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The Dutch disease revisited: consistency of theory and evidence

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Abstract
The Dutch disease literature reveals several gaps between empirical evidence and theoretical predictions. To bridge such gaps, I develop a model that accounts for uneven spillovers of technological progress from the resource sector to other domestic sectors. I then employ a dynamic panel approach to align the theory with the data. I find that the real exchange rate appreciation resulting from a resource boom (i.e., the spending channel) is more pronounced in resource-poor countries than in resource-rich countries. Additionally, the resource movement channel exhibits differences between resource-rich and resource-poor countries. In resource-rich countries, a resource boom reduces the growth rate in the manufacturing sector more than in the service sector, leading to a decrease in relative sectoral output and a slowdown in economic growth. On the other hand, in resource-poor countries, a resource boom accelerates the growth of the manufacturing sector and decelerates the growth of the service sector, resulting in an increase in relative sectoral output and economic growth.

Keywords Resource boom · Dutch disease · Real exchange rate · Sectoral output · Economic growth · Resource-rich and poor countries

JEL Classification C33 · O11 · O13 · O15

1 Introduction

Why do natural resources countries tend to experience slower growth than those without? What were the factors contributing to Sierra Leone's economic growth deceleration to an average of 37% between 1971 and 1989 (Humphreys et al. 2007)? Similarly, what has caused per capita income stagnation in Nigeria over a span of forty years (Sala-i Martin and Subramanian 2013)? Overall, why have resource-rich countries generally failed to exhibit better economic performance than others?

In recent decades, these questions have attracted increasing attention from researchers. The Dutch disease hypothesis serves as a conventional explanation for these inquiries. The

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seminal work introduced by Corden and Neary (1982), and subsequent contributions by Van Wijnbergen (1984), Krugman (1987), Sachs and Warner (1995), Torvik (2001), Bjørnland and Thorsrud (2016), and Bjørnland et al. (2019), strives to elucidate the Dutch disease mechanism in natural resource countries. A body of empirical research provides supporting evidence for the predictions proposed by this theory, as evident in studies by Sachs and Warner (2001), Ismail (2010), and more recently, Harding et al. (2020).

A helpful initial step is to outline the overarching mechanism of the Dutch disease. This can be illustrated using a two-sector small open economy framework, where the labor force is fully employed and moves freely between the traded and non-traded sectors.[1] The model highlights two effects: the spending effect and the resource movement effect. A resource boom increases national income, thereby expanding the demand for both traded and non-traded goods. While the price of traded goods is determined exogenously by the international market, the relative price of non-traded goods to traded goods must rise to counterbalance the increased demand for non-traded goods (i.e., the spending effect). An appreciation in relative prices elevates the real wage of labor employed in the non-traded sector relative to the traded sector. This triggers labor to move from the traded sector to the non-traded sector (i.e., the resource movement effect). Consequently, the traded sector contracts, and the non-traded sector expands, leading to de-industrialization.

While the static framework might explain the Dutch disease mechanism in the short term, it would be more realistic to investigate the long-term dynamic mechanism driven by learning by doing (*LBD*). Evidence suggests that, in the long run, the traded sector gains more from *LBD* effects (Ulku 2004). Therefore, the non-resource traded sector, hit by worsening competitiveness, is unlikely to fully recover once the resource income runs out (Van der Ploeg 2011). In a preliminary attempt, Van Wijnbergen (1984) examined a two-period, two-sector model in which future productivity in the traded sector becomes increasingly dependent on the current output of the same sector. Krugman (1987) later postulated, within an increasing returns to scale model, that only labor in the traded sector contributes to the generation of learning. Lucas (1988) introduced a model where both sectors generate learning, but with no spillover between them. While Sachs and Warner (1995) and Gylfason et al. (1999) assumed that learning generated by labor employment in the traded sector spills over perfectly to the non-traded sector. These models demonstrate that the learning process drives endogenous growth in both sectors. A natural resource boom reduces labor's share in the traded sector, hampers learning by doing (*LBD*), and potentially retards economic growth.

As one of the most influential studies, Torvik (2001) proposed a general model in which both sectors can contribute to the learning process, and there are imperfect learning spillovers between these sectors. The model demonstrates that a resource boom tends to depreciate the steady-state real exchange rate, while steady-state economic growth remains independent of a resource boom. Bjørnland and Thorsrud (2016) further developed the aforementioned model by assuming that external productivity spills over from the booming resource sector to other domestic sectors. The model concludes that a resource boom tends to accelerate steady-state growth rates at both the national and sectoral levels;

[1] According to the standard Dutch disease model proposed by Corden and Neary (1982), the model consists of three sectors: the booming sector, lagging sectors that produce traded goods, and the non-traded sector that produces service goods.

however, it still leads to the depreciation of the steady-state real exchange rates.[2] In a three-sector framework, Bjørnland et al. (2019) extended the earlier literature by incorporating the effects of resource movement, endogenous sectoral productivity, and the possibility of learning spillovers. Their findings, supported by empirical evidence from Norway, demonstrate that an increase in oil prices may yield results similar to those found in Torvik (2001). Nevertheless, greater oil activity enhances productivity in most industries. Despite this, the model reaches the same conclusion as Torvik (2001) regarding the steady-state real exchange rate and economic growth.

While there is an extensive empirical literature on the Dutch disease, it can be broadly divided into three main categories. Firstly, there are those that concentrate on the connection between proxies of resource booms and growth rates at both the national and sectoral levels. Secondly, there are those that analyze the spending effect, and thirdly, there are those that examine the resource movement effect.

The influential works of Sachs and Warner (1995, 2001), Rodriguez and Sachs (1999) represent a body of empirical literature that examines the relationship between resource rents and economic growth.[3] In a cross-section of countries during 1970–1990, Sachs and Warner (2001) demonstrated that a 10% increase in the ratio of natural resource exports (% of GDP) is associated with a 0.4–0.7% lower annual per capita GDP growth. In recent studies, researchers have used panel data instead of a cross-sectional approach to alleviate concerns about omitted variable bias. Among these studies, some have shown that a natural resource boom hampers institutional development, consequently hindering economic growth [e.g., Murshed (2004); Collier and Hoeffler (2005); Mehlum et al. (2006)].

Furthermore, by utilizing annual data for 81 manufacturing sectors in 90 countries spanning the period 1977–2004, Ismail (2010) demonstrated that a 10% increase in oil prices, on average, slows down the manufacturing growth rate by 3.4%.[4] Similarly, Apergis et al. (2014) examined the impact of oil rents on agricultural value-added using a panel of *MENA* countries for the period 1970–2011. Their findings indicate a long-term negative relationship between oil rents and agricultural value added. Moreover, additional evidence for 135 countries from 1975 to 2007 reveals that windfall income from natural resources leads to a 30% increase in savings, a 35–70% reduction in non-resource exports, and a 0–35% expansion of non-resource imports (Harding and Venables 2016).

A group of studies exclusively examines the spending effect. Convincing evidence that supports the positive impact of commodity price increases on the real exchange rate has been documented by Koranchelian (2005) in Algeria, Zalduendo (2006) in Venezuela, Oomes and Kalcheva (2007) in Russia, and Beine et al. (2012) in Canada. Moreover, Cashin et al. (2004) analyzed a panel of 58 commodity-exporting countries spanning from

[2] Bjørnland and Thorsrud (2016) use a Bayesian Dynamic Factor Model (BDFM) for Australia and Norway as representative case studies. Their results are twofold: (1) a resource boom has significant and positive productivity spillovers in non-resource sectors, and (2) there is a two-speed transmission phase in which the non-traded sector expands faster than the traded sector.

[3] Two different criteria are utilized to categorize economies based on their natural resources: (1) resource dependence, which measures the value of natural resources as a percentage of GDP or total national wealth, and (2) resource abundance, which gauges the per capita stock of natural resource wealth. Empirical studies covering a comprehensive range of countries indicate that the abundance of natural resources positively influences economic performance [see Brunnschweiler and Bulte (2008); Alexeev and Conrad (2009); Esfahani et al. (2013); Cavalcanti et al. (2011)].

[4] Several studies [e.g., Rajan and Subramanian (2011) among others] focus on foreign aid instead of resource rents, and they conclude that foreign aid contributes to slower growth in the manufacturing sector.

1980 to 2002. Korhonen and Juurikkala (2009) studied a sample of 12 oil-exporting countries covering the period from 1975 to 2005, and Ricci et al. (2013) investigated a panel of 27 developing countries and 21 developed countries from 1980 to 2004. All three studies established a robust positive correlation between commodity prices and the real exchange rate.

On the contrary, a group of the existing literature focuses solely on the resource movement effect. Empirical evidence demonstrates that an appreciation in the real exchange rate leads to a slowdown in growth. This is evident in studies such as Aguirre and Calderón (2005), Eichengreen (2007), Rodrik (2008), Williamson (2009), Habib et al. (2017)—all well-known contributors to this subject. Regarding sectoral performance, Sekkat and Varoudakis (2000) investigated this relationship in a panel of major Sub-Saharan African countries spanning from 1970 to 1992. Their findings suggested that a depreciation in the real exchange rate enhances performance in manufacturing exports. Additionally, using a panel dataset encompassing 39 Latin American countries and 22 manufacturing sectors during the period 1995–2008, Vaz and Baer (2014) demonstrated a positive and substantial impact on the manufacturing sector arising from the undervaluation of the real exchange rate.

Among the limited number of studies on both channels, Lartey et al. (2012) investigated the Dutch disease effect of remittances as a significant capital inflow. They utilized a dynamic estimation method for a sample of 109 countries spanning the period 1990–2003. The findings indicate that remittance flows (i.e., remittances to GDP) lead to an appreciation of the real exchange rate, an increase in the share of the service sector, a decrease in the share of the manufacturing sector, and a reduction in the relative sectoral output level (manufacturing to service sector). Their estimates also reveal that the resource movement effect is more pronounced under fixed nominal exchange rate regimes. Recently, Harding et al. (2020) estimated the effects of oil and gas discoveries on bilateral real exchange rates, sectoral labor share, and labor productivity in 23 OECD countries over the period 1970–2013. Using a quasi-natural experiment, they show that a discovery worth 10% of a country's GDP results in a real exchange rate appreciation of 1.5% within ten years after the discovery. Moreover, a median discovery reduces the employment share in the manufacturing sector by 0.45%, while also increasing labor productivity in the traded sector by 1.8% and decreasing labor productivity in the non-traded sector by 0.3%.

This paper makes a substantial contribution to the existing literature in both theory and empirical methodology. First, I have developed a theoretical model to address major gaps between the predictions of Dutch disease dynamic models and empirical evidence. In contrast to empirical evidence, prevailing theories predict that a resource boom leads to the depreciation of the long-run real exchange rate and has either no effect or a positive impact on the long-run growth rate [e.g., Torvik (2001); Bjørnland and Thorsrud (2016)]. To address this, I introduce a two-sector growth model and assume the presence of learning by doing (*LBD*) in both sectors, along with spillovers between them. Additionally, I postulate that technological improvements are unevenly transferred from the resource sector to both domestic sectors. This novel aspect of the theory distinguishes the *LBD* mechanism from the one proposed in Torvik (2001), while retaining its core essence. The modified model demonstrates that a resource boom results in an appreciation of the real exchange rate (in the steady state) and stimulates the growth rate (in the steady state) at both the national and sectoral levels-outcomes not anticipated by previous models.

Second, this paper aims to test whether the spending and resource movement channels exhibit differences in resource-rich and resource-poor countries. The literature suggests that (i) these channels have been examined separately; (ii) less attention has been given to studying the impact of resource rents on sectoral growth, as opposed to GDP growth, within the context of resource movement channel analysis; and (iii) only a few studies have explored these channels for resource-rich and resource-poor countries, and/or discussed the disparities in resource rent mechanisms between them. To bridge these gaps in the existing literature, I employ a dataset that covers 152 countries and spans from 1970 to 2019. Initially, I investigate the impact of a resource proxy on the real exchange rate to explore the spending channel. Subsequently, for a more comprehensive examination of the resource movement channel, I analyze the effects of a resource proxy on growth rates within the manufacturing sector, the service sector, and the overall national economy, along with relative sectoral output. This approach allows me to delve into the mechanisms of resource rent within each category of resource-dependent countries.

Third, I examine the relationship between the key mechanism variables using an estimation method and data specifications that differ from those of prior studies. The adopted estimation procedure in this study is designed to address notable concerns. Several explanatory variables are jointly determined with the dependent variables. To tackle this challenge, I implement a generalized method of moments (*GMM*) model that addresses the endogeneity issue by employing lag differences and levels of explanatory variables as internal instruments. Regarding data specifications, earlier studies employ alternative proxies to represent a resource boom, including commodity prices, resource discoveries, or resource rents (% of exports). In contrast, this paper employs a distinct proxy for this variable: the total natural resource rent (% of GDP). This choice aligns with the theory and introduces a novel feature to the paper.

Fourth, empirical evidence that aligns with the theory significantly contributes to the literature. The primary findings reveal distinctions in the resource rent mechanism between resource-rich and resource-poor countries. Both groups experience a real exchange rate appreciation due to a resource boom, but this appreciation is more pronounced in resource-poor countries than in resource-rich ones. Furthermore, within resource-rich countries, the main driver behind productivity growth in domestic sectors is the *LBD* effect. As a result, a resource boom reduces the growth rate in the manufacturing sector more than in the service sector. This, in turn, leads to a lower relative sectoral output and slower economic growth. In contrast, resource-poor countries experience the primary driver of productivity growth in the manufacturing sector as the resource spillover effect. In these countries, a resource boom accelerates growth in the manufacturing sector while slowing down growth in the service sector. This, in turn, leads to an increase in relative sectoral output and faster economic growth. The empirical results contradict the predictions of the prevailing theoretical models developed by Sachs and Warner (1995), Torvik (2001), Bjørnland and Thorsrud (2016), but are entirely consistent with the theoretical predictions of my model.

Finally, to the best of my knowledge, this is the first study to employ net foreign assets (% of GDP) as a proxy for the resource rent variable. Evidence indicates that long-run net foreign assets are positive in most natural resource-rich countries (Lane and Milesi-Ferretti 2007). This potentially signifies the influence of natural resource rents on the real exchange rate through the international payment's transmission channel (i.e., the transfer problem). Hence, if the transfer problem is paraphrased as a long-term change in natural resource income, it can offer additional evidence supporting the real exchange rate appreciation.

The rest of the paper is structured as follows: Sect. 2 introduces a developed theory, Sect. 3 conducts an empirical study, Sect. 4 discusses a cohesive and integrated approach between theory and empirics, and Sect. 5 concludes the paper.

2 A Developed Model of the Dutch Disease

Consider a two-sector economy: Manufacturing (Traded) and service (non-Traded), indexed by M and S respectively. Assume there are no assets and capital accumulation. The labor force is the only production factor and it can move freely across sectors.I normalize the total labor force to one: $L_M + L_S = 1$, where L_M and L_S denote the labor shares in the manufacturing and service sectors, respectively. As in Matsuyama (1992) and Torvik (2001), the production function in each sector operates under decreasing returns to scale, $X_M = A_M L_M^{\alpha}$, and $X_S = A_S L_S^{\alpha}$, where A_J, $J = \{M, S\}$ is total factor productivity in sector J. To simplify the calculations, I assume the labor intensity (α) is equal in both sectors.

The price of manufacturing goods is normalized to unity. Thus, the price of service goods, denoted by P, represents the real exchange rate. Total income in an economy, denoted as Y, will now be the sum of the value of manufacturing goods, X_M, service goods, PX_S, and total resource rent, $NR = A_M R$, where NR is measured in manufacturing goods' units, as in Torvik (2001). This formulation prevents the resource rent from losing value relative to total income as the economy grows.[5]

Finally, we assume productivity in the sectors to have the following growth rates:

$$\frac{\dot{A}_M}{A_M} = \delta_M L_M + \gamma_S \delta_S L_S + \delta_{RM}(R) \tag{1a}$$

$$\frac{\dot{A}_S}{A_S} = \gamma_M \delta_M L_M + \delta_S L_S + \delta_{RS}(R). \tag{1b}$$

The productivity growth rate of a unit of labor employed in sector J is denoted by δ_J ($J = M, S$). The constant $0 < \gamma_J < 1$ measures a fraction of the learning generated in sector J and spills over into another sector. Improvements in natural resource extraction caused by external factors, such as technology transfer, are likely to lead to productivity spillovers in domestic sectors. For example, complex technical processes for offshore oil (gas) exploitation or shale oil extraction can generate positive knowledge externalities that, in turn, benefit domestic sectors. This assumption is based on recent literature documenting strong positive spillovers from the resource sector to other sectors [see Weber (2012); Feyrer et al. (2017); Allcott and Keniston (2018); Bjørnland et al. (2019)]. Hence, the spillover effects from the exogenous resource sector to the manufacturing and service sectors are respectively governed by $\delta_{RM}(R) > 0$ and $\delta_{RS}(R) > 0$.

Furthermore, it is reasonable to assume that technological progress in the resource sector shifts the resource process activity (i.e., resource boom). Thus, increased resource activity can be translated as technological progress, so that the more resource rents are produced, the more productivity spills over to domestic sectors [i.e., $\delta'_{RM}(R) > 0$ and $\delta'_{RS}(R) > 0$].[6]

[5] The other alternatives are the measurement of NR in the service goods' unit or as a fraction of total income. Hence, R denotes total natural resource rent relative to the productivity level (i.e, $R = \frac{NR}{A_J}$, where $J = \{M, S\}$) or the income level (i.e, $R = \frac{NR}{Y}$). However, the qualitative outcomes of the model remain consistent regardless of these selections.

[6] This general *LBD* model (i.e., Eq. 1) can also capture the earlier literature: Krugman (1987) represents the case where $\delta_{RS} = \delta_{RM} = \delta_S = \gamma_M = \gamma_S = 0$, while Lucas (1988) assumes the case where $\delta_{RS} = \delta_{RM} = \gamma_S = \gamma_M = 0$. Additionally, it can be simplified to the model proposed in Sachs and Warner

From the demand perspective, a representative household maximizes the utility function with a constant elasticity of substitution, σ, subject to the budget constraint ($PC_S + C_M = C = Y$). Now, I characterize two combinations of the real exchange rate (P) and the labor share in the service sector (L_S) to determine the static equilibrium of the model. The first combination is derived by equalizing marginal labor productivity between sectors, which represents the equilibrium in the labor market, the *LL*-curve. The second one is determined by the market-clearing condition in the service sector (i.e., $X_S = C_S$), which represents the equilibrium in the goods market, the *NN*-curve. The relative productivity ratio between the two sectors is defined as $\phi \equiv \frac{A_M}{A_S}$. Thus, the corresponding expressions are as follows:

$$P = \phi \left(\frac{L_S}{1 - L_S} \right)^{1-\alpha} \qquad \text{LL-curve} \tag{2a}$$

$$P = \phi^{\frac{1}{\sigma}} \left(\frac{\left(1 - L_S\right)^{\alpha} + R}{L_S^{\alpha}} \right)^{\frac{1}{\sigma}} \qquad \text{NN-curve} \tag{2b}$$

Now, it is worthwhile to investigate a balanced growth path, in which the productivity levels grow equally in both sectors. The growth rate of the relative productivity ratio is,

$$\frac{\dot{\phi}}{\phi} = \frac{\dot{A}_M}{A_M} - \frac{\dot{A}_S}{A_S} = \left[\left(1 - \gamma_M\right)\delta_M + \delta_R(R)\right] - \left[\left(1 - \gamma_M\right)\delta_M + \left(1 - \gamma_S\right)\delta_S\right] L_S(\phi, R). \tag{3}$$

where $\delta_R(R) = \delta_{RM}(R) - \delta_{RS}(R)$ is the gap in the resource spillover between sectors. The rate of change in the relative productivity ratio is governed by:

$$\frac{d\left(\dot{\phi}/\phi\right)}{d\phi} = -\left[\left(1 - \gamma_M\right)\delta_M + \left(1 - \gamma_S\right)\delta_S\right] \frac{dL_S(\phi, R)}{d\phi}. \tag{4}$$

Equation (4) states that a balanced growth path exists *if and only if* the labor share in the service sector increases as the relative productivity level goes up (i.e., $\frac{dL_S}{d\phi} > 0$). As shown in Torvik (2001), the stability of the dynamic system is satisfied, and thus a balanced growth path exists if $\sigma < 1$ holds (see Appendix A.1).[7]

When the stability condition is satisfied, the model possesses a stable solution for the relative productivity ratio, denoted by ϕ^*. The steady-state level of the labor share in the service sector is then as follows[8]

Footnote 6 (continued)
(1995) when $\delta_{RS} = \delta_{RM} = \delta_S = 0$ and $\gamma_M = 1$, in Torvik (2001) when $\delta_{RS} = \delta_{RM} = 0$, and in Bjørnland and Thorsrud (2016) when $\delta_{RS} = \delta_{RM} = \delta_R R$.

[7] When a Cobb-Douglas utility function is used (i.e., $\sigma = 1$), the vertical shifts of both the *LL* and *NN* curves are equal. Therefore, the labor share in the service sector remains independent of changes in ϕ (i.e., $\frac{dL_S}{d\phi} = 0$), thus leading to the existence of a set of growth paths.

[8] The steady-sate labor share in the manufacturing sector is $L_M^* = 1 - L_S^* :\Rightarrow L_M^*(\phi^*, R) = \frac{(1-\gamma_S)\delta_S - \delta_R(R)}{(1-\gamma_M)\delta_M + (1-\gamma_S)\delta_S}$.

$$L_S^*(\phi^*, R) = \frac{\left(1-\gamma_M\right)\delta_M + \delta_R(R)}{\left(1-\gamma_M\right)\delta_M + \left(1-\gamma_S\right)\delta_S}. \tag{5}$$

In Eq. (5), the steady-state labor share in the service sector is driven by both the direct and spillover effects of the *LBD* process, as well as the spillover effects of the resource process activity.[9] In earlier literature, the steady-state labor share in sectors remains unaffected by an exogenous shock to R. In models like those presented in Torvik (2001) and Bjørnland and Thorsrud (2016), the steady-state labor share in the service sector is determined by both the direct and indirect *LBD* effects: $L_S^*(\phi^*) = \frac{(1-\gamma_M)\delta_M}{(1-\gamma_M)\delta_M+(1-\gamma_S)\delta_S}$.[10]

Equation (5) also shows that a resource boom changes the steady-state labor share in the service sector,

$$\frac{dL_S^*}{dR} = \frac{\delta_R^{'}}{\left(1-\gamma_M\right)\delta_M + \left(1-\gamma_S\right)\delta_S} = \frac{\delta_{RM}^{'} - \delta_{RS}^{'}}{\left(1-\gamma_M\right)\delta_M + \left(1-\gamma_S\right)\delta_S}. \tag{6}$$

Equation (6) suggests that a resource boom increases (or decreases) the steady-state labor share in the service sector when the marginal spillover benefit of the resource process activity in the manufacturing sector (i.e., $\delta_{RM}^{'}$) is greater (or smaller) than that in the service sector (i.e., $\delta_{RS}^{'}$). To clarify the intuition, let's consider an economy initially in a steady state. A resource boom causes the labor force to shift from the manufacturing sector to the service sector. Over time, productivity levels change in both sectors, and the economy progresses towards a new steady state. The difference between the new steady-state level of the labor share in the service sector and its initial level depends on the gap in the marginal spillover benefit of the resource process activity ($\delta_R^{'}$). If there is no resource spillover effect, as shown in Torvik (2001), or if the effects are equal across sectors, as seen in Bjørnland and Thorsrud (2016), there is no gap in the marginal resource spillover benefit (i.e., $\delta_R^{'} = 0$). Consequently, the labor share in the sectors returns to its initial level in the long run. In the presented model, the gap in marginal resource spillover effects plays a pivotal role. With a positive (or negative) gap, the service (or manufacturing) sector benefits more, resulting in a higher (or lower) labor share in the service sector at the new steady-state level compared to the initial steady-state level.

I now analyze the impact of a resource boom on the growth rate of the relative productivity ratio. Considering Eq. (3), the derivative of the growth rate of the relative productivity ratio with respect to the resource rent (R) is given by:

$$\frac{d\left(\dot{\phi}/\phi\right)}{dR} = \delta_R^{'} - \left[\left(1-\gamma_M\right)\delta_M + \left(1-\gamma_S\right)\delta_S\right]\frac{dL_S(\phi, R)}{dR}. \tag{7}$$

[9] Unlike previous models, the presented model (i.e., Eq. 5) satisfies $0 \le L_S^* \le 1$ conditionally. This condition is met when, in absolute value terms, the gap in the resource spillover effects across sectors is greater than the gap in the direct and indirect effects of *LBD* generated by the manufacturing sector but smaller than the gap in the direct and indirect effects of *LBD* generated by the service sector [i.e., $-\left(1-\gamma_M\right)\delta_M \le \delta_R \le \left(1-\gamma_S\right)\delta_S$].

[10] The steady-state labor share in the service sector is solely affected by the direct *LBD* effects in Lucas (1988) model: $L_S^*(\phi^*) = \frac{\delta_M}{\delta_M+\delta_S}$. While, Krugman (1987) and Sachs and Warner (1995) models result in a corner solution $L_S^*(\phi^*) = 1$.

Referring to Eq. (7), when a resource boom causes a labor share in the service sector to become larger (smaller) than its steady-state level, the growth rate of the relative productivity ratio decreases (increases).[11] Further information about the dynamic Dutch disease is available in Appendix A.2.

Figure 1 illustrates the dynamic Dutch disease. The *LL*-curve (Eq. 2a) and the *NN*-curve (Eq. 2b) are depicted as upward-sloping and downward-sloping curves, respectively. Initially, these curves intersect at point E_0. A resource boom (R) increases the total national income (Y) and leads to higher demand for both manufacturing (traded) and service (non-traded) goods. The augmented demand for manufacturing goods might be counteracted by an increase in imported goods, while the real exchange rate (P) appreciates to accommodate the expanded demand for service goods. Graphically, the *NN*-curve shifts upwards while the *LL*-curve remains unchanged. The new static equilibrium is established at higher levels of the real exchange rate and the labor share in the service sector (point E_1). The appreciation of the real exchange rate increases the real wage of service sector workers relative to those in the manufacturing sector. Consequently, workers transition from the manufacturing sector to the service sector. As a result, the labor share in the service sector increases due to the resource boom (i.e., $\frac{dL_S}{dR} > 0$). Therefore, in the short run when productivity levels are assumed to be constant, the manufacturing sector contracts while the service sector expands (i.e., deindustrialization).

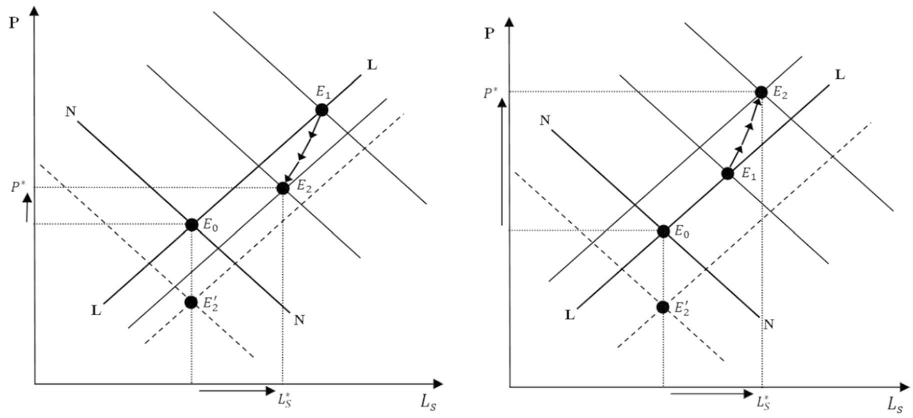
In line with the empirical findings detailed in the upcoming section, I specifically address the case $\delta'_{RM} > \delta'_{RS} \Rightarrow \frac{dL_S^*}{dR} > 0$ to elucidate the dynamic mechanism of the model. The alternative scenario (i.e., $\delta'_{RM} < \delta'_{RS}$) is discussed in Appendix A.3. Considering Eq. (7), the response of relative productivity to a labor movement between sectors depends on to what extent the labor share in the service sector increases in the short term due to a resource boom. In the first case, let's assume that a resource boom initially causes the labor share in the service sector to rise beyond the steady-state level (i.e., $\frac{dL_S}{dR} > \frac{dL_S^*}{dR}$) (see Fig. 1a). Now, L_S exceeds the steady-state level (L_S^*), resulting in a negative relative productivity growth (i.e., $\frac{\dot{\phi}}{\phi} < 0$). Consequently, the productivity level decreases more in the manufacturing sector than in the service sector, leading to a decline in the relative productivity ratio throughout the transition path.[12] Graphically, both curves shift downward. As regards the *NN*-curve shifts more than the *LL*-curve (i.e., $\sigma < 1$ holds), the falling relative productivity ratio triggers a countervailing labor movement from the service to the manufacturing sector. This movement persists until the labor share in the service sector converges to a new steady-state level (E_1 to E_2 in Fig. 1a).[13]

In a similar manner, I address the second case, in which the increase in the labor share of the service sector is below its steady-state level (i.e., $\frac{dL_S}{dR} < \frac{dL_S^*}{dR}$) (see Fig. 1b). The

[11] It suggests that if $\frac{dL_S}{dR} > \frac{dL_S^*}{dR} = \frac{\delta'_R}{(1-\gamma_M)\delta_M+(1-\gamma_S)\delta_S}$ then $\frac{d(\dot{\phi}/\phi)}{dR} < 0$, and if $\frac{dL_S}{dR} < \frac{dL_S^*}{dR} = \frac{\delta'_R}{(1-\gamma_M)\delta_M+(1-\gamma_S)\delta_S}$ then $\frac{d(\dot{\phi}/\phi)}{dR} > 0$.

[12] An alternative scenario may arise due to the deceleration of productivity growth in the manufacturing sector and the acceleration of productivity growth in the service sector. Furthermore, if the productivity level increases more rapidly in the service sector than in the manufacturing sector, the relative productivity ratio could also decrease. However, in line with the empirical findings, I do not address these alternative scenarios.

[13] This suggests that the steady-state level of labor employment in the manufacturing sector is lower than its initial level.



(a) $\frac{dL_S}{dR} > \frac{dL_S^*}{dR}$ (b) $\frac{dL_S}{dR} < \frac{dL_S^*}{dR}$

Fig. 1 The Dutch disease mechanism: the case $\left(\delta'_{RM} > \delta'_{RS} \Rightarrow \frac{dL_S^*}{dR} > 0\right)$

relative productivity growth is positive (i.e., $\frac{\dot{\phi}}{\phi} > 0$). Since L_S is smaller than its steady-state value (L_S^*), the productivity level increases in the manufacturing sector, while it decreases in the service sector. This results in an increase in the relative productivity ratio throughout the transition path. Graphically, the *NN*-curve shifts upward more significantly than the *LL*-curve. The rising relative productivity ratio leads to additional labor movement from the manufacturing sector to the service sector. This causes the labor share in the service sector to gradually converge to a higher steady-state level (E_1 to E_2 in Fig. 1b).[14]

A note about the real exchange rate at the steady-state level (i.e., P^*) can be deduced from a close graphical analysis of the various possible slopes of the isoclines. This analysis reveals that, in the first case (see Fig. 1a), the steady-state real exchange rate may conditionally be positioned at a higher level than its initial level. Conversely, in the second case (see Fig. 1b), it is placed unconditionally. Further details are discussed in Appendix A.4. As a result, this new feature of the model addresses one of the gaps present in the previous literature: the steady-state real exchange rate depreciation, as observed in Torvik (2001), Bjørnland and Thorsrud (2016).

I also analyze the dynamic adjustment of sectoral growth. Equation (1) reveal that sectoral productivity growth is driven by the *LBD* effects and the spillover effect from the resource sector. Let's assume that the direct effect of the learning process in each sector is stronger than its indirect effect, which spreads from another section. Additionally, the resource process activity has a positive spillover effect on the productivity growth of domestic sectors. Consequently, an increase in the labor share of the service sector resulting from a resource boom tends to accelerate productivity growth in the service sector. Meanwhile, productivity growth in the manufacturing sector depends on whether the *LBD* effects or the spillover effect from the resource sector is stronger. If the *LBD* effect

[14] The alternatives encompass a slower increase in productivity growth in the service sector compared to the manufacturing sector, or a faster decline in the service sector than in the manufacturing sector. However, in alignment with empirical findings, I do not consider these alternative scenarios.

dominates, productivity growth decelerates; if the resource spillover effect dominates, productivity growth accelerates. Further discussion is presented in Appendix A.5.

So far, I have discussed how a resource boom impacts relative productivity growth and sectoral growth. However, studying the dynamic adjustment of the growth rate at the national level also holds significance. By substituting the steady-state labor share in the service sector (i.e., Eq. 6) into one of the two Eqs. 1, the steady-state growth rate, denoted as g^*, is obtained as follows:

$$g^* = \frac{\left(1-\gamma_M\gamma_S\right)\delta_M\delta_S}{\left(1-\gamma_M\right)\delta_M + \left(1-\gamma_S\right)\delta_S} + \frac{\left(\delta_S-\gamma_M\delta_M\right)\delta_{RM}(R) + \left(\delta_M-\gamma_S\delta_S\right)\delta_{RS}(R)}{\left(1-\gamma_M\right)\delta_M + \left(1-\gamma_S\right)\delta_S}. \tag{8}$$

Equation (8) verifies that the steady-state growth rate is driven by the *LBD* effects and the spillover effects from the resource process activity. To simplify the discussion, let's assume that the impact of a technological improvement in the resource sector spills over to one of the sectors. In this scenario, the response of the steady-state growth rate to a resource boom depends on the strength of the direct and indirect *LBD* effects in the other sector. If the direct *LBD* effect is stronger (weaker) than the indirect effect, the steady-state growth rate increases (decreases) as resource rents increase.[15] A general case is discussed in Appendix A.6.

Given Eq. (8), I can also compare the predictions of my model with the previous models by Torvik (2001) and Bjørnland and Thorsrud (2016). If there are no resource spillover effects ($\delta_{RM} = \delta_{RS} = 0$), Eq. (8) simplifies to the results presented in Torvik (2001). Therefore, the steady-state growth rate is dependent only on the *LBD* effects: $g^* = \frac{(1-\gamma_M\gamma_S)\delta_M\delta_S}{(1-\gamma_M)\delta_M+(1-\gamma_S)\delta_S}$. In this special case, a resource boom affects the steady-state levels of sectoral productivity but not the steady-state growth rate.[16]

Furthermore, if the effect of technological progress in the resource sector spreads equally to both sectors ($\delta_{RM} = \delta_{RS} = \delta_R R$), as observed in Bjørnland and Thorsrud (2016), the steady-state growth rate becomes a direct positive function of the resource rent: $g^* = \delta_R R + \frac{(1-\gamma_M\gamma_S)\delta_M\delta_S}{(1-\gamma_M)\delta_M+(1-\gamma_S)\delta_S}$. Hence, a resource boom enhances the steady-state growth rate. These models indicate that the steady-state growth rate remains constant (or increases) in the Dutch disease mechanism. In contrast, the proposed model can represent cases that align more closely with empirical evidence (as discussed in the next section). The model illustrates that a resource boom causes the sectoral growth rates to change not only along the transition path but also at the steady-state level. Therefore, this new feature of the model addresses another gap in the previous literature: the growth rate deceleration resulting from a resource boom.

[15] Let's assume that only the spillover effect from the resource sector into the manufacturing sector exists (i.e., $\delta_{RS} = 0$). If the direct *LBD* effect in the service sector becomes greater than its indirect effect ($\delta_S > \gamma_M\delta_M$), a resource boom leads to a faster expansion of the economy in the steady state (i.e., $\frac{dg^*}{dR} = \frac{(\delta_S-\gamma_M\delta_M)\delta'_{RM}(R)}{(1-\gamma_M)\delta_M+(1-\gamma_S)\delta_S} > 0$); otherwise, it results in a slower expansion.

[16] Earlier studies are special cases of Torvik (2001), such that $g^* = 0$ in Krugman (1987); Sachs and Warner (1995) and $g^* = \frac{\delta_M\delta_S}{\delta_M+\delta_S}$ in Lucas (1988)

3 Empirical Approach

The main contribution of this section is twofold. First, it provides empirical evidence relevant to the theoretical model. Second, it examines spending and resource movement channels in both resource-rich and resource-poor countries. To achieve this, the empirical study is conducted in the following four steps: (1) First, I analyze the real exchange rate response to the resource dependence proxy to investigate the spending channel. Then, for a more detailed exploration of the resource movement channel, I estimate the effects of the resource dependence proxy on (2) the relative output of the manufacturing sector to the service sector, (3) the per capita growth rate of sectoral output, and (4) the GDP per capita growth rate.

3.1 Data and Methodology

The dataset consists of an unbalanced panel of 152 countries, covering 5-year periods between 1970 and 2019.[17] The list of countries in the sample is presented in Table 6. Table 1 reports descriptive statistics for the variables.

The real effective exchange rate (*REER*) is collected from the *Bruegel* database (Darvas 2012). This serves as a proxy for the relative price of services (non-traded) to manufacturing (traded) goods.[18] I also gather data on *GDP* per capita (Constant 2010 US dollars) as well as manufacturing (*M*) and service (*S*) value-added (Constant 2010 US dollars) from the World Bank's World Development Indicator Database (*WDI*) to construct the relative sectoral output of M to S and the natural logarithm of per capita output in each sector ($J = M, S$).

Based on the theory, a resource boom (R) is defined as the total resource rent relative to the sectoral productivity levels (i.e., $\frac{NR}{A_M}, \frac{NR}{A_S}$) or national income (i.e., $\frac{NR}{Y}$). Hence, my primary treatment measure is the total natural resource rents (% of *GDP*), provided by *WDI*. This proxy ensures strong consistency between the empirical methodology and the theory. Thus, it is henceforth referred to as the resource-dependence index, representing the expansion of a resource rent relative to the income level. Control variables are detailed in Appendix B.

I adopt a dynamic panel data model to examine the symptoms of the Dutch disease hypothesis. The general regression model takes the form of:

$$y_{i,t} = \delta y_{i,t-1} + \lambda R_{i,t-1} + X'_{i,t}\beta + \mu_i + \varepsilon_{i,t}. \tag{9}$$

where the subscripts $i = 1, \dots N$ and $t = 1, \dots T$ index the countries and periods in the panel dataset, respectively. $y_{i,t}$ represents the dependent variable, $R_{i,t-1}$ corresponds to the lagged resource boom proxy, and $X'_{i,t}$ denotes a vector of other explanatory variables. The

[17] Periods are: 1970–1974, 1975–79, 1980–84, 1985–89, 1990–94, 1995–99, 2000–04, 2005–09, 2010–14, and 2014–19.

[18] (*REER*) is calculated as $REER = \frac{NEER \cdot CPI^{domestic}}{CPI^{foreign}}$, where *NEER*, the geometrically weighted average of the nominal bilateral exchange rate between a given country and its trading partner, is measured as the foreign currency's price of one unit of domestic currency. $CPI^{domestic}$ denotes the domestic consumer price index, and $CPI^{foreign}$ is the geometrically weighted average of *CPI* indices of trading partners. Therefore, the relative consumer price index of domestic to foreign goods implies that an increase in *REER* tends to appreciate the relative price. The real effective exchange rate unit is set at 100 in the base year of 2007.

Table 1 Summary statistics for the variables

	Obs.	Mean	Std. Dev.	Min.	Max.
Real effective exchange rate	1310	1.356	4.186	0.298	136.197
Ln (relative sectoral output of M to S)	1023	3.167	0.569	1.017	5.880
Ln (per capita *GDP* of Manufacturing)	1067	6.200	1.671	2.056	9.882
Ln (per capita *GDP* of Service)	1099	7.565	1.673	3.917	11.331
Ln (per capita *GDP*)	1317	8.2561	1.538	5.036	11.574
Resource-dependence index	1321	7.386	10.155	0	62.897
Net foreign assets	1157	11.889	49.819	−447.104	738.083
Population growth	1322	1.698	1.367	−3.674	15.740
Investment ratio	1056	21.584	7.929	0.278	83.787
Human capital index	1216	2.199	0.741	1.009	3.808
Openness index	1091	68.520	44.851	1.859	456.583
Terms of trade	1302	1.063	0.722	0.116	21.272
Foreign direct investment	1309	2.819	5.023	−17.505	81.648
Government spending	1098	16.679	6.674	1.253	56.456
Inflation	1321	35.673	259.644	−6.628	6945.242
Institution index	1272	−0.119	0.874	−2.069	2.249

lagged resource boom proxy can effectively capture the long-term effects of the resource boom, enabling me to test the empirical model in alignment with the theory. Additionally, μ_i indicates the country-specific fixed effect and $\varepsilon_{i,t}$ represents the error term, assumed to be independently and normally distributed with a mean of zero and constant variance (i.e., $\varepsilon_{i,t} \simeq N\left(0, \sigma_u\right)$).

The lagged dependent variable ($y_{i,t-1}$) is incorporated both directly and indirectly in a dynamic panel, serving as the denominator in the resource boom proxy.[19] This violates the orthogonality assumption and leads to the endogeneity problem. Consequently, the *OLS* estimates of the coefficients on these independent variables are likely to be biased upwards (so-called dynamic panel bias) (Nickell 1981). The Differenced *GMM* method, proposed by Arellano and Bond (1991), and the System *GMM* method, developed by Blundell and Bond (1998), offer alternative estimators to address this potential econometric problem. The underlying concept of these methods is to use instrumental variables to mitigate the endogeneity problem associated with the explanatory variables. In the former method, lagged difference variables are employed as instruments for the explanatory variables, while in the latter method, both lagged differences and lagged levels are utilized.

The Differenced *GMM* approach suggests that the regression equation is first differenced to get rid of the country-specific fixed effect, and then used all possible lagged levels as instruments. Taking the first differences, Eq. (9) can be differenced as follows:

$$\Delta y_{i,t} = \delta \Delta y_{i,t-1} + \lambda \Delta R_{i,t-1} + \Delta X'_{i,t}\beta + \Delta \varepsilon_{i,t}. \tag{10}$$

[19] The lagged resource-dependence index is represented by the lagged level of total natural resource rents (% of *GDP*), denoted as $R_{i,t-1} = \frac{NR_{i,t-1}}{Y_{i,t-1}}$.

However, the *OLS* estimate of Eq. (10) generates inconsistent parameters due to the correlation between the variables of interest ($\Delta y_{i,t-1}, \Delta R_{i,t-1}$) and the transformed error term ($\Delta \varepsilon_{i,t}$). This correlation implies that these regressors are treated as endogenous variables. Consequently, the opportunity arises to employ lagged variables as instruments to tackle the endogeneity problem. When an endogenous variable is correlated with both past and current error terms, lagged levels from two or more periods earlier serve as valid instruments for it. This is because $\Delta y_{i,t-2}, \Delta R_{i,t-2}$, and preceding values are correlated with $\Delta y_{i,t-1}, \Delta R_{i,t-1}$ but not with $\Delta \varepsilon_{i,t}$.[20]

However, the Differenced *GMM* estimator is prone to yielding poor performance when the time series are persistent or closely resemble a random walk process. This is attributed to the weak correlation between the lagged values of the variables and the endogenously transformed variables. Blundell and Bond (1998) proposed a solution to this issue by introducing the System *GMM* estimator, which involves applying *GMM* to a system of two sets of equations. The first equation consists of the standard set of moment conditions in first differences, while the second equation comprises an additional set of moment conditions derived from the equations in levels. Under the assumption that $\Delta X'_{i,t}$ is not correlated with the country-specific fixed effect, the lagged first differences of dependent and independent variables can be utilized as instruments for the level equations.

The consistency of the estimators depends on assessing the proliferation of instruments, which can lead to overidentification in the regression model. Furthermore, these estimators cannot be considered consistent unless there is no serial autocorrelation in the error term. The proliferation of instruments is evaluated using the *Hansen* test for over-identifying restrictions.[21] Meanwhile, the second *Arellano-Bond* test is employed to confirm the absence of serial autocorrelation in the error term, thereby ensuring the validity of lagged variables as instruments.[22]

Moreover, the first rule of thumb involves checking the coefficient of the lagged dependent variable. A consistent estimate of this coefficient is expected to fall between the *OLS* estimate as the upper bound and the fixed effect estimate as the lower bound (Bond et al. 2001). If the differenced *GMM* coefficient estimate is close to or lower than the fixed effect estimate, it could suggest a downward bias, potentially resulting from weak instruments. As a result, the System *GMM* method might be more preferable. The second rule of thumb suggests keeping the number of instruments lower than the count of country groups to prevent overidentification (Roodman 2009). Lastly, I employ a two-step System *GMM* (Differenced *GMM*) approach with Windmeijer (2005)'s robust correction procedure.

3.2 Empirical Results

3.2.1 Real Exchange Rate

The purpose of this section is to examine the response of the real exchange rate to a resource boom (i.e., the spending effect). The dependent variable in the dynamic regression

[20] Other regressors could be either predetermined or exogenous variables. Predetermined variables, meaning they are only correlated with past error terms, are instrumented with lagged levels from one or more periods earlier, whereas the exogenous variables are either current or from lagged periods.

[21] *Hansen* test is adequate when the estimation involves a *heteroscedastic* weight matrix. The null hypothesis states that the instruments, as a group, are uncorrelated with the error term.

[22] The null hypothesis is that autocorrelation doesn't exist.

model is the real effective exchange rate, and the explanatory variable of interest is the resource-dependence index. Additionally, *GDP* per capita, inflation, government spending, terms of trade, openness index, and foreign direct investment are included to control the regression model. Dependent and independent variables are log-transformed.

Table 2 presents the empirical results. As the coefficient value of the lagged dependent variable is smaller than the value estimated by the fixed-effect model, the system *GMM* appears to be the preferred method.[23] Column (1) reports the main results. The coefficient on the resource-dependence proxy enters with a positive sign and is significant at the 1% level. The estimate indicates that a 1% increase in the resource-dependence index appreciates the real effective exchange rate by approximately 0.023%. This result provides further confirmation of the findings in the literature. However, previous studies utilize remittance flows (Lartey et al. 2012), commodity prices (Ricci et al. 2013), or resource discovery (Harding et al. 2020), instead of total natural resource rent (% of GDP), which aligns with my proposed theoretical model.

Based on the theory, a question that arises is whether the real exchange rate appreciation resulting from an increase in the resource-dependence index is moderated along the transition path. To explore this, I introduce a second-lagged dependent variable into the regression model. The estimates for the full sample are outlined in Column (2). These results somehow shed light on the short-term (or medium-term) and long-term effects of resource booms on the real effective exchange rate. This implies that the appreciation in the real exchange rate slightly moderates over time. However, this reduction isn't substantial enough for the long-term real exchange rate to settle at a level lower than the initial level (i.e., 0.11 < 0.67).[24] Consistent with the predictions of the proposed theory (see Appendix A.4), these empirical findings may confirm that, for the full sample, a resource boom, on average, results in an appreciation of the real exchange rate. While this appreciation moderates in the long term, the real exchange rate eventually stabilizes at a level higher than the initial level. Moreover, it might implicitly confirm that resource booms increase the steady-state labor share in the service sector to a greater extent than the critical threshold (i.e., $\frac{dLS}{dR} > \frac{dLS}{dR}|_C$) (see Appendix A.4). Holding this condition is sufficient to lead to an appreciation of the real exchange rate in the long term. In summary, in a steady state, an increase in the real exchange rate is associated with a higher labor share in the service sector. This, in turn, might suggest that the advantages of resource process activity spill over more significantly to the manufacturing sector than to the service sector (i.e., Eq. 6).

I also examine the heterogeneity across countries regarding their dependence on resource rents. To achieve this, I utilize a criterion to classify countries as either resource-rich or resource-poor. The criterion stipulates that the average total natural resource rent (% of *GDP*) over the given period equals 4% (see Table 6). The sensitivity of the results to

[23] The fixed-effect (*FE*) estimation is reported in Column (2) of Table 8. The *Hausman* test, which checks whether the preferred model is random effects, is rejected with a p-value of 0.000.

[24] $y_{i,t} = \delta y_{i,t-1} + \gamma y_{i,t-2} + \lambda R_{i,t-1} + X'_{i,t}\beta + \mu_i + \varepsilon_{i,t}$, where y is the dependent variable, R denotes the independent variable of interest, and X represents other control variables. The short-term (or intermediate-term) and long-term effects of R on y are respectively given as: $\frac{dy_i}{dR_i}|_{Short} = \frac{\lambda}{1-\delta}$ and $\frac{dy_i}{dR_i}|_{Long} = \frac{\lambda}{1-\delta-\gamma}$. It demonstrates that $\frac{dy_i}{dR_i}|_{Short} > \frac{dy_i}{dR_i}|_{Long} > 0$ when $\lambda > 0$, $0 < \delta < 1$, $-1 < \gamma < 0$, and $0 < \delta + \gamma < 1$, as shown in the estimated result in Column (2).

Table 2 Estimation results for the real effective exchange rate

Explanatory variable	(1) Full sample	(2) Full sample	(3) Res. rich	(4) Res. poor	(5) Full sample	(6) Developing
Real exchange rate (Ln) (lagged)	0.570***	0.676***	0.498***	0.559***	0.498***	0.508***
	(0.0284)	(0.0505)	(0.0818)	(0.0384)	(0.103)	(0.0838)
Real exchange rate (Ln) (second lagged)		−0.111**				
		(0.0487)				
Resource-dependence (Ln) (lagged)	0.0232***	0.0209**	0.0166**	0.0346**		
	(0.00807)	(0.00887)	(0.00829)	(0.0175)		
Net foreign assets (Ln) (lagged)					0.0745***	0.0664***
					(0.0287)	(0.0217)
Time dummies	YES	YES	YES	YES	YES	YES
Observations	843	751	389	454	556	467
Number of Countries	132	132	67	65	127	100
Number of instruments	127	125	66	60	89	89
Arellano-Bond test for AR(2) (p-v)	0.416	0.913	0.413	0.228	0.625	0.501
Hansen OID test (p-v)	0.350	0.294	0.214	0.463	0.305	0.324

The dependent variable is the real effective exchange rate (Ln) obtained from *Bruegel*. The real effective exchange rate (Ln) (lagged) is instrumented by the second and prior lags, while the resource-dependence index (Ln)(lagged) is instrumented by the first and prior lags. Additionally, control variables are instrumented by the second lag in the first two columns. However, in Columns (3) and (4), they are assumed to be exogenous to satisfy the rule of thumb. Note that their estimates are not provided in the table, but estimation results for control variables can be provided upon request. The regression models are estimated using the System *GMM* method. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. The null hypothesis of the *Arellano-Bond* test indicates the absence of autocorrelation, while the null hypothesis of the *Hansen* test assumes that the instruments, as a group, are uncorrelated with the error term

alternative thresholds (set at 2% and 6% of *GDP*) is detailed in Table 14 and discussed in Appendix F.[25]

Under these cutting-off criteria, we have an adequate number of countries in each category to apply the instruments. Columns (3) and (4) present the results for the groups of resource-rich and resource-poor countries, respectively. The coefficients on the resource-dependence index have positive signs and are statistically significant at the 5% level. The relatively lower statistical significance might stem from the smaller number of countries in the sample, leading to a reduced number of instruments. Nevertheless, the coefficient values indicate that the appreciation of the real exchange rate is more pronounced in resource-poor countries than in resource-rich countries (i.e., 0.0346 > 0.0166). These findings are in line with prior studies on resource-rich countries (Korhonen and Juurikkala 2009; Al-mulali and Che Sab 2012), but not for

[25] For criteria 2 and 4, all countries categorized as resource-rich by the IMF (Ghura and Pattillo 2012) align with my sample classification. However, under criterion 6, certain countries (Albania, Mexico, Norway, Côte d'Ivoire, Sudan, and Botswana) are placed in a different category than my sample. Table 14 displays that the results are similar qualitatively but not quantitatively.

resource-poor countries (Chen and Chen 2007).[26] The key difference between these studies and the present paper lies in the use of a resource proxy. While most studies estimate this relationship using oil prices, the present study takes an alternative approach by incorporating resource rents as a percentage of GDP.

In addition, based on the theory, the results may suggest that in resource-rich countries, a resource boom leads to an increase in the labor share within the service sector beyond its steady-state level. As a result, the appreciation of the real exchange rate is moderated along the transition path (see Fig. 1a). Conversely, in resource-poor countries, a resource boom elevates the labor share in the service sector to a level below its steady-state level. Consequently, the appreciation of the real exchange rate will intensify along the transition path (see Fig. 1b).

The impact of natural resources on the real exchange rate may highlight the international transfer problem. The relationship between these variables is two-fold. First, empirical evidence indicates a positive long-run net foreign asset position (% of *GDP*) in most natural resource-rich countries [see Lane and Milesi-Ferretti (2007)]. Consistent with this evidence, I estimate the effect of the resource dependence index on net foreign assets. The results, as reported in Table 7, suggest that a natural resource boom leads to the accumulation of net foreign assets.

Second, a transfer from a foreign country to the home country implies a rise in domestic demand, leading to an increase in the real exchange rate. To elaborate further, within a simple Keynesian context, countries with substantial external assets (accumulated, for example, through commodity exports) would experience capital inflows, resulting in an appreciation of the real exchange rate. In this context, Lane and Milesi-Ferretti (2001, 2004, 2007) and later Ricci et al. (2013) documented that, in the long run, a larger net external position should be associated with a more significant appreciation of the real exchange rate. In general, these relationships might indicate the impact of natural resource rents on the real exchange rate through the international payments transmission channel, commonly referred to as the transfer problem.

The argument suggests that the variable of net foreign assets (% of *GDP*) might effectively reflect resource dependence. However, to the best of my knowledge, it has never been used as a proxy for natural resources. Therefore, this estimation stands as one of the novel features of my empirical study. In this regard, I substitute the resource-dependence index with net foreign assets as a percentage of *GDP* (log-transformed) in the baseline regression model (i.e., Column 1 in Table 2). The results are reported in Column (5). The coefficient of the variable of interest exhibits a positive value and holds significance at the 1% level. This presents compelling evidence of a robust transfer effect. The estimates indicate that a 1% increase in net foreign assets as a percentage of *GDP* leads to an appreciation of the real exchange rate by approximately 0.07%. The finding is consistent with previous studies (Lane and Milesi-Ferretti 2001, 2004, 2007; Ricci et al. 2013).

Furthermore, considering the potential impact of economic size heterogeneity on the transfer effect's magnitude, I run the regression model for developing countries as outlined in the International Monetary Fund's World Economic Outlook Database. The results in Column (6) demonstrate that the transfer effect remains statistically

[26] For the G7 countries, which are categorized as resource-poor countries in my sample, Chen and Chen (2007) found that an increase in real oil prices leads to a depreciation of the real exchange rates in the long run.

significant at the 1% level. However, the coefficient value within the sample of developing countries is slightly lower compared to the full sample. Aligning with Lane and Milesi-Ferretti (2004)'s findings, I can conclude that the transfer effect is less pronounced in developing economies.

3.2.2 Relative Sectoral Output

In this subsection, I analyze the effect of the real exchange rate and the resource-dependence index on the relative sectoral output to investigate the resource movement effect. Following the model proposed by Torvik (2001), labor allocation remains constant at the steady state [i.e., $L_S^* = \frac{(1-\gamma)\delta_M}{(1-\gamma)\delta_M+\delta_S}$]. Consequently, the relative sectoral output at the steady-state level becomes a function of the steady-state relative productivity ratio ϕ^* [i.e., $\frac{X_M}{X_S} = \phi^* \frac{\left(1-L_S^*\right)^\alpha}{\left(L_S^*\right)^\alpha}$]. In the present theory, both the labor share in the service sector and the relative productivity ratio influence the steady-state relative sectoral output. Consistent with the real exchange rate adjustment along the transition path discussed in the previous subsection, the simultaneous increase in the labor share in the service sector and decrease in the relative productivity ratio diminish the relative sectoral output at the steady-state level. Nevertheless, due to the lack of a comprehensive dataset for sectoral productivity levels or insufficient data for required labor shares to estimate the sectoral productivity level, an alternative proxy becomes necessary.

It appears that the relative sectoral output remains a reliable and plausible proxy for the relative productivity level. Consequently, I consider the relative output of the manufacturing sector to the service sector (at constant prices) as the dependent variable. The explanatory variables of interest consist of the real effective exchange rate and the resource-dependence index. Additionally, I include per capita GDP, investment ratio, human capital index, openness index, government spending, and institution index as control variables.

The estimated results using the Differenced GMM method are shown in Table 3.[27] The estimated results in Column (1) indicate that a 1% increase in the real value of a country's currency against the basket of the country's trading partners results in a reduction of approximately 0.1% in the relative sectoral output. Furthermore, a one-percentage-point increase in the resource dependence index is associated with a 0.6% decrease in the relative sectoral output.[28]

According to the theory, a resource boom triggers *LBD* effects through changes in the real exchange rate. Consequently, I omit the resource-dependence index to focus solely on the *LBD* effect. The results for this case are presented in Column (2). A negative and statistically significant coefficient on the real exchange rate may suggest that the contraction

[27] Column (2) in Table 9 presents the fixed effect estimates. The *Hausman* test rejects with a p value of 0.000. The results indicate that the coefficient value on the lagged dependent variable is smaller in the Differenced *GMM* estimator compared to the Fixed-effect estimator. It does not meet the rule of thumb and may suggest that the Differenced *GMM* method is not the preferred choice due to weak instruments. However, the System *GMM* estimator raises suspicions of a potential unit root process. It is worth noting that I have not conducted a unit root test, as panel unit root tests possess low power and carry the risk of incorrectly identifying the panel as non-stationary, especially with a smaller number of periods in this empirical study (Baltagi 2008; Wooldridge 2010). Hence, I opt to use the Differenced *GMM* method for estimating the regression model.

[28] Note that the dependent variable is in natural logarithm form, the resource dependence index ranges from 0 to 100, and the real effective exchange rate unit is fixed at 100 in the base year of 2007.

Table 3 Estimation results for the relative sectoral output

Explanatory variable	(1) Full sample	(2) Full sample	(3) Full sample	(4) Res. rich	(5) Res. poor
Relative sectoral output (Ln) (lagged)	0.774***	0.800***	0.834***	0.896***	0.379***
	(0.0831)	(0.0723)	(0.0920)	(0.145)	(0.0714)
Real effective exchange rate (lagged)	−0.00107***	−0.00101***			
	(0.000312)	(0.000350)			
Recourse-dependence (lagged)	−0.00578**		−0.00821***	−0.0110***	0.0331**
	(0.00249)		(0.00249)	(0.00317)	(0.0136)
Time dummies	YES	YES	YES	YES	YES
Observations	590	590	590	266	324
Number of countries	112	112	112	52	60
Number of instruments	107	103	85	44	59
Arellano-bond test for AR(2) (p-v)	0.138	0.126	0.086	0.412	0.623
Hansen OID test (p-v)	0.476	0.496	0.270	0.548	0.579

The dependent variable is the relative output per capita of the manufacturing to the service sector (Ln) (in constant prices). The real effective exchange rate data estimated by *Bruegel* is used. The relative sectoral output (lagged) is instrumented by the second and prior lags, while the real effective exchange rate (lagged) and the resource-dependence index (lagged) are instrumented by the first and prior lags. Additionally, control variables are instrumented by the second lag. However, their estimates are not presented in the table. Estimation results for the control variables can be provided upon request. The regression models are estimated using the Differenced *GMM*. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. The null hypothesis of the *Arellano-Bond* test indicates the absence of autocorrelation, while the null hypothesis of the *Hansen* test assumes that the instruments, as a group, are uncorrelated with the error term

in the manufacturing sector is more pronounced than in the service sector, resulting in a decline in the relative sectoral output level.

I also estimate a regression model that solely includes the resource dependence index to analyze the combined effects of *LBD* and technological improvement spillover from the resource sector. The results are presented in Column (3). The coefficient on the resource-dependence index is negative and significant at the 1% level. The estimated results suggest that a one-percentage-point increase in the resource dependence index correlates with a 0.8% decrease in the relative sectoral output. Furthermore, it implicitly indicates that, for the full sample of countries, the positive spillover effects from the resource sector to domestic sectors cannot neutralize the *LBD* effects caused by the appreciation of the real exchange rate. To the best of my knowledge, only a few studies have explored the relationship between resource rents and the relative sectoral output ratio across a wide range of countries and over an extended time period. My study is akin to the one conducted by Lartey et al. (2012). Although they employ remittance flows as a proxy for resource income, unlike my specification, both studies yield the same qualitative results.

The results in Columns (1)–(3) may prompt the question of whether the response in relative sectoral output to the variables of interest is noteworthy, despite the statistical significance of the estimates. This issue could primarily be attributed to the fact that the economic response to a resource boom takes time. The estimation in Column (3) indicates that a one-percentage-point increase in the resource dependence index results in a long-term decrease of around 5% in relative sectoral output.[29]

This issue could also be attributed to heterogeneity across country groups in terms of their dependence on resource rents.[30] The results for a sample of resource-rich and resource-poor countries are reported in Columns (4) and (5), respectively. The coefficient of the resource dependence index is negative for resource-rich countries and positive for resource-poor countries. Additionally, the results suggest a relatively larger economic significance in the country groups' samples compared to the full sample. These results indicate that a one-percentage-point increase in the resource dependence index raises the relative sectoral output by approximately 3.3% in the resource-poor country group and decreases it by approximately 1.1% in the resource-rich country group. This latter finding aligns with the outcomes of a recent empirical study conducted by Amiri et al. (2019).

Furthermore, these statistically significant results are consistent with the findings of the preceding subsection and theoretical predictions. The theory suggests that a resource boom conditionally changes the growth rate of the relative productivity ratio through an appreciation in the real exchange rate (as detailed in Appendix A.2). The estimated result for the sample of resource-rich countries might suggest that the relative productivity ratio decreases when the resource boom leads to a greater increase in the labor share of the service sector than what would occur in the steady state. As a result, the relative productivity ratio (relative sectoral output) decreases along the transition path, thereby moderating the appreciation of the real exchange rate [i.e., $\frac{dL_S}{dR} > \frac{dL_S^*}{dR} \Longrightarrow \frac{d(\dot{\phi}/\phi)}{dR} < 0 \Rightarrow \frac{d\phi^*}{dR} < 0$]. While the estimated result for the sample of resource-poor countries might imply that the relative productivity ratio increases when the resource boom leads to a smaller increase in the labor share of the service sector than what would occur in the steady state. Consequently, the relative productivity ratio (relative sectoral output) increases along the transition path, thereby accelerating the appreciation of the real exchange rate [i.e., $\frac{dL_S}{dR} < \frac{dL_S^*}{dR} \Longrightarrow \frac{d(\dot{\phi}/\phi)}{dR} > 0 \Rightarrow \frac{d\phi^*}{dR} > 0$]. In conclusion, these findings can be regarded as another confirmation of the theory's mechanism (see Fig. 1).

3.2.3 Sectoral Growth

Up to this point, I have analyzed the impact of a proxy for the natural resource boom and the appreciation of the real exchange rate on relative sectoral output. However, this is not the sole matter of interest. Following the proposed theoretical mechanism, it is valuable to examine the response of sectoral economic growth to the explanatory variables of interest. The dependent variable is the sector's per capita income (in constant prices), and the desired explanatory variables are the effective real exchange rate and the resource dependence index. Additionally, GDP per capita (in natural logarithmic form), population growth, investment ratio, human capital index, openness index, government spending, and institution index are included in the regression model as control variables.

Table 4 presents the estimation results. Following the rule of thumb, the System *GMM* estimator is preferred. The first five columns display the results for the manufacturing sector, while the remaining columns present the results for the service sector. Columns (1) and

[29] The long-term effect of the resource-dependence index (R) on relative sectoral output (y) is as follows: $\frac{dy_i}{dR_i} = \frac{-0.00821}{1-0.834} = -0.049$.

[30] I excluded the real exchange rate and focused solely on the model presented in Column (3) because the number of instruments becomes smaller than the number of country groups, adhering to the rule of thumb.

Table 4 Estimation results for the sectoral growth

Explanatory variable	(1) Full sample Manufac	(2) Full sample Manufac	(3) Full sample Manufac	(4) Res. rich Manufac	(5) Res. poor Manufac	(6) Full sample Service	(7) Full sample Service	(8) Full sample Service	(9) Res. rich Service	(10) Res. poor Service
Sectoral output per capita (Ln) (lagged)	0.801***	0.837***	0.742***	0.743***	0.835***	0.488***	0.564***	0.421***	0.355***	0.338***
	(0.0408)	(0.0456)	(0.0723)	(0.0500)	(0.0481)	(0.0469)	(0.0634)	(0.0629)	(0.0707)	(0.0795)
Real effective exchange rate (lagged)	−0.00209***	−0.00191***				−0.00182***	−0.00156***			
	(0.000408)	(0.000365)				(0.000263)	(0.000329)			
Recourse-dependence (lagged)	−0.00567***		−0.00646***	−0.00627***	0.0216**	−0.00641***		−0.00471***	−0.00556***	−0.0186**
	(0.00204)		(0.00212)	(0.00223)	(0.0107)	(0.00134)		(0.00141)	(0.00189)	(0.00779)
Time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	736	736	736	343	333	751	751	751	352	339
Number of countries	121	121	121	58	60	124	124	124	60	61
Number of instruments	108	98	104	55	59	116	116	85	62	53
Arellano-Bond test for AR (3) (p-v)	0.071	0.072	0.070	0.169	0.219	0.815	0.836	0.895	0.505	0.415
Hansen OID test (p-v)	0.210	0.218	0.186	0.539	0.200	0.442	0.175	0.453	0.282	0.213

The dependent variable is Sectoral output per capita (Ln). The first 5 columns present the results for the manufacturing sector, and the remaining columns report the results for the service sector. The sectoral output level (lagged) is instrumented by the second lag and prior lags, while the real effective exchange rate (lagged) and resource dependence index (lagged) are instrumented by the first and prior lags. Furthermore, except for population growth and institution index, which are assumed to be exogenous to satisfy the rule of thumb, other control variables are instrumented by the second lag and prior lags. However, their estimates are not included in the table. Estimation results for the control variables are available upon request. The regression models are estimated using the System *GMM*. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. The null hypothesis of the *Arellano-Bond* test indicates the absence of autocorrelation, the null hypothesis of the *Hansen* test assumes that the instruments, as a group, are uncorrelated with the error term. I report AR(3) instead of AR(2) since the null hypothesis is rejected in AR(2)

(6) present the coefficients on the real exchange rate and the resource dependence index for the manufacturing and service sectors, respectively. The negative and statistically significant coefficients on the explanatory variables of interest indicate that the appreciation of the real exchange rate caused by the natural resource boom reduces the size of both sectors on average.

Furthermore, in accordance with the proposed theory, the resource boom stimulates sectoral growth rates through the *LBD* effect and the spillover impact of technological improvement from the resource sector. Therefore, I first exclude the resource dependence index and subsequently estimate the regression model to investigate the *LBD* effect triggered by real exchange rate appreciation. Columns (2) and (7) present the results. The coefficient on the real exchange rate for both sectors is negative and significant at the 1% level. The findings for the manufacturing sector align with those reported in Sekkat and Varoudakis (2000), Vaz and Baer (2014). Nevertheless, it is worth noting that these studies focused on specific groups of countries rather than encompassing all countries.[31] This might also suggest that the learning process of the *LBD* approach, originating in the manufacturing sector and spilling over to the service sector, serves as the dominant driving force behind productivity growth in both sectors. Additionally, this indirectly verifies the findings presented in Column (2) of Table 4. The estimated coefficient value in the manufacturing sector surpasses that in the service sector (i.e., 0.191%> 0.156%), indicating a more significant contraction in the manufacturing sector compared to the service sector due to the *LBD* effects. Consequently, this supports the notion of decreased relative sectoral output caused by exchange rate appreciation.

Following the previous subsection, I further investigate the impact of the resource spillover effect on sectoral growth in terms of cross-country resource dependence. In this context, I exclusively focus on the coefficient of the resource dependence index, which encompasses both the *LBD* effect and the resource spillover effect. Columns (3) and (8) present the estimation results for the full sample of countries in the manufacturing sector and the service sector, respectively. The estimates reveal that the coefficients exhibit negative signs and hold statistical significance at the 1% level. The estimated results indicate that a one-percentage-point increase in the resource dependence index leads to a 0.65% decrease in output per capita in the manufacturing sector and a 0.47% decrease in output per capita in the service sector. This finding is in line with Rajan and Subramanian (2011), who employed *OLS* panel regression to estimate the impact of the 10-year average of aid (% of *GDP*) on the growth rate of industry value added. Additionally, the results can be compared with those of Lartey et al. (2012), who studied the effect of remittance flows on sectoral growth. While their findings for the manufacturing sector are qualitatively similar to my estimated results, they differ for the service sector. This finding also appears to align with the decrease in the level of relative sectoral output discussed in the previous subsection. The coefficient values indicate that the contraction in the service sector is less pronounced than in the manufacturing sector, which likely contributes to a reduction in the level of relative sectoral output.

The results for the sample of resource-rich countries are presented in Columns (4) and (9) of Table 4. They show that the coefficient for the resource-dependence index is significantly negative in both sectoral estimations. The findings indicate that a

[31] Unlike my estimation for a sample of all countries in the period 1970–2019, Sekkat and Varoudakis (2000) derived this result from a sample of sub-Saharan African countries during the period 1970–1992, while Vaz and Baer (2014) did so from a sample of Latin American countries between 1995 and 2008.

one-percentage-point increase in the resource dependence index corresponds to an approximate 0.6% reduction in per capita output for both sectors. In summary, this implies that resource booms lead to slower growth in both sectors. The finding for the manufacturing sector aligns with the findings of Ismail (2010), who examined the effect of oil prices on the level of manufacturing firms in oil-exporting countries.

Furthermore, the negative coefficients on the resource dependence index can be explained by the proposed theory. This implies that the positive effect of the resource spillover effect on the growth rate of domestic sectors is insufficient to counteract the *LBD* effects induced by the appreciation of the real exchange rate. Moreover, this suggests two outcomes in resource-rich countries: (1) the dominance of the *LBD* effect over the resource spillover effect, and (2) a stronger direct *LBD* effect in the manufacturing sector and a weaker direct *LBD* effect in the service sector.[32]

In a closer examination, the theory suggests that the deceleration in sectoral growth can result from slower growth in productivity levels, labor share, or a combination of both. Empirical evidence and the theory's description indicate that an increase in the real exchange rate is associated with a rise in the labor share within the service sector. Therefore, the significant reduction in productivity levels should primarily account for the decline in the growth rate of the service sector. This, in turn, is a consequence of a more pronounced *LBD* effect in comparison to the resource spillover effect. On the other hand, the decrease in both productivity levels and the labor share within the manufacturing sector can potentially explain the deceleration in growth observed in this sector.

Furthermore, comparing the value of the coefficients reported in Columns (4) and (9) reveals that an increase in the resource dependence index results in slower growth in the manufacturing sector compared to the service sector. The more significant contraction in the manufacturing sector aligns with the empirical findings of the previous subsection. This observation may imply that declines in productivity levels and labor share contribute to a more pronounced contraction in the manufacturing sector than in the service sector.

Estimates for the sample of resource-poor countries are presented in Columns (5) and (10) of Table 4. These estimates indicate that a resource boom accelerates the growth rate in the manufacturing sector, while it decelerates the growth rate in the service sector. A one-percentage-point increase in the resource dependence index increases the output in the manufacturing sector by roughly 2.2% and decreases the output in the service sector by roughly 1.9%. In line with the proposed theory, this suggests that the *LBD* effect is stronger in the service sector and weaker in the manufacturing sector compared to the resource spillover effect. Consequently, the growth rate of the service sector in resource-poor countries will decrease similarly to that in resource-rich countries. However, the dominant resource spillover effect accelerates productivity growth in the manufacturing sector.[33] The latter is consistent with recent literature that documents strong positive spillovers from the

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[32] According to Appendix A.5, the change in the labor share of the service sector resulting from the resource boom surpasses the ratio of the marginal benefit effect of the resource sector spillover to the gap between the direct and indirect effects of *LBD* in both sectors (i.e., $\frac{dL_S}{dR} > \frac{\delta'_{RM}}{\delta_M - \gamma_S \delta_S} \implies \frac{d(\dot{A}_M/A_M)}{dR} < 0$ and $\frac{dL_S}{dR} > \frac{\delta'_{RS}}{\gamma_M \delta_M - \delta_S} \implies \frac{d(\dot{A}_S/A_S)}{dR} < 0$).

[33] According to Appendix A.5, when the change in the labor share of the service sector due to the resource boom is smaller than the ratio of the marginal benefit effect of the resource sector spillover to the gap between the direct and indirect effects of *LBD* in the manufacturing sector, the resource spillover effect becomes strong enough to entirely neutralize the adverse effect of *LBD*, resulting in an acceleration of the productivity growth rate (i.e., $\frac{dL_S}{dR} < \frac{\delta'_{RM}}{\delta_M - \gamma_S \delta_S} \implies \frac{d(\dot{A}_M/A_M)}{dR} > 0$).

resource sector to the manufacturing sector [e.g., Weber (2012); Kuralbayeva and Stefanski (2013); Feyrer et al. (2017); Allcott and Keniston (2018); Bjørnland et al. (2019)]. Since the majority of OECD countries in my dataset are categorized as resource-poor, my estimates also appear to align well with Harding et al. (2020), but not with Bjørnland and Thorsrud (2016).[34]

Finally, the expansion in the manufacturing sector and the contraction in the service sector resulting from a resource boom confirm the increase in the relative sectoral output level discussed in the preceding subsection. Consequently, this may suggest a more pronounced appreciation of the real exchange rate for the sample of resource-poor countries.

3.2.4 Economic Growth

The model's mechanism and previous empirical findings indicate that in resource-rich countries, the *LBD* effect dominates. As a result, a resource boom diminishes the growth rate of both the manufacturing and service sectors. In contrast, in resource-poor countries, the prevailing resource spillover effect accelerates the growth rate of the manufacturing sector, while the prevailing indirect *LBD* effect decelerates the growth rate of the service sector. Consequently, a resource boom leads to slower economic growth in resource-rich countries. However, if the manufacturing sector serves as the primary economic engine, resource-poor economies are likely to experience faster expansion.

This prompts me to investigate how economic growth responds to the explanatory variables of interest. The level of GDP per capita (at constant prices) is considered the dependent variable,[35] while the resource dependence index and the real exchange rate are the explanatory variables of interest. Additionally, I include population growth, investment ratio, human capital index, openness index, government spending, and institution index in the regression model as control variables.

Table 5 displays the results. Despite the rule of thumb suggesting System *GMM* as the preferred method, I employ the Difference *GMM* to estimate the regression model. This choice is driven by the suspicion that the System *GMM* estimator may yield a unit root process, whereas the Difference *GMM* estimates exhibit higher statistical significance.[36] The estimate reported in Column (1) indicates that both coefficients enter with negative signs and are significant at the 1% level. To investigate the effect of *LBD*, I initially exclude the resource dependence index and then proceed to estimate the regression model. The estimated results in Column (2) show that a 1% increase in the real value of a country's currency against the basket of the country's trading partners results in a reduction

[34] Bjørnland and Thorsrud (2016)'s study of Australia and Norway, both OECD countries, suggests an increase in value-added within the non-tradable sectors compared to the traded sectors. These findings, which differ from my own estimates and those of Harding et al. (2020), could result from the heterogeneity within each group of resource-dependent countries in terms of their level of development and technology.

[35] The standard setup in growth regression involves using the growth rate as the dependent variable and the initial GDP level as the independent variable, as demonstrated in Barro and Sala-i Martin (1992). However, Eq. (9) illustrates that I consider a level of GDP as the dependent variable, similar to the approach in Bond et al. (2001). These are two sides of the same coin, as subtracting the lagged GDP level from both sides of the regression aligns my model with the standard form: $Growth_{i,t} = y_{i,t} - y_{i,t-1} = \alpha + (\delta - 1)y_{i,t-1} + \lambda R_{i,t-1} + X'_{i,t}\beta + \varepsilon_{i,t}$. My estimation of the standard setup confirms this point, and the estimation results are available upon request.

[36] I have also estimated regression models using the System *GMM*. The estimates obtained through the *GMM* approaches are qualitatively similar, but they exhibit quantitative differences. Further details can be obtained from the author upon request.

of approximately 0.1% in GDP per capita. This finding aligns with empirical studies that emphasize the adverse effect of real exchange rate appreciation on the growth rate [e.g., Eichengreen (2007); Rodrik (2008); Rajan and Subramanian (2008); Habib et al. (2017)]. In line with theoretical predictions, this result may suggest that the *LBD* effect caused by the appreciation of the real exchange rate tends to decrease economic growth on average.

Furthermore, I examine the impact of the resource spillover effect on the growth rate, taking into account the heterogeneity of resource dependence across countries. The estimates for the full sample of countries are displayed in Column (3), revealing that a one-percentage-point increase in the resource dependence index increases the GDP per capita by roughly 0.85%. This finding supports the hypothesis of the natural resource curse [e.g., Sachs and Warner (1995); Rodriguez and Sachs (1999); Gylfason et al. (1999); Zallé (2019)].

Following the preceding subsections, I also present results for samples of resource-rich and resource-poor countries. The results are detailed in Columns (4) and (5), respectively. These estimates indicate that a one-percentage-point increase in the resource dependence index decreases GDP per capita by approximately 0.48% in the resource-rich country group and raises it by approximately 3.9% in the resource-poor country group. These findings demonstrate a deceleration of growth in resource-rich countries and an acceleration of growth in resource-poor countries. In light of the empirical findings discussed earlier, a resource boom leads to contractions in both sectors in resource-rich countries. Consequently, a slower growth rate is expected for this particular group of countries. Theoretically, this suggests that the *LBD* effect plays a crucial role in determining the growth rate. Conversely, a resource boom triggers the expansion of the manufacturing sector while simultaneously reducing the service sector in resource-poor countries. Consequently, the observed acceleration in the growth rate signifies that the manufacturing sector functions as the primary economic engine in resource-poor countries. Theoretically, this suggests that the resource spillover effect governs the growth rate in resource-poor countries. The positive spillover effect from the resource sector is significant, fully compensating for the adverse impact of *LBD* on the manufacturing sector, thus facilitating a faster expansion of the manufacturing sector. This, in turn, becomes the primary driving force behind the economy, resulting in accelerated economic growth.

3.2.5 Robustness Tests

The Appendix presents several robustness checks, providing additional insights into my baseline results. Firstly, I analyze the robustness of the results regarding country-group heterogeneity, including development level, institutional quality, and currency union effects. Additionally, I examine the influence of the Great Recession and various real exchange rate measurement methods on result consistency. Tables 8, 9, 10, and 11 report these robustness checks, and the estimates are discussed in Appendix D. Furthermore, in line with Mihasonirina and Kangni (2011), I provide additional estimates to assess the sensitivity of the coefficient on the explanatory variables of interest to variations in sample size. The results are reported in Table 13 and discussed in Appendix E.

I reported the results of the AR(3) test instead of the AR(2) estimates in Tables 4 and 5. The assumption of no AR(2) correlation is rejected when only one lag of the output level is included. A specification with only one lag is incapable of adequately capturing the dynamics in the output level (Acemoglu et al. 2019). Therefore, I integrated deeper lags

Table 5 Estimation results for the economic growth

Explanatory variable	(1) Full sample	(2) Full sample	(3) Full sample	(4) Res. rich	(5) Res. poor
GDP per capita (Ln) (lagged)	0.722***	0.812***	0.823***	0.697***	0.760***
	(0.0428)	(0.0381)	(0.0557)	(0.105)	(0.0694)
Real effective exchange rate (lagged)	−0.000874***	−0.00107***			
	(0.000218)	(0.000223)			
Recourse-dependence (lagged)	−0.00787***		−0.00849***	−0.00478**	0.0395***
	(0.00257)		(0.00316)	(0.00219)	(0.00991)
Time dummies	YES	YES	YES	YES	YES
Observations	694	694	694	288	406
Number of countries	120	120	120	58	62
Number of instruments	110	108	104	56	55
Arellano-Bond test for AR(3) (p-v)	0.598	0.661	0.827	0.543	0.334
Hansen OID test (p-v)	0.304	0.274	0.152	0.486	0.169

The dependent variable is the natural logarithm of the *GDP* per capita level. the natural logarithm of *GDP* per capita (lagged) and resource dependence index (lagged) are instrumented by the second lag and prior lags, while the real effective exchange rate (lagged) is instrumented by the first and prior lags. Furthermore, except for population growth and institution index, which are assumed to be exogenous to satisfy the rule of thumb, other control variables are instrumented by the second lag and prior lags. However, their estimates are not included in the table. Estimation results for the control variables are available upon request. The regression models are estimated using the Differenced *GMM*. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. The null hypothesis of the *Arellano-Bond* test indicates the absence of autocorrelation, the null hypothesis of the *Hansen* test assumes that the instruments, as a group, are uncorrelated with the error term. I report AR(3) instead of AR(2) since the null hypothesis is rejected in AR(2)

into the regression model. The results presented in Table 12 suggest no further evidence of serial correlation in the residuals when additional lags in output per capita are included. Furthermore, the estimates for the explanatory variable of interest show qualitative similarity to my baseline results, but not quantitative similarity. More discussion is presented in Appendix D.5.

4 Theory Meets Evidence

To provide context for our estimates, I first summarize the empirical results and then discuss them in terms of theory. The estimated empirical results provide clear evidence of symptoms related to the Dutch disease phenomenon. In summary, the empirical study demonstrates that a resource boom leads to an appreciation of the real exchange rate, which is more pronounced in resource-poor countries compared to resource-rich countries. Within resource-rich countries, a resource boom has a greater decelerating effect on the growth rate in the manufacturing sector than in the service sector. Consequently, this is associated with a lower level of relative sectoral output and slower economic growth. Conversely, in resource-poor countries, a resource boom accelerates the growth of the manufacturing sector while decelerating the growth of the service sector. This is associated with a higher level of relative sectoral output and faster economic growth.

The Dutch Disease mechanism, as illustrated in Fig. 1a, explains the empirical findings well for resource-rich countries. In the short run, a resource boom increases aggregate demand for both goods. Given the constant price of manufactured goods, the real exchange rate appreciates due to the expanded demand for service goods. This appreciation causes the real wage to rise in the service sector relative to the manufacturing sector. As a result, workers shift away from the manufacturing sector and move into the service sector. The labor share in the service sector increases to a greater extent than the given steady-state level. In the long-run process, the *LBD* effect serves as the primary driving force behind productivity growth in domestic sectors. Given the stability conditions of the dynamic system, the larger share of labor in the service sector compared to its steady-state level leads to a positive growth rate of the relative productivity ratio. Consequently, productivity growth in the manufacturing sector slows down more than in the service sector, resulting in a decrease in the economic growth rate. The declining relative productivity ratio along the transition path triggers a compensatory labor movement from the service to the manufacturing sector. This movement, in turn, mitigates the real exchange rate appreciation along the transition path. However, since the change in the service sector's labor share in the steady state due to the resource boom surpasses the given critical threshold, the real exchange rate eventually settles at a higher level than the initial level.

While Fig. 1b explains the empirical findings well for resource-poor countries. In the short run, a resource boom appreciates the real exchange rate under a mechanism similar to that of resource-rich countries. However, it causes the labor share in the service sector to increase somewhat below the steady-state level. In the long run, the resource spillover effect becomes the main driver of productivity growth in the manufacturing sector, while the *LBD* effect remains the primary driver of productivity growth in the service sector. Given the stability conditions of the dynamic system, the lower share of labor in the service sector compared to its steady-state level leads to a negative growth rate of the relative productivity ratio. Consequently, productivity growth accelerates in the manufacturing sector and slows down in the service sector, leading to an increase in the economic growth rate. The rising relative productivity ratio along the transition path induces a stronger alignment of labor movement from the manufacturing to the service sector. In turn, this exacerbates the appreciation of the real exchange rate along the transition path.

5 Conclusion

This study provides robust empirical validation for a modified Dutch disease theory that considers unequal spillovers of technological progress from the resource sector to the domestic sector. The proposed model addresses significant gaps between the predictions of Dutch disease dynamic models and empirical evidence. Using a dataset spanning 152 countries from 1970 to 2019, I employ the *GMM* method to control for the endogeneity problem and apply the theory to real-world data. Through this approach, I estimate the impact of a theory-consistent proxy for resource booms on spending and resource movement channels, illustrating the mechanism of resource rents in both resource-rich and resource-poor countries.

I present robust evidence of real exchange rate appreciation in response to a resource boom (spending effect). This appreciation is more pronounced in resource-poor countries than in resource-rich countries. Furthermore, I provide additional evidence for the spending effect through the international payments transmission channel. Consistent with the proposed theory, I demonstrate differences in the resource movement channel between resource-rich and resource-poor countries. The *LBD* effect serves as the primary driver of sectoral productivity growth in resource-rich countries. Consequently, a resource boom diminishes the growth rate in the manufacturing sector more than in the service sector, leading to a decline in the relative sectoral output and a slowdown in economic growth. Conversely, the resource spillover effect underlies the manufacturing sector's productivity growth in resource-poor countries. As a result, a resource boom accelerates productivity growth in the manufacturing sector and decelerates it in the service sector, leading to an increase in the relative sectoral output and an acceleration in economic growth.

These results emphasize the significance of distinguishing between resource-rich and resource-poor countries when analyzing the Dutch disease hypothesis. To the best of my knowledge, this is the first paper to discuss the spending and resource movement channels for groups of countries homogeneous in terms of resource dependence, establishing strong consistency between theory and empirical evidence.

Appendix

A: More Discussion on Theory

A.1: Dynamic Stability Condition

For the purpose of dynamic analysis, I investigate how the static equilibrium of labor allocation reacts to a change in relative productivity. Two driving forces come into play in labor allocation's response to an increase in the relative productivity ratio ϕ, as mentioned in Torvik (2001). On one hand, as the relative productivity level rises, the labor requirement in the manufacturing sector falls while it increases in the service sector (Labor requirement effect). With an unchanged composition basket, labor shifts from the manufacturing sector to the service sector. Hence, the higher the relative productivity level, the greater the service sector employment. On the other hand, the relative price of manufacturing goods decreases as the relative productivity ratio increases (Substitution effect). Consequently, the relative demand for manufacturing goods expands, which, in turn, induces labor to move from the service sector to the manufacturing sector. Thus, the higher the relative productivity level, the lower the service sector employment. In summary, two driving forces exert opposing influences on L_S.

The question that arises is which one of these driving forces is dominant. First, concerning the labor requirement effect, for a given labor allocation, an increase in the relative productivity ratio leads to a faster expansion of the manufacturing sector compared to the service sector. As manufacturing goods become relatively cheaper than service goods, the real exchange rate rises to restore equilibrium in the goods market (i.e., the *NN*-curve shifts upward and to the right). The vertical shift is equal to $\frac{P}{\phi\sigma}$. Second, concerning the substitution effect, for a given real exchange rate, an increase in the relative productivity ratio results in smaller marginal labor productivity in the service sector than in the manufacturing sector. Consequently, the labor force in the service sector decreases to restore equilibrium in the labor market (i.e., the *LL*-curve shifts upward and to the left). The vertical shift equals $\frac{P}{\phi}$. These observations indicate that the vertical shift is larger in the *NN*-curve than in the LL-curve if the elasticity of substitution is less than one (i.e., $\sigma < 1$). In conclusion, when the labor requirement effect is dominant ($\sigma < 1$), the labor force in the service sector increases as the relative productivity ratio rises (i.e., $\frac{dL_S}{d\phi} > 0$).

$$\text{Summarized argument:} \quad L_S = L_S(\phi, R), \quad \frac{dL_S}{d\phi} > 0 \quad \text{if } \sigma < 1 \text{ and } \frac{dL_S}{dR} > 0.$$

A.2: Dynamic Dutch Disease

Based on Eq. (7), a resource boom diminishes (augments) the growth rate of the relative productivity ratio if the change in the service sector's labor share resulting from a resource boom (i.e., $\frac{dL_S}{dR}$) exceeds (lags behind) its change in the steady state (i.e., $\frac{dL_S^*}{dR}$).

Proof Given Eqs. (6) and (7),

(a) if $\frac{dL_S}{dR} > \frac{dL_S^*}{dR} = \frac{\delta_R'}{(1-\gamma_M)\delta_M + (1-\gamma_S)\delta_S}$ then $\frac{d(\dot{\phi}/\phi)}{dR} < 0$

(b) if $\frac{dL_S}{dR} < \frac{dL_S^*}{dR} = \frac{\delta_R'}{(1-\gamma_M)\delta_M + (1-\gamma_S)\delta_S}$ then $\frac{d(\dot{\phi}/\phi)}{dR} > 0$.

Figure 2 depicts the adjustment balanced growth path (phase diagram). The locus of the relative productivity ratio is represented by a downward-sloping line to fulfill the stability condition (i.e., $\sigma < 1$).[37]

As the resource rent increases, the economy deviates from its steady-state equilibrium. If $\frac{dL_S}{dR} > \frac{dL_S^*}{dR}$, an increase in the service sector's labor share triggers the economy to jump vertically downward from the solid line to the dotted line. From there, it transitions towards a smaller equilibrium level of the relative productivity ratio, denoted as ϕ_1^{**}. Conversely, if the condition isn't met, the economy first jumps upward and then moves towards a larger equilibrium level of the relative productivity ratio, ϕ_2^{**}. In a special case where there is no spillover effect from the resource sector to the domestic sectors (i.e., $\delta_{RM} = \delta_{RS} = 0$ and so $\delta_R' = 0$), as discussed in Torvik (2001); Sachs and Warner (1995), or in the scenario of equal spillover effects from the resource sector to the domestic sectors (i.e., $\delta_{RM} = \delta_{RS} \neq 0$ but $\delta_R' = 0$), as studied in Bjørnland and Thorsrud (2016), a resource boom unconditionally leads to a reduction in the growth rate of the relative productivity ratio. □

[37] Assuming the resource spillover effects are given, let's consider an initial scenario where $\phi > \phi^*$. Because the labor requirement effect is dominant (i.e., $\sigma < 1$), employment in the service sector surpasses what it would be at the steady state. This leads to more robust productivity growth in the service sector compared to the manufacturing sector. Consequently, the relative productivity ratio declines over time until it reaches its steady-state value.

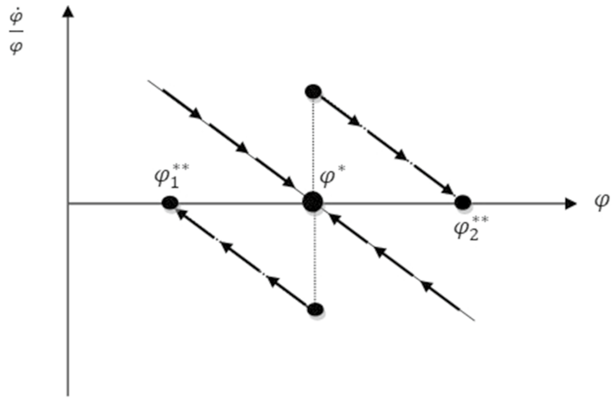


Fig. 2 Adjustment balanced growth path

A.3: Dynamic Ducth Disease for Case $\delta'_{RM} < \delta'_{RS}$

Given Eq. (6), if $\delta'_{RM} < \delta'_{RS}$ holds, a change in the (steady-state) labor share in the service sector due to a resource boom is always negative. Consequently, an initial labor movement from the manufacturing sector to the service sector, resulting from the real exchange rate appreciation, is graphically represented by shifting up the *NN*-curve (see Fig. 3).

Similar to the scenario depicted in Fig. 1a, the relative productivity ratio decreases during the transition path to restore equilibrium. This, in turn, results in a reverse labor movement from the service sector to the manufacturing sector. The reallocation of labor is illustrated by a more substantial downward shift of the *NN*-curve compared to the *LL*-curve. The labor share in the service sector gradually converges to a new steady-state level. Unlike the models presented by Torvik (2001) and Bjørnland and Thorsrud (2016), in which the labor share in the service sector returns to its initial level in the long term, the current model predicts that the new equilibrium of the labor share in the service sector establishes itself at a level lower than its initial value. While consistent with those models, my model also predicts that the new equilibrium of the real exchange rate is attained at a lower level compared to the initial one.

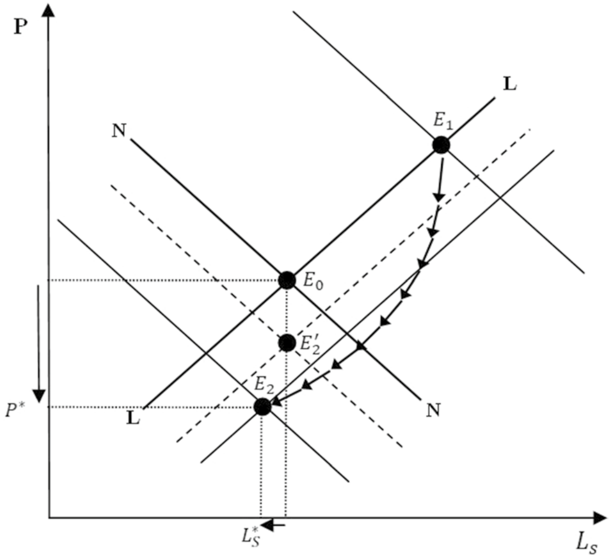
A.4: Steady State Response of the Real Exchange Rate

In a general state, if a resource boom alters the steady-state labor share in the service sector to the point where it exceeds a critical threshold, the resulting real exchange rate appreciation from the resource boom becomes permanent. Otherwise, the appreciation is temporary.

Proposition *Given the critical threshold for a change in the steady-state service sector labor share due to a resource boom,* $\frac{dL_S^*}{dR}|_C = \frac{L_S^* L_M^*}{(L_M^*)^\alpha + R[(1-\alpha)L_S^* - L_M^*]}$,

(a) *If* $\frac{dL_S^*}{dR}$ *is larger than the critical threshold,* $\frac{dL_S^*}{dR}|_C$*, a resource boom appreciates the steady-state real exchange rate (If* $\frac{dL_S^*}{dR} > \frac{dL_S^*}{dR}|_C \Rightarrow \frac{dP^*}{dR} > 0$).

Fig. 3 The Dutch disease mechanism: the case $\left(\delta'_{RM} < \delta'_{RS} \Rightarrow \frac{dL_S^*}{dR} < 0\right)$



(b) *If* $\frac{dL_S^*}{dR}$ *is smaller than the critical threshold,* $\frac{dL_S^*}{dR}|_C$*, a resource boom depreciates the steady-state real exchange rate* $(If \frac{dL_S^*}{dR} < \frac{dL_S^*}{dR}|_C \Rightarrow \frac{dP^*}{dR} < 0)$.

Proof By combining Eq. (2) to eliminate ϕ^*, we obtain:

$$P^*(R) = \left[\frac{L_S^*(R)}{1 - L_S^*(R) + R\left(1 - L_S^*(R)\right)^{1-\alpha}}\right]^{\frac{1}{1-\sigma}}$$

Now, the derivative of the steady-state real exchange rate with respect to R is as follows:

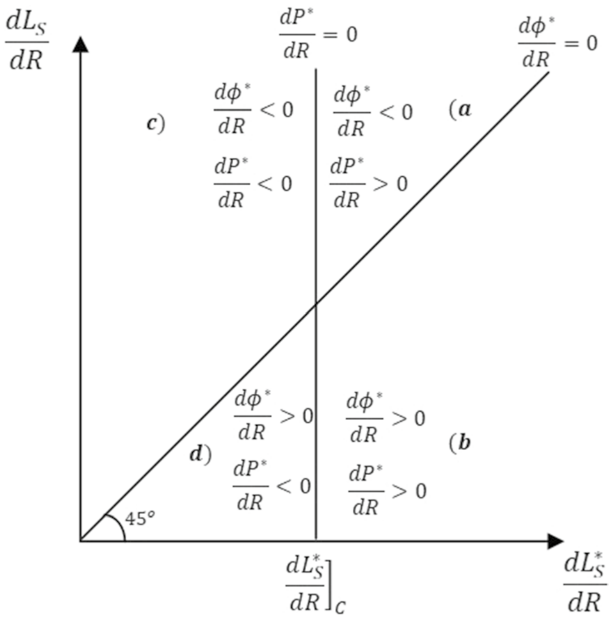
$$\frac{dP^*}{dR} = \frac{(P^*)^\sigma}{(1-\sigma)\left(L_M^*\right)^\alpha}\left(\left[\left(L_M^*\right)^\alpha - L_M^* R + (1-\alpha)L_S^* R\right]\frac{dL_S^*}{dR} - L_S^* L_M^*\right)$$

Then $\frac{dP^*}{dR} = 0 \;\; if \;\; \frac{dL_S^*}{dR}|_C = \frac{L_S^*\,L_M^*}{\left(L_M^*\right)^\alpha + R\left[(1-\alpha)L_S^* - L_M^*\right]}$.

Figure 4 illustrates the conditional responses of the steady-state real exchange rate and the steady-state relative productivity ratio to a resource rent change. The first case, $\frac{dL_S}{dR} > \frac{dL_S^*}{dR} > \frac{dL_S^*}{dR}|_C$, corresponds to part (*a*) in Fig. 4 and is in line with Fig. 1a. The analysis demonstrates that a decrease in the relative productivity ratio, triggered by a resource boom, mitigates the real exchange rate appreciation along the transition path. However, both in the short term due to the labor movement effect and in the long term due to the labor productivity effect, a resource boom results in the real exchange rate settling at a higher level compared to the initial level.

The second case, $\frac{dL_S^*}{dR} > \frac{dL_S}{dR} > \frac{dL_S^*}{dR}|_C$, corresponds to part (*b*) in Fig. 4 and is consistent with Fig. 1b. It reveals that an increase in the relative productivity ratio, triggered by a resource boom, exacerbates the real exchange rate appreciation along the transition path. Additionally, the case $\frac{dL_S^*}{dR} < \frac{dL_S}{dR} < \frac{dL_S^*}{dR}|_C$, corresponding to part (*c*) in Fig. 4, refers to the case $\delta'_R = 0$ as discussed in Torvik (2001), Sachs and Warner (1995), Bjørnland and

Fig. 4 Steady-state responses of the real exchange rate and the relative productivity ratio to a change in the resource rent



Thorsrud (2016), or the case $\delta'_{RM} < \delta'_{RS}$ discussed in Appendix A.3. A decrease in the relative productivity ratio leads to the depreciation of the real exchange rate along the transition path. As a result, the new steady-state real exchange rate eventually settles at a level lower than the initial level (i.e., E'_2 in Fig. 1). Given the stability condition (Proposition 1), the last case $\frac{dL_S}{dR} < \frac{dL_S^*}{dR} < \frac{dL_S^*}{dR}|_C$, corresponding to part (*d*) in Fig. 4, does not exist. □

A.5: Sectoral Dynamic Adjustment

Equation (1) reveal that the response of sectoral productivity growth depends on the *LBD* effect and the technology improvement spillover effect from the resource sector. The former effect encompasses the direct impact of the learning process generated within the sector and the indirect effect of the learning process spilling over from another sector. Assuming that the direct effect of the learning process in each sector is stronger than its indirect effect spilled over from another sector. Additionally, the resource process activity has a positive spillover effect on the domestic sectors' productivity growth. Therefore, an increase in the labor share in the service sector resulting from a resource boom tends to speed up productivity growth in the service sector.[38] Otherwise, productivity growth responds conditionally to labor reallocation.

[38] If the direct effect is weaker than the indirect effect, a resource boom tends to accelerate the productivity growth in the manufacturing sector.

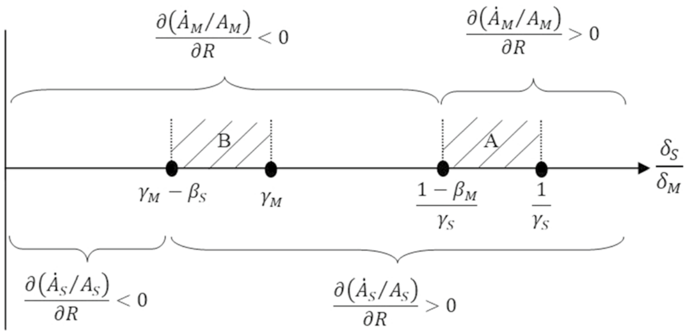


Fig. 5 Absolute productivity growth change

Proposition *For any* $\delta_M, \delta_S > 0$, $0 < \gamma_M, \gamma_S < 1$, *and* $\delta'_{RM}, \delta'_{RS} > 0$ *assume* $\beta_M \equiv \frac{\delta'_{RM}}{\delta_M \frac{dL_S}{dR}}$ *and* $\beta_S \equiv \frac{\delta'_{RS}}{\delta_M \frac{dL_S}{dR}}$, *where* β_M *and* β_S *are the relative marginal spillover benefit of the resource process activity in sector* X ($X = M, S$) *to the marginal benefit of the direct LBD effect in the manufacturing sector*;

(a) *If* $\frac{\delta_S}{\delta_M} < \frac{1-\beta_M}{\gamma_S}$, *a natural resource boom decelerates the productivity growth in the Manufacturing sector. Otherwise, it accelerates the productivity growth in the Manufacturing sector.*
(b) *If* $\frac{\delta_S}{\delta_M} < \gamma_M - \beta_S$, *a natural resource boom decelerates the productivity growth in the Service sector. Otherwise, it accelerates the productivity growth in the Service sector.*

Proof The results are found by taking the derivative of the absolute productivity growth to R, $\frac{d(\dot{A}_M/A_M)}{dR} = \left(\gamma_S\delta_S - \delta_M\right)\frac{dL_S}{dR} + \delta'_{RM}$ & $\frac{d(\dot{A}_S/A_S)}{dR} = \left(\delta_S - \gamma_M\delta_M\right)\frac{dL_S}{dR} + \delta'_{RS}$, and given the summarized argument $\frac{dL_S}{dR} > 0$.

Figure 5 illustrates the changes in the growth rate of sectoral productivity levels due to a resource boom. If $\frac{\delta_S}{\delta_M}$ is less than $\frac{1}{\gamma_S}$, the direct *LBD* effect dominates in the manufacturing sector. Consequently, as the resource rent increases, the *LBD* effects decelerate productivity growth, while the resource spillover effect accelerates productivity growth unconditionally. These two opposing forces determine how productivity growth in the manufacturing sector responds to a resource boom. Similarly, for the service sector's productivity growth, if $\frac{\delta_S}{\delta_M}$ is less than γ_M, the *LBD* and the resource spillover effects work in opposite directions. With the increase in resource rent, the dominated indirect *LBD* effect slows down productivity growth, while the positive spillover effect of the resource process activity enhances productivity growth. The hatched parts A and B in Fig. 5 represent the positive spillover effects of the resource process activity on the productivity of the manufacturing and the service sectors, respectively. If there is no spillover effect from the resource sector (i.e., $\delta'_S = \delta'_M = 0$), $\beta_S = \beta_M = 0$, as in Torvik (2001). However, the present theory can clearly capture the unequal positive resource spillover effect on the domestic sectors. Stronger spillover effects from the resource sector cause β_S and β_M to be larger, thereby reducing the threshold values (i.e., $\gamma_M - \beta_S$ and $\frac{1-\beta_M}{\gamma_S}$) even further. This graphical representation indicates that the thresholds shift to the left and the hatched parts expand. In conclusion, a significant positive resource spillover effect on the domestic sectors can counteract the opposing *LBD* effects, leading to faster productivity growth in both sectors.

In earlier literature, sectoral productivity was solely driven by the *LBD* effect. Since Krugman (1987) dismisses the *LBD* effect in the service sector by assuming $\delta_{RS} = \delta_{RM} = \delta_S = \gamma_M = \gamma_S = 0$, the productivity of the service sector remains unchanged, while the productivity of the manufacturing sector experiences slower growth due to the Dutch disease. Additionally, Lucas (1988) assumes a direct *LBD* effect in both sectors without any spillover effect between them (i.e., $\delta_{RS} = \delta_{RM} = \gamma_S = \gamma_M = 0$). Consequently, a resource boom accelerates productivity growth in the service sector and decelerates it in the manufacturing sector. This outcome differs from Sachs and Warner (1995), where they propose that the manufacturing sector is exclusively driven by the direct *LBD* effect, while the service sector is solely driven by the indirect spillover *LBD* effect, denoted as $\delta_{RS} = \delta_{RM} = \delta_S = 0$ and $\gamma_M = 1$. Thus, a resource boom decelerates productivity growth in both sectors.

Furthermore, the current model, without any spillover effect from the resource sector (i.e., $\delta_{RS} = \delta_{RM} = 0$), corresponds to a specific case outlined in Torvik (2001). In this case, a direct *LBD* effect exists in both sectors, along with an indirect spillover effect between these sectors. When the condition $\delta_S < \gamma_M \delta_M$ is satisfied, the spillover *LBD* effect prevails in the service sector, whereas the direct *LBD* effect takes precedence in the manufacturing sector.[39] Labor movement from the manufacturing sector to the service sector, resulting from a resource boom, leads to a deceleration in productivity growth in both sectors. Furthermore, if the direct effect dominates in both sectors (i.e., $\delta_S > \gamma_M \delta_M$ and $\delta_M > \gamma_S \delta_S$), productivity growth slows down in the manufacturing sector while accelerating in the service sector. Lastly, when $\delta_M < \gamma_S \delta_S$ holds, productivity growth speeds up in both sectors,[40] In contrast, similar to the current model, Bjørnland and Thorsrud (2016) clarifies the significant role of the spillover effect from the resource processing activity on sectoral productivity growth. The greater the spillover effect from the resource processing activity, the less likely the sectoral productivity growth is to decline. □

A.6: Steady-State Growth Rate

In a general case involving resource spillover effects on both sectors, a shift in the steady-state growth rate due to a resource boom relies on the relative marginal resource spillover

[39] Given $0 < \gamma_S, \gamma_M < 1$, if $\delta_S < \gamma_M \delta_M$ thus $\gamma_S \delta_S < \delta_S < \gamma_M \delta_M < \delta_M$. Since $\beta_S = 0$, the hatched part B in Fig. 5 disappears.

[40] Given $0 < \gamma_S, \gamma_M < 1$, if $\delta_M < \gamma_S \delta_S$ thus $\gamma_M \delta_M < \delta_M < \gamma_S \delta_S < \delta_S$. Since $\beta_M = 0$, the hatched part A in Fig. 5 disappears.

Table 6 List of countries

	Period	*ARR* (%*GDP*)		Period	*ARR* (%*GDP*)		Period	*ARR* (%*GDP*)
Albania	1985–2019	4.27	Gambia, The	1970–2019	3.53	Romania	1990–2019	2.54
Algeria	1970–2019	21.02	Germany	1970–2019	0.28	Russia	1990–2019	13.56
Angola	1980–2019	29.88	Ghana	1970–2019	8.83	Rwanda	1970–2019	7.83
Argentina	1970–2019	2.9	Greece	1970–2019	0.24	Saudi Arabia	1970–2019	41.78
Armenia	1990–2019	1.23	Guatemala	1970–2019	1.55	Senegal	1970–2019	2.7
Australia	1970–2019	4.45	Haiti	1970–2019	1.56	Sierra Leone	1970–2019	13.86
Austria	1970–2019	0.29	Honduras	1970–2019	2.95	Slovakia	1990–2019	0.36
Azerbaijan	1995–2019	27.74	Hungary	1990–2019	0.56	Slovenia	1995–2019	0.21
Bahrain	1980–2019	7.72	India	1970–2019	2.96	South Africa	1970–2019	5.87
Bangladesh	1970–2019	0.77	Indonesia	1970–2019	10.61	Spain	1970–2019	0.15
Barbados	1970–2019	0.62	Iran	1970–2019	23.31	Sri Lanka	1970–2019	0.43
Belarus	1990–2019	1.76	Ireland	1970–2019	0.23	Sudan	1970–2019	4.32
Belgium	1970–2019	0.08	Italy	1970–2019	0.11	Suriname	1970–2019	15.61
Belize	1975–2019	1.56	Jamaica	1970–2019	5.11	Swaziland	1970–2019	7.07
Benin	1970–2019	6.84	Japan	1970–2019	0.08	Switzerland	1980–2019	0.02
Bhutan	1980–2019	5.76	Jordan	1975–2019	0.8	Sweden	1970–2019	0.58
Bolivia	1970–2019	6.66	Kazakhstan	1990–2019	18.57	Tajikistan	1995–2019	0.92
Botswana	1970–2019	3.24	Kenya	1970–2019	4.1	Tanzania	1990–2019	7.7
Brazil	1970–2019	2.76	Korea south	1970–2019	0.16	Thailand	1970–2019	1.7
Brunei	1985–2019	25.81	Kuwait	1990–2019	46.29	Togo	1970–2019	11.36
Bulgaria	1980–2019	1.74	Kyrgyzstan	1990–2019	3.77	Trinidad &Tobago	1970–2019	15.4
Burkina Faso	1970–2019	9.32	Lao PDR	1980–2019	7.87	Turkey	1970–2019	0.59
Burundi	1970–2019	16.43	Latvia	1995–2019	1.62	Tunisia	1970–2019	6.57
Cambodia	1990–2019	4.11	Lithuania	1995–2019	0.71	Ukraine	1990–2019	4.79
Cameron	1970–2019	7.44	Luxembourg	1970–2019	0.05	Uganda	1980–2019	16.71
Canada	1970–2019	3.46	Madagascar	1970–2019	5.19	United Kingdom	1970–2019	1.74
Central Africa	1980–2014	9.56	Malawi	1970–2019	7.97	United States	1970–2019	1.58

Table 6 (continued)

	Period	*ARR* (%*GDP*)		Period	*ARR* (%*GDP*)		Period	*ARR* (%*GDP*)
Chad	1970–2019	13.77	Malaysia	1970–2019	19.06	Uruguay	1970–2019	0.65
Chile	1970–2019	10.37	Mali	1970–2019	6.09	Venezuela	1970–2019	18.99
China	1970–2019	6.19	Mauritania	1970–2019	18.58	Vietnam	1985–2019	7.46
Colombia	1970–2019	4.51	Mexico	1970–2019	5.22	Yemen	1990–2019	28.95
Congo, Dem	1970–2019	19.92	Moldova	1995–2019	0.25	Zambia	1970–2019	14.87
Congo, Rep	1970–2019	33.04	Mongolia	1990–2019	18.56	Bosnia	2000–2019	1.67
Costa Rica	1970–2019	3.2	Morocco	1970–2019	1.96	Cuba	1970–2019	1.32
Cote d′Ivoire	1970–2019	5.22	Mozambique	1980–2019	10.94	Dominica	1970–2019	0.06
Croatia	1995–2019	0.94	Namibia	1980–2019	4.38	Georgia	2000–2019	0.8
Cyprus	1975–2019	0.15	Nepal	1970–2019	1.98	Guinea	1985–2019	16.15
Czech	1990–2019	0.78	Netherlands	1970–2019	0.79	Guinea-Bissau	1970–2019	17.13
Denmark	1970–2019	0.66	New Zealand	1970–2019	1.75	Equatorial Guinea	1980–2019	35.12
Dominican Rep	1970–2019	1.44	Nicaragua	1970–2019	2.69	Guyana	1970–2019	19.67
Ecuador	1970–2019	9.35	Niger	1970–2019	7.32	Iceland	1995–2019	0.0
Egypt	1970–2019	12	Nigeria	1980–2019	15.74	Israel	1995–2019	0.13
El Salvador	1970–2019	0.73	Norway	1970–2019	5.9	Lebanon	1985–2019	0.01
Eritrea	1990–2014	6.19	Pakistan	1970–2019	1.3	Lesotho	1980–2019	5.87
Estonia	1995–2019	1.61	Panama	1970–2019	0.25	North Macedonia	1990–2019	1.23
Ethiopia	1980–2019	17.92	Paraguay	1970–2014	2.24	Oman	1970–2019	41.72
Fiji	1970–2019	1.5	Peru	1970–2019	6.42	Papua New Guinea	1970–2019	20.04
Finland	1970–2019	0.73	Philippine	1970–2019	2.51	Qatar	2000–2019	30.88
France	1970–2019	0.11	Poland	1990–2019	1.32	Tonga	1980–2019	0.08
Gabon	1970–2019	27.1	Portugal	1970–2019	0.3	Uzbekistan	1995–2019	18.06
Afghanistan	2000–2019	0.64	Bahamas	1970–2019	0.16			

benefits across sectors (i.e., $\frac{\delta'_{RM}}{\delta'_{RS}}$) and the relative gap between the direct and indirect *LBD* effects within sectors (i.e., $\frac{\delta_M-\gamma_S\delta_S}{\delta_S-\gamma_M\delta_M}$).

Proposition *For any* $\delta_M, \delta_S > 0$, $0 < \gamma_M, \gamma_S < 1$, *and* $\delta'_{RM}, \delta'_{RS} > 0$, $\delta_{Economy} \equiv \frac{\delta'_{RM}}{\delta'_{RS}} + \frac{\delta_M-\gamma_S\delta_S}{\delta_S-\gamma_M\delta_M}$ *is defined as the sum of the marginal resource spillover benefit in the manufacturing sector relative to that in the service sector and the gap between the direct and indirect LBD effects in the manufacturing sector relative to that in the service sector*

(a) *If* $\delta_{Economy} > 0 \Rightarrow \frac{dg^*}{dR} < 0$
(b) *If* $\delta_{Economy} = 0 \Rightarrow \frac{dg^*}{dR} = 0$
(c) *If* $\delta_{Economy} < 0 \Rightarrow \frac{dg^*}{dR} > 0$.

Proof By taking a derivative of the steady state growth rate in Eq. (8) with respect to *R* and subsequently simplifying the result. □

B: Description of Explanatory Variables and List of Countries

- *ARR* (%GDP) denotes the average total natural resource rent (% of *GDP*) over the period.
- *Net foreign assets* (% of *GDP*) I collect data on net foreign assets and *GDP* (both in local currency units) from the World Development Indicators (*WDI*) to calculate the average value for the 5-year period.
- *Population growth* The average value for the 5-year period is sourced from the World Development Indicators (*WDI*).
- *Investment ratio* The gross fixed capital formation as a percentage of *GDP* (Constant 2010 US dollars) is used to proxy the investment ratio. Observed values, averaged over 5-year periods, are obtained from the World Development Indicators (*WDI*).
- *Human Capital Index* My measure of human capital is an index constructed by the *Penn World Table*. This index is based on the database from Barro and Lee (2013) for the average years of schooling and an estimated rate of return for primary, secondary, and tertiary education, as introduced by Caselli (2005).
- *Openness ratio* I gather data on the trade-to-GDP ratio (Constant 2010 US dollars), a proxy for the openness level, from the World Development Indicators (*WDI*) database. The ratio is observed as averages over 5-year periods.
- *Terms of trade* The net barter terms of trade index (2010=1) is calculated as the percentage ratio of the export unit value indexes to the import unit value indexes. The average value for the 5-year periods is derived from the World Development Indicators (*WDI*) database. Note that the base year of the database is 2005=1.
- *Foreign direct investment* It is defined as the net inflows of investment divided by *GDP*. The average value for the 5-year period is collected from the World Development Indicators (*WDI*) database.
- *Government spending* It refers to the General government final consumption expenditure (% of *GDP*) (constant 2010 US dollars). The data represents average values for 5-year periods, sourced from the World Development Indicators (*WDI*) database.

- *Inflation GDP* deflator (annual %)
- *Institution index* The Rule of Law indicator is regarded as a proxy for institutional quality. The indicators proposed by the *World Bank′s Governance Indicators Project* are within the range of −2.5 (weak) to +2.5 (strong). The data is available from 1996 to 2015. For earlier periods, I assume that the indicators are equal to the earliest value (Table 6).

C: The Net Foreign Assets and Resource-Dependence

In this appendix, I address the long-run relationship between natural resource rents and net foreign assets. I collect data on net foreign assets and *GDP* (both in local currency units) from *WDI* to create the explanatory variable of net foreign assets (% of *GDP*). The sample comprises 114 countries over the period 1970–2014. The dependent variable is net foreign assets (% of *GDP*), while the explanatory variable of interest is the resource dependence index. Additionally, I have included several control variables, namely *GDP* per capita, Foreign Direct Investment, Terms of Trade, Openness index, and Institution index.

Table 7 reports the results. Column (1) represents the results estimated using the *OLS* as a benchmark, while column (2) shows the results of the baseline regression model estimated using the *Sys.GMM*. These results highlight a significant association between an increase in the resource-dependence index and larger net foreign assets. This finding confirms that the impact of resource rent on economic performance is likely transmitted through international transfer payments. As a test of robustness, I conduct panel regressions for country subgroups. Columns (3)–(5) exhibit the results for samples of developing, resource-poor, and resource-rich countries, respectively. The coefficient on resource dependence enters with a positive sign for all samples, remaining statistically significant only for the samples of developing and resource-rich countries. The larger coefficient value for the resource-rich country sample compared to the full sample plausibly explains why most resource-rich countries are creditors.

D: Robustness Check

D.1: Real Exchange Rate

Columns (1) and (2) in Table 8 report the *OLS* and fixed effect (*FE*) estimates of the base specification model, respectively. Although the results might not be highly informative, they still serve as valuable benchmarks. Columns (3) and (4) present additional robustness checks for the baseline model, considering heterogeneity across countries.

For one check, I narrow down the sample to developing countries, as defined by the International Monetary Fund's World Economic Outlook Database. Additionally, I perform the regression analysis on the sub-sample of Non-European countries to eliminate the effects of currency unions. The estimated results reveal that the positive effect of the resource-dependence index on the real exchange rate is even more pronounced in the cases of developing and Non-European countries. A 1% increase in the resource-dependence index results in a real effective exchange rate appreciation of approximately 0.0301% for developing countries and 0.0321% for Non-European countries. These findings may suggest that resource rents have a greater tendency to boost the relative demand for service goods in developing countries. Furthermore, the currency union within Europe seems to be even more effective in mitigating the resource curse.

The global recession spanning 2008–2013 stands as the most severe downturn since the postwar recession, both in terms of the decline in real-world GDP per capita and the number of affected countries. A recession might lead to a real exchange rate depreciation resulting from reduced interest rates. Thus, it appears worthwhile to investigate the impact of a recession on the coherence of the relationship between the variables of interest. For this purpose, I conduct the regression analysis for a sub-sample covering the period 1970–2004, aiming to exclude the influence of the recession. The results are detailed in Column (5). The positive and statistically significant coefficient of the resource-dependence index verifies the real exchange rate appreciation due to a resource boom. Furthermore, it indicates that the Great Recession does not substantially change the nature of the relationship between these variables. Moreover, the coefficient value for the full sample is smaller than that of the restricted sample. This phenomenon may reflect the downward effect of the real exchange rate stemming from the decline in interest rates during the recession.

The consistency of the results is also examined by employing a different measurement approach for the dependent variable database. I conduct the baseline regression model using a database of real effective exchange rates estimated by the *IMF*.[41] The results are presented in Column (6). The *IMF* database includes real effective exchange rates for 49 developing countries and 26 developed countries among those selected in the sample. The coefficient on the resource-dependence index displays a positive sign, and its value is smaller than what I discovered in the base sample estimate. However, the statistical significance of the coefficient is weaker for the sample based on the *IMF* dataset (i.e., significant at 5% level). This is likely attributed to the smaller amount of country data available in the *IMF* database compared to the *Bruegel* database.

D.2 Relative Sectoral Output

Columns (1) and (2) in Table 9 present the *OLS* and fixed effect estimates, respectively. To assess the robustness of the results, I initially categorize countries with weak institutions, where the institution index (i.e., the rule of law index) is less than 1.5. Subsequently, I estimate the baseline regression model (i.e., Column 1 in Table 3) for developing countries, countries with weak institutions, and non-European countries. The results are reported in Columns (3)–(5), respectively. The coefficients of interest in all three sub-samples remain negative and statistically significant.

Furthermore, I analyze the consistency of the results within a sample that excludes periods of the Great Recession. The results presented in Column (6) affirm the robustness of

[41] The main distinction between the *Bruegel* and *IMF* databases lies in the computation of the geometrically weighted average of *CPI* indices of trading partners.

Table 7 Estimation results for the net foreign assets

Explanatory variable	(1) Full sample OLS	(2) Full sample Sys. GMM	(3) Developing Sys. GMM	(4) Res. poor Sys. GMM	(5) Res. rich Sys. GMM
Net foreign assets (lagged)	0.736***	0.699***	0.653***	0.642***	0.807***
	(0.0211)	(0.117)	(0.129)	(0.198)	(0.0837)
Resource-dependence (lagged)	0.177***	0.356***	0.359***	0.997	0.549***
	(0.0447)	(0.112)	(0.113)	(1.473)	(0.196)
Time dummies	YES	YES	YES	YES	YES
Observations	763	763	682	375	313
Number of countries	66	114	103	72	66
Arellano-bond test for AR(2) (*p* value)	–	0.136	0.199	0.178	0.585
Hansen OID test (*p* value)	–	0.231	0.371	0.596	0.341
R-squared	0.727	–	–	–	–

The dependent variable is the net foreign assets. The resource dependence (lagged) is instrumented by the first and prior lags in the first-differences equation. Additionally, control variables in the full and developing countries' samples are instrumented by the second lag level in the first-differences equation, while they are instrumented by the second lag level to satisfy the rule of thumb in Columns (4) and (5). However, their estimates are not presented in the table. Estimation results for control variables are available upon request. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. The null hypothesis of the *Arellano-Bond* test indicates the absence of autocorrelation, the null hypothesis of the *Hansen* test assumes that the instruments, as a group, are uncorrelated with the error term

the primary findings, regardless of the influence of recession effects. The value of the real exchange rate coefficient remains nearly identical to the estimated value for the sample encompassing all periods. While the coefficient on the resource-dependence index is more negative for the restricted sample compared to the full sample. In conclusion, these observations suggest minimal sensitivity in the relationship between the dependent variable and explanatory variables of interest to heterogeneity across country groups in terms of development level, institutional quality, currency union effects, and the impact of recession.[42]

I further regress the model on a sample of the real effective exchange rate estimated by the *IMF*. This allows me to examine the dependence of the results on the measurement approaches for the explanatory variable of interest. The results presented in Column (7), similar to those estimated by the *Bruegel* database, align with the theory's prediction. However, the absolute value of the coefficient estimated by the *IMF* database is significantly larger than the coefficient estimated by the *Bruegel* database [i.e., Column (2) in Table 3]. In conclusion, this demonstrates that the empirical findings confirm the theory's prediction, regardless of the measurement approaches for the real effective exchange rate.

[42] I also investigate heterogeneity across countries for regression models that include either the real exchange rate variable or the resource dependence index. Similar to Table 3, the coefficients on these variables exhibit negative signs and are statistically significant. Further details are available from the author upon request.

Table 8 Robustness check, estimation results for the real effective exchange rate

Explanatory variable	(1) *Bruegel* Full sample OLS	(2) *Bruegel* Full sample FE	(3) *Bruegel* Developing Sys. GMM	(4) *Bruegel* Non-Europe Sys. GMM	(5) *Bruegel* Recession Sys. GMM	(6) *IMF* Full sample Sys. GMM
Real exchange rate (Ln) (lagged)	0.628***	0.526***	0.467***	0.467***	0.573***	0.436***
	(0.0217)	(0.0295)	(0.0616)	(0.0633)	(0.0337)	(0.0610)
Resource-dependence (Ln) (lagged)	0.00699	0.0160	0.0301**	0.0321***	0.0357**	0.0137**
	(0.00482)	(0.0119)	(0.0135)	(0.0116)	(0.0163)	(0.00686)
Time dummies	YES	YES	YES	YES	YES	YES
Observations	843	843	625	676	487	438
Number of countries	132	132	103	109	115	75
Number of instruments	–	–	73	73	84	70
Arellano-Bond test for AR(2) (p-v)	–	–	0.430	0.415	0.329	0.987
Hansen OID test (p-v)	–	–	0.106	0.181	0.471	0.560
R-squared	0.585	0.432	–	–	–	–

The dependent variable is the real effective exchange rate (Ln). The lagged real effective exchange rate (Ln) is instrumented by second and prior lags, while the lagged resource-dependence index (Ln) is instrumented by first and prior lags. Control variables are instrumented by the second lag, but they are assumed to be exogenous in Column (6) to satisfy the rule of thumb. However, their estimates are not included in the table. Estimation results for control variables are available upon request. The regression models in Columns (3)–(6) are estimated using the System *GMM*. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. The null hypothesis of the *Arellano-Bond* test indicates the absence of autocorrelation, the null hypothesis of the *Hansen* test assumes that the instruments, as a group, are uncorrelated with the error term

D.3 Sectoral Growth

Column (1) in Table 10 presents the fixed effect estimates.[43] Additionally, I investigate the robustness of the results with respect to country-group heterogeneity, considering development level, institutional quality, and currency union effects. The results are detailed in Columns (2)–(4) for the manufacturing sector and Columns (8)–(10) for the service sector. Although statistically significant results maintain qualitative similarity to the full sample, there are quantitative variations. In the context of the manufacturing sector estimates, the coefficient of the resource dependence index is more negative in the restricted samples than in the full sample (i.e., Column 1 of Table 4). Conversely, for the service sector estimate, it displays a less negative value.

I also assess the consistency of the results within a sample limited to the period preceding the Great Recession. While the coefficient exhibits a more negative value for the manufacturing and service sector estimates in Columns (5) and (11), the reported results validate the robustness of the primary findings against recession effects. Additionally, Columns (6) and (12), presenting the results estimated using the *IMF* database, indicate that

[43] *Hausman* tests are rejected for both sectors with a *pvalue* of 0.000.

Table 9 Robustness check, estimation results for the relative sectoral output

Explanatory variable	(1) Full sample OLS	(2) Full sample FE	(3) Developing Dif. GMM	(4) Poor-instit Dif. GMM	(5) Non-Europe Dif. GMM	(6) Recession Dif. GMM	(7) IMF Dif. GMM
Relative sectoral output (Ln) (lagged)	0.922***	0.805***	0.798***	0.759***	0.786***	0.628***	0.720***
	(0.0116)	(0.0231)	(0.0949)	(0.0855)	(0.0945)	(0.106)	(0.111)
Real effective exchange rate (lagged)	−0.000580	−0.00116	−0.000925*	−0.00126***	−0.000870**	−0.000908***	−0.0291**
	(0.00113)	(0.00106)	(0.000534)	(0.000359)	(0.000427)	(0.000348)	(0.0146)
Recourse-dependence (lagged)	−0.000429	0.00277*	−0.00612**	−0.00605**	−0.00839***	−0.00870***	
	(0.000711)	(0.00166)	(0.00265)	(0.00283)	(0.00286)	(0.00318)	
Time dummies	YES	YES	YES	YES	YES	YES	YES
Observations	710	710	443	359	476	279	327
Number of countries	120	120	83	73	89	87	68
Number of instruments	–	–	80	71	87	67	64
Arellano-bond test for AR(2) (p-v)	–	–	0.207	0.366	0.161	0.571	0.161
Hansen OID test (p-v)	–	–	0.348	0.354	0.430	0.348	0.582
R-squared	0.909	0.711	–	–	–	–	–

The dependent variable is the relative output per capita of the manufacturing to the service sector (Ln) (in constant price). The real effective exchange rate data estimated by *Bruegel* is used in Columns (1)–(6), while the data estimated by *IMF* is employed in Column (7). The lagged relative sectoral output, real effective exchange rate, and resource-dependence index are instrumented by the first and prior lags. Additionally, control variables are instrumented by the second lag. However, their estimates are not provided in the table. Estimation results for control variables can be provided upon request. The regression models in Columns (3)–(7) are estimated using the Differenced *GMM*. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. The null hypothesis of the *Arellano-Bond* test indicates the absence of autocorrelation, the null hypothesis of the *Hansen* test assumes that the instruments, as a group, are uncorrelated with the error term

Table 10 Robustness check, estimation results for the sectoral growth

Explanatory variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Manufac	Manufac	Manufac	Manufac	Manufac	Manufac	Service	Service	Service	Service	Service	Service
	Full sample	Developing	Poor-instit	Non-Europe	Recession	IMF	Full sample	Developing	Poor-instit	Non-Europe	Recession	IMF
	FE	Sys. GMM	Sys. GMM	Sys. GMM	Sys. GMM	Sys. GMM	FE	Sys. GMM	Sys. GMM	Sys. GMM	Sys. GMM	Sys. GMM
Sctoral output per capita (Ln) (lagged)	0.637***	0.448***	0.498***	0.411***	0.363***	0.523***	0.349***	0.406***	0.436***	0.385***	0.457***	0.693***
	(0.0245)	(0.0766)	(0.0781)	(0.0790)	(0.107)	(0.0909)	(0.0207)	(0.0643)	(0.0663)	(0.0652)	(0.0644)	(0.0606)
Real effective exchange rate (lagged)	−0.00192*	−0.00163***	−0.00156***	−0.00183***	−0.00199***	−0.0390***	−0.000951*	−0.00159***	−0.00147***	−0.00165***	−0.00170***	−0.0291**
	(0.00114)	(0.000420)	(0.000372)	(0.000564)	(0.000704)	(0.0143)	(0.000532)	(0.000179)	(0.000197)	(0.000194)	(0.000176)	(0.0131)
Recourse-dependence (lagged)	0.00135	−0.0113***	−0.00889**	−0.0129***	−0.0253***		−0.000721	−0.00607***	−0.00532***	−0.00592***	−0.00929***	
	(0.00176)	(0.00422)	(0.00420)	(0.00489)	(0.00832)		(0.000791)	(0.00115)	(0.00132)	(0.00120)	(0.00268)	
Time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	736	560	456	599	403	404	751	575	476	610	410	403
Number of countries	121	92	83	98	104	72	124	95	86	101	108	73
Number of instruments	–	87	80	87	73	64	–	82	77	86	73	70
Arellano-bond test for AR(3) (p-v)	–	0.179	0.165	0.248	0.953	0.172	–	0.952	0.771	0.868	0.324	0.242
Hansen OID test (p-v)	–	0.365	0.344	0.262	0.119	0.214	–	0.446	0.672	0.253	0.169	0.246
R-squared	0.846	–	–	–	–	–	0.962	–	–	–	–	–

The dependent variable is the sectoral income per capita (Ln). The first 6 columns present results for the manufacturing sector, while the remaining columns provide results for the service sector. The lagged sectoral output level is instrumented by the second lag and prior lags, while the lagged real effective exchange rate and resource dependence index are instrumented by the first and prior lags. Additionally, control variables are assumed to be exogenous to fulfill the rule of thumb. However, their estimates are not included in the table. Estimation results for control variables can be requested. The regression models are estimated using the System *GMM*. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. The null hypothesis of the *Arellano-Bond* test indicates the absence of autocorrelation, the null hypothesis of the *Hansen* test assumes that the instruments, as a group, are uncorrelated with the error term. I report AR(3) instead of AR(2) since the null hypothesis is rejected in AR(2)

Table 11 Robustness check, estimation results for the Economic Growth

Explanatory variable	(1) Full sample OLS	(2) Full sample FE	(3) Developing Dif. GMM	(4) Poor-instit Dif. GMM	(5) Non-Europe Dif. GMM	(6) Recession Dif. GMM	(7) IMF Dif. GMM
GDP per capita (Ln) (lagged)	0.963***	0.783***	0.734***	0.686***	0.732***	0.690***	0.629***
	(0.00482)	(0.0180)	(0.0564)	(0.0557)	(0.0454)	(0.0535)	(0.0964)
Real effective exchange rate (lagged)	−0.00237***	−0.00130*	−0.00105***	−0.00106***	−0.00103***	−0.00124***	−0.0283***
	(0.000787)	(0.000710)	(0.000272)	(0.000242)	(0.000306)	(0.000250)	(0.00949)
Recourse-dependence (lagged)	−0.000572	−0.00200*	−0.00701***	−0.00735**	−0.00763***	−0.00695**	
	(0.000555)	(0.00108)	(0.00245)	(0.00301)	(0.00276)	(0.00287)	
Time dummies	YES	YES	YES	YES	YES	YES	YES
Observations	817	817	463	380	508	401	361
Number of countries	123	123	91	79	97	106	70
Number of instruments	–	–	90	78	90	99	65
Arellano-bond test for AR(3) (p-v)	–	–	0.573	0.818	0.688	0.188	0.141
Hansen OID test (p-v)	–	–	0.227	0.250	0.259	0.377	0.154
R-squared	0.995	0.909	–	–	–	–	–

The dependent variable is the natural logarithm of the *GDP* per capita level. the natural logarithm of *GDP* per capita (lagged) and resource dependence index (lagged) are instrumented by the second lag and prior lags, while the real effective exchange rate (lagged) is instrumented by the first and prior lags. Furthermore, except for population growth and institution index, which are assumed to be exogenous to satisfy the rule of thumb, other control variables are instrumented by the second lag and prior lags. However, their estimates are not included in the table. Estimation results for the control variables are available upon request. The regression models are estimated using the Differenced *GMM* in Columns (3)–(7). Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. The null hypothesis of the *Arellano-Bond* test indicates the absence of autocorrelation, the null hypothesis of the *Hansen* test assumes that the instruments, as a group, are uncorrelated with the error term. I report AR(3) instead of AR(2) since the null hypothesis is rejected in AR(2) the coefficient on the real exchange rate is notably stronger compared to the coefficient estimated by the *Bruegel* database (i.e., Columns 2 and 7 of Table 4).

D.4: Economic Growth

The *OLS* and fixed effect estimates are respectively presented in Columns (1) and (2) of Table 11 as benchmarks.[44] Additionally, I perform regressions of the baseline model (i.e., column 1 in Table 5) on samples of developing countries, countries with poor institutions, and non-European countries to test potential country-group heterogeneity. The results detailed in columns (3) to (5) demonstrate that such heterogeneity among country groups does not change the qualitative response of economic growth to the explanatory variables of interest.

Due to the impact of the Great Recession, the sample is limited to periods before 2004 to assess the reliability of the findings. The estimated results are presented in Column (6). This indicates that a recession might influence the economic growth response to both variables of interest solely in terms of quantity and not quality. Additionally, I compute the baseline regression model using a sample from the *IMF* database to investigate the influence of the real exchange rate measurement approach on the results. The estimated outcomes are provided in Column (7). A statistically significant negative coefficient on the real exchange rate confirms the previous interpretation and underscores the independence of the results from various real exchange rate databases.

D.5: Analysis of Deeper Lags of the Dependent Variable

Following Acemoglu et al. (2019), the columns in Table 12 incorporate control for the three lags of output per capita on the right-hand side. This test demonstrates that including three lags of output per capita appears sufficient to capture the intricate dynamics of sectoral and GDP levels in the linear regression. This is because when I include additional lags in output per capita, there is no evidence of further serial correlation in the residuals. The coefficients on the resource-dependence index are qualitatively similar to the baseline estimates, though not quantitatively identical. The only notable distinction is that the persistence of the output level has consistently been lower in the service sector and the overall economy, while being slightly higher in the manufacturing sector. This implies that there are slightly smaller long-run effects in the service sector and the overall economy, and slightly larger long-run effects in the manufacturing sector.

[44] The *Hausman* test is rejected with a *pvalue* of 0.000.

Table 12 Robustness check, effect of deeper lags of the dependent variable on estimation results

Explanatory variable	(1) Manufact Full sample	(2) Manufact Res. rich	(3) Manufact Res. poor	(4) Service Full sample	(5) Service Res. rich	(6) Service Res. poor	(7) GDP Full sample	(8) GDP Res. rich	(9) GDP Res. Poor
Output per capita (Ln) (first lagged)	1.172***	1.108***	1.193***	0.453***	0.287***	0.535***	0.910***	0.705***	0.765***
	(0.0656)	(0.107)	(0.0778)	(0.0763)	(0.0925)	(0.171)	(0.0613)	(0.138)	(0.0831)
Output per capita (Ln) (second lagged)	−0.361***	−0.366***	−0.263***	−0.152***	−0.0850	−0.164**	−0.251***	−0.180*	−0.0975
	(0.0810)	(0.105)	(0.0966)	(0.0533)	(0.0568)	(0.0729)	(0.0577)	(0.0924)	(0.0778)
Output per capita (Ln) (third lagged)	0.0236	0.0489	−0.0342	0.0807**	0.0250	0.0661*	0.0800**	0.121**	0.0710
	(0.0506)	(0.0855)	(0.0624)	(0.0403)	(0.0583)	(0.0391)	(0.0340)	(0.0550)	(0.0557)
Recourse-dependence (lagged)	−0.00420**	−0.00491**	0.0161**	−0.00638***	−0.00572***	−0.0177***	−0.00553***	−0.00511**	0.0239***
	(0.00203)	(0.00199)	(0.00669)	(0.00196)	(0.00210)	(0.00603)	(0.00185)	(0.00232)	(0.00870)
Time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	479	198	223	491	206	226	495	205	290
Number of countries	108	47	58	112	49	60	118	57	61
Output level persistence	0.835	0.791	0.964	0.382	0.227	0.437	0.739	0.646	0.738
Joint significance (p-v) (test < 1)	0.000	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000
Number of instruments	99	45	55	103	45	49	102	56	57
Arellano-bond test for AR(2) (p-v)	0.775	0.176	0.104	0.122	0.237	0.814	0.586	0.780	0.370
Hansen OID test (p-v)	0.262	0.452	0.285	0.197	0.722	0.277	0.218	0.738	0.205

The dependent variable varies across the columns: it's manufacturing income per capita (Ln) in the first three columns, service income per capita (Ln) in the next three, and GDP per capita (Ln) in the final three columns. The lagged resource-dependence index is instrumented by the first and prior lags. Control variables are considered exogenous to fulfill the rule of thumb. However, their estimates are not presented in the table. Estimation results for these control variables can be provided upon request. Regression models are estimated using the System *GMM* in Columns (1)–(6), and using the Differenced GMM in Columns (7)–(9). Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. The null hypothesis of the *Arellano-Bond* test indicates the absence of autocorrelation, the null hypothesis of the *Hansen* test assumes that the instruments, as a group, are uncorrelated with the error term

Table 13 Sensitivity analysis

Explanatory variable		98%	95%	80%	65%
Real exchange rate					
Resource-dependence (lagged)	Coefficient	0.02227	0.02103	0.01819	0.01634
	Standard deviation	0.00401	0.00614	0.01256	0.01428
Relative sectoral output					
Real effective exchange rate (lagged)	Coefficient	−0.00228	−0.00346	−0.00666	−0.01055
	Standard deviation	0.00616	0.00886	0.01907	0.04051
Resource-dependence (lagged)	Coefficient	−0.00742	−0.00628	−0.00345	−0.00185
	Standard deviation	0.00172	0.00227	0.00445	0.00527
Resource-dependence (lagged)	Coefficient	−0.00977	−0.00877	−0.00518	−0.00252
	Standard deviation	0.00230	0.00303	0.00503	0.00613
Resource-dependence (lagged)	Coefficient	0.02914	0.02678	0.01279	0.00744
	Standard deviation	0.00577	0.00941	0.01638	0.02324
Manufacturing sector					
Real effective exchange rate (lagged)	Coefficient	−0.00502	−0.00482	−0.01550	−0.01656
	Standard deviation	0.01222	0.01002	0.03331	0.05691
Resource-dependence (lagged)	Coefficient	−0.00615	−0.00583	−0.00460	−0.00338
	Standard deviation	0.00107	0.00167	0.00278	0.00360
Resource-dependence (lagged)	Coefficient	−0.00589	−0.00532	−0.00388	−0.00282
	Standard deviation	0.00111	0.00177	0.00388	0.00414
Resource-dependence (lagged)	Coefficient	0.01982	0.01818	0.01078	0.01108
	Standard deviation	0.00482	0.00948	0.02461	0.02645
Service sector					
Real effective exchange rate (lagged)	Coefficient	−0.00262	−0.00523	−0.01583	−0.03178
	Standard deviation	0.00587	0.01058	0.02428	0.03490
Resource-dependence (lagged)	Coefficient	−0.00468	−0.00480	−0.00515	−0.00524
	Standard deviation	0.00048	0.00069	0.00148	0.00320
Resource-dependence (lagged)	Coefficient	−0.00531	−0.00499	−0.00448	−0.00427
	Standard deviation	0.00068	0.00089	0.00197	0.00258
Resource-dependence (lagged)	Coefficient	−0.01864	−0.01845	−0.01588	−0.01569
	Standard deviation	0.00312	0.00580	0.01441	0.02861
Economic growth					
Real effective exchange rate (lagged)	Coefficient	−0.00186	−0.00307	−0.01017	−0.01369
	Standard deviation	0.00411	0.00742	0.01837	0.02707
Resource-dependence (lagged)	Coefficient	−0.00752	−0.00649	−0.00349	−0.00251
	Standard deviation	0.00160	0.00204	0.00259	0.00321
Resource-dependence (lagged)	Coefficient	−0.00421	−0.00366	−0.00272	−0.00216
	Standard deviation	0.00116	0.00176	0.00265	0.00372
Resource-dependence (lagged)	Coefficient	0.03979	0.03721	0.02802	0.01762
	Standard deviation	0.00382	0.00540	0.01190	0.01452

For the real exchange rate, it presents the estimated regression model corresponding to Column (1) in Table 2. For the relative sectoral output, each row provides the estimated regression model corresponding to Columns (2)–(5) in Table 3. For the manufacturing sector, each row shows the estimated regression model corresponding to Columns (2)–(5) in Table 4. Likewise, for the service sector, each row reports the estimated regression model corresponding to Columns (7)–(10) in Table 4. Finally, for economic growth, each row exhibits the estimated regression model corresponding to Columns (2)–(5) in Table 5

Table 14 Robustness test for the sensitivity of results to the classification of resource countries

Dependent variable	2% Rich	2% Poor	6% Rich	6% Poor
Real exchange rate	0.0156	0.0273**	0.0181	0.0211
Relative sectoral *GDP*	−0.0132***	0.0213	−0.0145***	0.0049
Manufacturing output per capita	−0.0064**	0.0603**	−0.0059**	−0.0041
Service output per capita	−0.0052***	−0.0164*	−0.0058***	−0.0076**
GDP per capita	−0.0062**	0.0702***	−0.0045*	0.0169***

The explanatory variable is the Resource-dependence index (lagged). The criterion for classifying countries as rich in resources is whether the average total natural resource rent is more than 2% of GDP or 6% of GDP. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

E: Sensitivity Analysis

I assess the sensitivity of the coefficients on the explanatory variables of interest to changes in sample size. In line with Mihasonirina and Kangni (2011), I randomly select the baseline regression models for 98% of the observations (without replacement). This process is repeated 250 times, yielding the average value and standard deviation of the coefficients on the explanatory variables of interest. The same procedure is applied randomly for 95%, 80%, and 65% of the observations. The estimated coefficients' values and standard deviations for each sample size are presented in Table 13.

The results for the coefficient of the resource dependence index indicate that when the regression is performed on 98% of the sample, the estimated coefficient remains close to the coefficient of the full sample. However, when the regression model is applied to other samples, their coefficient values decrease (in absolute terms), and their distributions become broader. The latter suggests that the significance of the coefficient diminishes as the sample size decreases. Furthermore, the estimates reveal that the coefficients for the real exchange rate consistently exhibit negative signs regardless of the sample size. However, as the sample size decreases, their normal distributions widen, and their tails flatten. This likely suggests a diminishing significance of the coefficients as the sample size decreases.

F: Analysis of Resource Countries Classification

Table 14 presents a robustness test that assesses the sensitivity of the results to the classification of resource countries. I estimate baseline regression models using two different thresholds to classify countries as resource-rich or resource-poor. The criterion for classifying countries as rich in resources is based on whether the average total natural resource rent is more than 2% or 6% of GDP. While statistical significance is not achieved in some cases, the results demonstrate qualitative similarity to the baseline models in Tables 2, 3, 4 and 5, though not quantitatively. Overall, this suggests that the empirical findings align well with the proposed theory, regardless of the classification threshold used to distinguish resource-rich and resource-poor countries.

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