions

Combining the results of variance decomposition with analysis of impulse-response structure for a specification of short-term (Appendices 5, Specification A and 6), the relative importance of NRD inside the Reer is practically limited (<5% variability), with response of real appreciation {-}; its main sources of variability focus on innovations variation of TNT sector (94% of maximum variability, at quarter 1) with response {+} of real depreciation; Variation in real economic activity (between 27 and 39%) and domestic demand (around 20%). Positive innovations in economic activity generate real appreciations {-}.

As for the response of the tradable sector in terms of non-tradable sector, it responds in greater magnitude of the positive shock of real exchange rate (89% in the quarter 1) **{+}** by positive way.

In the short term, the variability of real growth, economic activity responds predominantly to their own innovations in positive mechanism {+}.

3.3. Specification B: Responses by Long-term Restrictions

For a specification of long-term restrictions, unlike the findings of short-term mechanisms, the dependence on natural resources, on the real exchange rate are the main source of variability in the medium-term (variability between 37% and 64%) with real appreciation response **{-};** other secondary sources of variability focus on innovations of real growth in economic activity (52% Q1) and the variation of the tradable/non-tradable sector (around 22% of maximum variability, quarter 1), both with effect of real depreciation {+} (Appendices 5, Specification B and 7).

The response of the tradable sector in terms of non-tradable sector, same responds negatively to a greater magnitude in domestic demand (39% quarter 1) {-} and positively disturbances for both real economic activity (34%) for real exchange rate (24% in the quarter 1) **{+}.**

By long-term specification, positive shocks in the dependence on natural resources influence positively on the variance of real growth in economic activity (between 44 and 77% of variability), meaning that this factor is the largest source of variation **{+}.**

3.4. Specification C: Responses against Negative Shocks

As a third simulation exercise (Appendix 8), the responses of the endogenous variables in the face of negative shocks to one standard deviation in dependence on natural resources system were evaluated; for the percentage variation of the boom sector; In the percentage variation of the internal demand, as well as of its own shocks.

The results suggest that through various negative shocks; the real exchange rate tends to depreciate as a general rule {+}; the tradable goods sector tends to increase in terms of non-tradable {+} sector only against negative shocks of real economic activity and their response is negative against various disturbances {-}; finally, the real economic activity responds negatively among various disturbances {-} in the following order of importance: (a) Negative shock of boom sector; (b) shock of real appreciation; (c) negative shock of domestic demand; (d) relative decrease in tradable/non-tradable; (e) in the same magnitude, own shocks and NRD (the last factor).

In sum, long-term estimates have more significant effects compared to short-term inferences. Contemporary innovations long-term empirical evidence supports the theoretical representation given in Figure 3 for Bolivia (boom-TNT model). The NRD has no effect on the real exchange rate in the short-term, but in the long-term with real appreciation.

In the long-term, positive shocks of domestic demand tend to appreciate the real exchange rate. The changes in the tradable sector in terms of the non-tradable sector depend directly on the changes in the real exchange rate. Finally, the dependence on natural resources exerts asymmetric effects on real economic activity: Greater and directly in the presence of positive shocks and negative response, but less severe due to negative shocks (in the extent of smaller quantity).

4. DISCUSSION

In the sense of NRD as a measure of the share of exports in natural resources, the curse of natural resources argues that there is a negative impact on economic growth (DD effect): By increasing domestic demand (non-tradable goods), appreciation of the real exchange rate and symptoms of contraction in the tradable sector.

A relevant question to answer is when an economy actually depends on natural resources. As a general rule, three guidelines can be inferred with an arbitrary threshold of 20% that is similar to fiscal dependence on natural resource revenues (Baunsgaard et al., 2012 ; Banegas & Vergara, 2014): (i) Level of export concentration in natural resources; (ii) variability in economic activity generated by natural resources; (iii) strong link between changes in the real exchange rate and structural variations relative to tradable/non-tradable sector.

The basic characteristics of the DD and NRD are applicable in a small open economy (Bolivia case) (Table 1); however, its implications for economic activity are different in the presences during positive and negative shocks by long-term responses: Positive innovations tend to be more pronounced in upturns compared to the recessionary times phases.

This is coincident with Barja and Zavaleta (2016) in the sense that the boom industry (natural gas and oil) tends to behave with the line of countries rich in natural resources, therefore, the administration of the economic boom is an opportunity for economic growth, meaning that the effects of blessings are greater than the effects of nature resource curse in Bolivia; however, for the present case study, there is evidence of DD syndrome.

4.1. Research Agenda and Implications for Public Policy

Another relevant question to answer is about what to do after identifying DD conditions? How to reverse the process of DD? Within the paper limitations, there are some omissions related to current account deficit, which is rescheduled for future research work from the neo-Keynesian perspective (external constraint to economic growth).

For public policy implications, adjusting the real exchange rate is highlighted against a progressive and widespread deterioration in real economic activity, a negative shock in boom sector and dependence on natural resources[5].

Also, against various negative shocks in natural resources, becomes relevant sectoral respond to disruptions of oil, natural

5 The real change for Bolivia is considered as an adjustable variable rather than a policy to encourage the competitiveness of the external sector, this is considered because of the failure of the Marhsall-Lerner condition in Bolivia (Banegas, 2016).

Table 1: Comparison with previous studies in Bolivia. Dutch disease or natural resource dependence

Authors	Period of analysis	Methodology	Natural resource variable(s)	Main inferred conclusion
Cerutti and Mansilla (2008)	1990-2006	Cointegration	Term of trade	Evidence of Dutch Disease (DD) as its main symptom of the appreciation of real exchange rate for term of trade and productivity
De Mevius and Albarracín (2009)	1990-2006	Descriptive	Volume and Export prices	No Resource movement effect, not facing Dutch Disease (DD)
Cerezo (2014)	1990-2010	Cointegration	Oil price	No symptoms of DD in Bolivia
Borja and Zavaleta (2016)	2006	CGE model	Oil prices Mineral prices	Positive shocks with DD effects Mineral effects with DD and Resource natural curse implications (RNC) Gas Natural effects with natural resource dependence (NRD)
This paper***	2000-2015	SVAR, with three alternative specifications	Concentration of Natural resource exports Real growth of NR GDP Tradable (T) and Non-Tradable (NT) sector	Long-run estimates over short-term specifications for statistical significance Positive shocks with DD effects Greater implications on economic growth from negative effects of GDP growth of Natural Resources rather than concentration of natural resource exports (dependence)

***Own estimates and inference. CGE means Computable General Equilibrium model. NRD: Natural resource dependence, GDP: Gross domestic product, RNC: Resource natural curse, DD: Dutch disease, TNT: Tradable and non-tradable

gas and minerals compared to negative innovations in the concentration of exports of natural resources.

Finally, it is targeted for future research, the role in the diversification of industrialization as a possible policy to mitigate the DD syndrome.

5. CONCLUSIONS

In this paper two issues were presented: The first linked to the transmission channel between the dependence on natural resources and growth of a small open economy; the second related to the implications on the dynamics of the boom sector (B), tradable (T) and non-tradable (NT) on the real growth of economic activity, as also in situations of negative shocks.

In this regard, the theoretical framework of tradable (T) and non-tradable (NT) model was addressed to Bolivia, comparing short and long – term specifications, as the presence of negative shocks for the quarterly period from 2000 to 2015.

By proposing empirical strategy, it helps to explain the channel transmission with long - term dominance over short - term effects from the perspective of statistical significance. Moreover, the responses from the shocks of natural resource are asymmetric (different) with greater effect in boom times rather than periods of negative shocks.

For the first raised question, the overall evidence for the case study shows empirical support that a positive shock in NRD increases the boom sector in natural resources and generates positive innovations in domestic demand. In turn, the real exchange rate tends to be appreciated, and the tradable sector tends to contract in terms of non-tradable sector.

Positive shocks in dependence on natural resources generate positive effects on real growth of economic activity (with a variance explained between 44 and 70%). By contrary, against various negative shocks (dependence on natural resources, boom, economic activity and domestic demand), the real exchange rate reacts with real depreciation response widely; also, the tradable sector expands in terms of non-tradable against a fall in real economic activity.

For the second question about the negative effects on growth of economic activity, it responds more negatively with the fall of the boom sector compared with the relative decline of tradable/non-tradable sector and compared with negative shocks in the dependence on natural resources.

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APPENDICES

Appendix 1: Variable operationalization

Construct	Variable operationalization	Source of information
NRD	Natural resource exports as a percentage of total exports, both measured as weight in tonnes	National Institute of Statistics (INE)
Sector boom	(Hydrocarbons + mining sector GDP)/GDP at market prices	National Institute of Statistics (INE)
Tradable sector (T)	(Ind. Manufacturing + trade + agricult. Hunting and fishing GDP)/GDP at market prices	National Institute of Statistics (INE)
Non-tradable sector (NT)	(Sectoral GDP of construction, financial institutions, electricity, gas and water services, public administration, transport and communications + indirect taxes)/GDP at market prices	National Institute of Statistics (INE)
Domestic demand	(Gov. Cons. + Priv. Cons. + Gross. Inv. + Var.Ex.)/GDP at market prices	National Institute of Statistics (INE)
Participation of relative sector TNT	Tradables sector (T) in terms of non-tradable sector (NT)	Own calculations from the National Institute of Statistics (INE)
Foreing demand	Export index (base year=2005)	Own calculations from the National Institute of Statistics (INE)
Oil prices	Index oil prices (base=2005 years), average of WTI, Dubai and brent index	International Monetary Fund
Trade liberalization	(Exports+imports)/GDP at market prices	Own calculations from the National Institute of Statistics (INE)

GDP: Gross domestic product, NRD: Natural resource dependence, TNT: Tradable and non-tradable

APPENDIX 2: DESCRIPTIVE STATISTICS

Appendix 2A: Statistics on levels

Indicators	Nat. Res. Depend.	Boom sector	Domestic demand	Reer	Sector TNT	Oil prices	Trade liberalization
	Xnat.Res./total X	YNat. res./Y	Dom.Dem./Y	Index	YT/YNT	Index (base year=2005)	(X+M)/Y
Media	0.86	0.11	1.00	92.88	0.70	64.40	0.63
Median	0.87	0.11	1.00	93.71	0.72	60.99	0.65
Maximum	0.92	0.13	1.06	113.03	0.75	114.44	0.73
Minimum	0.64	0.09	0.93	61.44	0.62	20.03	0.52
SD	0.05	0.01	0.03	13.99	0.04	30.82	0.06
Asymmetry	−2.05	−0.29	−0.28	−0.37	−0.72	0.16	−0.32
Kurtosis	7.48	1.61	2.59	2.44	2.16	1.61	1.99
Jarque-Bera	98.18***	6.09**	1.27	2.27	7.35**	5.41*	3.81
Observation	64	64	64	64	64	64	64

Significance level: ***At 1%; **at 5%; *at 10%. SD: Standard deviation, TNT: Tradable and non-tradable

Appendix 2b: Statistics for first difference

Indicators	ΔTrade liberal	ΔBoom sector	ΔForeign demand	ΔDom. demand	ΔNat. Res. Depend.	ΔOil prices	ΔReer	ΔSectoral TNT	ΔGDP
Media	0.24	0.32	3.18	−0.07	0.42	0.71	−0.69	−0.22	1.07
Median	0.48	0.76	3.09	−0.13	−0.01	3.27	−0.58	−0.46	1.10
Maximum	10.39	10.66	22.51	7.05	8.92	25.15	6.78	3.87	3.44
Minimum	−14.73	−9.53	−21.92	−6.78	−5.06	−66.32	−11.20	−2.98	−1.68
SD	4.80	3.65	7.30	2.58	2.43	14.68	2.98	1.48	1.06
Asymmetry	−0.40	−0.24	−0.02	0.10	0.92	−1.92	−0.56	0.52	−0.54
Kurtosis	3.53	3.83	4.57	3.36	5.18	8.78	4.70	2.80	3.34
Jarque–Bera	2.42	2.40	6.46**	0.43	21.30***	126.17***	10.89***	2.91	3.37
Observations	63	63	63	63	63	63	63	63	63

Significance level: ***At 1%; ** at 5%; * at 10%. SD: Standard deviation, GDP: Gross domestic product

Appendix 3: Correlations

Probabilidad	ΔTrade Liberal	ΔBoom sector	ΔForeign demand	ΔDom. demand	ΔNat. Res. Depend.	ΔOil Prices	ΔReer	ΔSectoral TNT	ΔGDP
ΔTrade liberal	1.00								
ΔBoom sector	0.16	1.00							
ΔForeign demand	0.02	0.49***	1.00						
ΔDom. demand	0.06	−0.12	−0.15	1.00					
ΔNat. Res. Depend.	0.01	0.19	0.24*	−0.01	1.00				
ΔOil prices	0.35***	0.26**	−0.05	−0.03	0.26**	1.00			
ΔReer	0.22*	0.12	0.25*	−0.20	0.22*	0.47***	1.00		
ΔSectoral T/NT	−0.21*	0.26**	0.10	−0.19	0.23*	0.13	0.21*	1.00	
ΔGDP	−0.08	0.07	−0.05	−0.02	0.02	0.14	0.10	0.09	1.00

Significance level: ***At 1%; **at 5%; *at 10%. GDP: Gross domestic product

Appendix 4: Structural estimates (SVAR)

Adjusted sample: 2001 (T3) - 2015 (T4)

Specification A: Short-term model

$$\begin{bmatrix} 1.00 & & & & & \\ 0.11 & 1.00 & & & & \\ -0.17 & 0.00 & 1.00 & & & \\ 0.08 & 0.12 & 0.16 & 1.00 & & \\ -0.09 & -0.08 & -0.11^{*} & -0.12 & 1.00 & \\ -0.09 & -0.04 & 0.04 & -0.02 & 0.05 & \end{bmatrix} \begin{bmatrix} \varepsilon\,\Delta\text{Nat.Res.Depen.} \\ \varepsilon\,\Delta\text{Boom sector} \\ \varepsilon\,\Delta\text{Domestic Dem.} \\ \varepsilon\,\Delta\text{Reer} \\ \varepsilon\,\Delta\text{T/NT} \\ \varepsilon\,\Delta\text{Y} \end{bmatrix} = \begin{bmatrix} 0.02^{***} & & & & & \\ & 0.03^{***} & & & & \\ & & 0.02^{**} & & & \\ & & & 0.02^{***} & & \\ & & & & 0.01^{***} & \\ & & & & & 0.01^{***} \end{bmatrix} \begin{bmatrix} \mu\text{ dependence} \\ \mu\text{ boom} \\ \mu\text{ domestic demand} \\ \mu\text{ Relative prices} \\ \mu\text{ T/ NT} \\ \mu\text{ real growth} \end{bmatrix}$$

*Significance level:*** at 1%; ** at 5%; * at 10%*

Specification B: Short-term model

$$\begin{bmatrix} \varepsilon\,\Delta\text{Nat.Res.Depen.} \\ \varepsilon\,\Delta\text{Boom sector} \\ \varepsilon\,\Delta\text{Domestic Dem.} \\ \varepsilon\,\Delta\text{Reer} \\ \varepsilon\,\Delta\text{T/NT} \\ \varepsilon\,\Delta\text{Y} \end{bmatrix} = \begin{bmatrix} 0.11^{***} & & & & & \\ 0.34^{***} & 0.04^{***} & & & & \\ 0.09^{***} & 0.00 & 0.01^{***} & & & \\ -0.29^{***} & -0.02^{***} & -0.02^{***} & 0.03^{***} & & \\ -0.01^{***} & 0.01^{***} & -0.01^{***} & 0.01^{***} & 0.01^{***} & \\ 0.05^{***} & 0.04^{***} & 0.004^{**} & -0.004^{***} & -0.003^{**} & 0.004^{***} \end{bmatrix} \begin{bmatrix} \mu\text{ dependence} \\ \mu\text{ boom} \\ \mu\text{ domestic demanc} \\ \mu\text{ Relative prices} \\ \mu\text{ T/ NT} \\ \mu\text{ real growth} \end{bmatrix}$$

*Significance level:*** at 1%; ** at 5%; * at 10%*

Appendix 5: Structural variance decomposition. Adjusted sample: 2001 (T3)-2015 (T4)

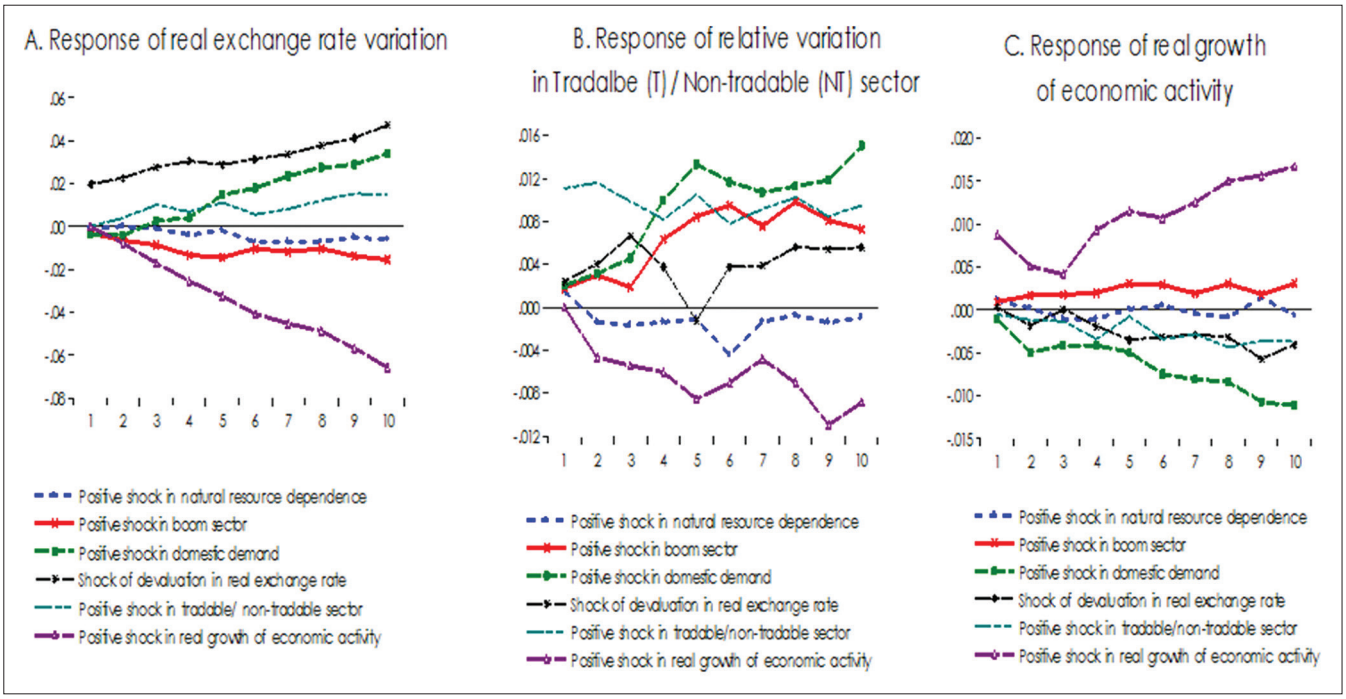
Specification A: Short-term model							Specification B: Long-term model						
Decomposition of Δreal effective exchange rate							Decomposition of Δreal effective exchange rate						
Quarters	Innovations						Quarters	Innovations					
	Δ Nat. Res. Depend	Δ Boom sector	Δ Dom. demand	ΔT/NT relative sector	Δ Reer	ΔGDP		ΔNat. Res. Depend.	ΔBoom sector	ΔDom. demand	ΔSectoral T/NT	ΔReer	ΔGDP
1	1	2	3	94	0	0	1	4	1	3	19	22	52
4	2	6	7	51	7	27	4	37	3	5	11	15	28
8	4	5	18	35	10	28	8	46	5	4	8	17	21
12	3	5	20	29	8	35	12	55	5	3	7	14	16
16	3	4	21	27	8	37	16	60	4	3	6	12	14
20	2	4	22	25	7	39	20	64	4	3	5	11	13
Decomposition of ΔTNT relative sector							Decomposition of ΔTNT relative sector						
Quarters	Innovations						Quarters	Innovations					
	ΔNat. Res. Depend.	ΔBoom sector	ΔDom. demand	ΔSectoral T/NT	ΔReer	ΔGDP		ΔNat. Res. Depend.	ΔBoom sector	ΔDom. demand	ΔSectoral T/NT	ΔReer	ΔGDP
1	2	2	3	4	89	0	1	7	0	39	0	20	34
4	4	10	15	9	52	9	4	17	5	24	4	19	30
8	8	10	14	20	37	11	8	15	9	21	8	21	26
12	8	10	15	19	34	15	12	17	8	20	8	23	25
16	8	10	15	18	34	15	16	17	9	19	8	24	24
20	8	10	15	18	34	15	20	17	9	19	8	23	23
Decomposition of Δeconomic activity							Decomposition of Δeconomic activity						
Quarters	Innovations						Quarters	Innovations					
	ΔNat. Res. Depend.	ΔBoom sector	ΔDom. demand	ΔSectoral TNT	ΔReer	ΔGDP		ΔNat. Res. Depend.	ΔBoom sector	ΔDom. demand	ΔSectoral TNT	ΔReer	ΔGDP
1	1	1	1	0	0	96	1	70	1	1	12	10	5
4	2	1	11	8	3	74	4	52	2	6	14	19	7
8	3	2	12	7	11	64	8	47	3	8	12	22	8
12	7	4	14	11	9	55	12	44	8	7	13	19	8
16	8	4	14	12	11	51	16	43	9	7	12	21	8
20	8	4	15	12	10	51	20	44	9	7	12	20	8

Structural factorization. ***Estimates free of autocorrelations, heteroscedasticity and multivariate non-normal residual distributions. Shaded areas with innovations equal or greater than 20% (arbitrary threshold). GDP: Gross domestic product, TNT: Tradable and non-tradable

Appendix 6: Specification A: Accumulated response by short-term SVAR model

Versus positive structural shocks (one standard deviation)

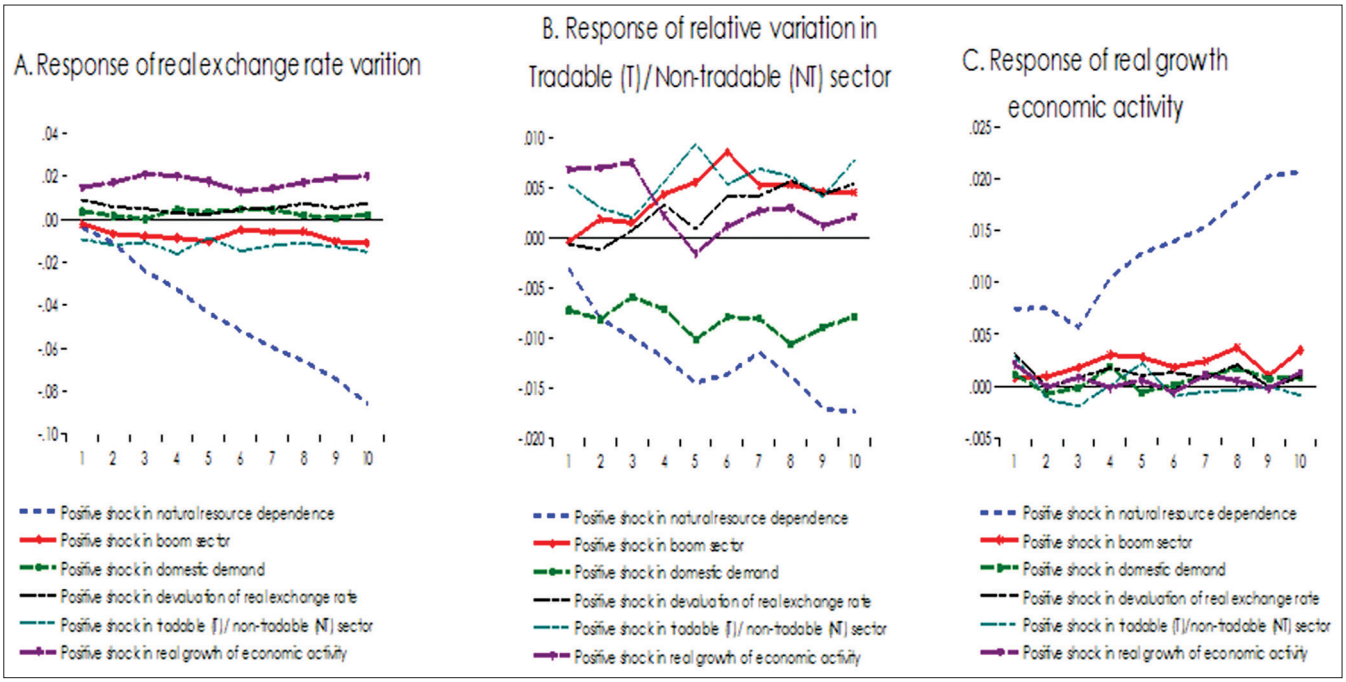
Quarters ahead.



Appendix 7: Specification B: Accumulated response by long-term SVAR model

Versus positive structural shocks (one standard deviation)

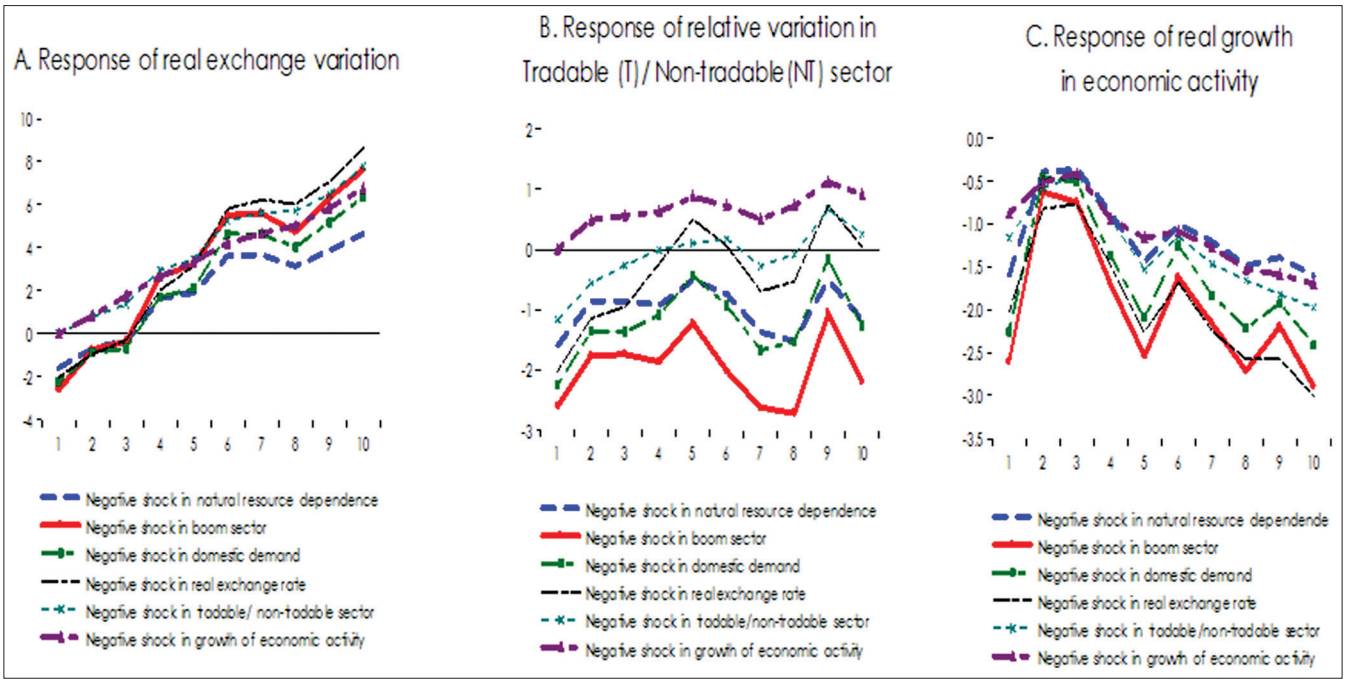
Quarters ahead



Appendix 8: Specification C: Accumulated response

Against shocks negative (One standard deviation for each variable)

Quarters ahead



Appendix 9a: VAR order selection criteria

Sample: 2000Q1 2015Q4						
Included observations: 58						
Laga	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	904.6011	NA	2.62E-21	−30.36555	−29.51296*	−30.03345*
1	945.772	68.14493*	2.23e-21*	−30.54386	−28.41237	−29.7136
2	980.2096	49.87516	2.52E-21	−30.48999	−27.0796	−29.16157
3	1011.757	39.16186	3.42E-21	−30.33644	−25.64715	−28.50986
4	1039.954	29.1694	5.96E-21	−30.06737	−24.09919	−27.74264
5	1096.334	46.6595	4.88E-21	−30.77014*	−23.52306	−27.94725

*Indicates lag order selected by the criterion. LR: Sequential modified LR test statistic (each test at 5% level). FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion

Appendix 9b: Stability of VAR model

Roots of characteristic polynomiala	
Lag specification: 1 5	
Root	**Modulus**
0.937498+0.031618i	0.938031
0.937498−0.031618i	0.938031
−0.887662+0.257454i	0.924243
−0.887662−0.257454i	0.924243
0.185997−0.897418i	0.91649
0.185997+0.897418i	0.91649
−0.114291−0.897561i	0.904808
−0.114291+0.897561i	0.904808
−0.711584+0.551699i	0.900402
−0.711584−0.551699i	0.900402
0.465758−0.747187i	0.880465
0.465758+0.747187i	0.880465
−0.398573+0.781729i	0.877474
−0.398573−0.781729i	0.877474
0.498857−0.577817i	0.763368
0.498857+0.577817i	0.763368
−0.651614+0.392964i	0.760935
−0.651614−0.392964i	0.760935
0.634392+0.335557i	0.717671
0.634392−0.335557i	0.717671
−0.317601+0.637579i	0.712304
−0.317601−0.637579i	0.712304
0.322550+0.617984i	0.697096
0.322550−0.617984i	0.697096
−0.652780−0.078287i	0.657457
−0.652780+0.078287i	0.657457
−0.393588+0.484139i	0.623941
−0.393588−0.484139i	0.623941
0.552093+0.186145i	0.582629
0.552093−0.186145i	0.582629

No root lies outside the unit circle. VAR satisfies the stability condition

Appendix 9c: Multivariable normal distribution of residuals

Null hypothesis: Residuals are multivariate normal				
Sample: 2000Q1 2015Q4.				
Included observations: 58				
Component	**Skewness**	**Chi-square**	**df**	**Prob.**
1	(0.15)	0.22	1.00	0.64
2	(0.19)	0.35	1.00	0.56
3	0.36	1.24	1.00	0.27
4	(0.10)	0.10	1.00	0.75
5	0.36	1.27	1.00	0.26
6	(0.55)	2.90	1.00	0.09
Joint		6.08	6.00	0.41
Component	**Skewness**	**Chi-sq**	**df**	**Prob.**
1	2.62	0.35	1.00	0.55
2	2.66	0.28	1.00	0.59
3	3.60	0.87	1.00	0.35
4	2.90	0.02	1.00	0.87
5	2.74	0.17	1.00	0.68
6	3.32	0.25	1.00	0.62
Joint		1.94	6.00	0.93
Component	**Jarque-Bera**	**df**	**Prob**	
1	0.57	2.00	0.75	
2	0.63	2.00	0.73	
3	2.11	2.00	0.35	
4	0.13	2.00	0.94	
5	1.44	2.00	0.49	
6	3.15	2.00	0.21	
Joint	8.02	12.00	0.78	

Appendix 9d: No autocorrelation at LAG order

Null hypothesis: No serial correlation at lag order h		
Lags	**LM-Statics**	**P**
1	34.32136	0.5486
2	33.53376	0.5865
3	21.05078	0.9777
4	46.16243	0.1195
5	40.32655	0.2848
6	31.46152	0.6843

Probs from Chi-square with 36 df