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Inter-Sectoral Economic Linkages in the Mining Industries of Botswana and Tanzania: Analysis Using Partial Hypothetical Extraction Method

Fitsum Semere Weldegiorgis [1,*], Evelyn Dietsche [2,3] and Shabbir Ahmad [4]

[1] Sustainable Minerals Institute (SMI), The University of Queensland, Brisbane, QLD 4072, Australia
[2] Swisspeace, University of Basel, 4058 Basel, Switzerland; evelyn.dietsche@swisspeace.ch
[3] Energy, Environment and Society, University of Dundee, Dundee DD1 4HN, UK
[4] Institute for Social Science Research, The University of Queensland, Brisbane, QLD 4072, Australia; s.ahmad@business.uq.edu.au
* Correspondence: f.weldegiorgis@uq.edu.au

Abstract: Fiscal and local content policies aimed at promoting linkages between mining and other economic sectors have been informed by theories built on historical observations dating back to the 1950s. This paper contends that there is a need to rethink theories about mining-based economic linkages and the prospects for structural change based on an improved understanding of existing and potential inter-sectoral linkages. Using the input–output tables for Tanzania and Botswana, we apply the Partial Hypothetical Extraction Method within the Leontief and Gosh input–output frameworks to examine the linkages between the mining and quarrying sector and other economic sectors within these two economies. We find that, for Botswana, possible linkage pathways lie in scaling-up coal, soda ash and salt mining and investing in glass, polymer, and chemicals manufacturing. For Tanzania, opportunities for linkage pathways lie with the mining and manufacturing of non-metallic and construction materials as well as metallic minerals and natural gas. For both countries, the prospects for transforming their economies away from a heavy reliance on mineral extraction hinges on leveraging extractives for infrastructure, innovative technology, and technical skills, as well as capturing business opportunities, knowledge, and financial returns to invest in more diversified economic activities.

Keywords: economic transformation; diversification; mineral utilisation; industrialisation; Africa

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1. Introduction

For many decades, the mineral riches of African countries have attracted substantial foreign direct investment (FDI). This development resulted in the continent producing a significant amount of minerals, currently accounting for 61% of the world's production of cobalt, 51% of the manganese, 50% of the chromite, 47% of the diamond, 21% of the gold, and 13% of the uranium [1]. In 2016, 12 African countries were among the top 20 mining countries flagged by the Mining Contribution Index [2] (MCI uses four indicators: (1) total production value at mine stage of metallic minerals, industrial minerals, and coal expressed as a percentage of GDP; (2) exports of minerals, including coal as a share of total merchandise exports; (3) exploration expenditure as a percentage of production value at mine stage; and (4) mineral rents as a percentage of GDP). For that year, mining contributed to 70–90% of exports in countries such as Botswana, Sierra Leone, DRC, Mali, Burkina Faso, and Zambia. In 2020, the minerals sector accounted for about 51% of the USD 457 billion in estimated total exports by Africa as a whole, about 41% of which was related to petroleum and gas exports [3]. Extractive resource investments and exports have combined to show high levels of growth that several resource-rich African countries (RRACs) have enjoyed.

Despite recording some economic growth, especially since 2000, RRACs have seen a widening gap with East Asia and the Pacific, South Asia, and advanced economies

since 2010 [4]. With a manufacturing value added of only USD 221 billion in 2021, Africa substantially lags other regions of the world, particularly the East Asian and Pacific region (USD 5463 billion), which approaches the manufacturing value added level of USD 7002 billion of the Organisation for Economic Co-operation and Development (OECD) member countries [5]. Broadly speaking, and despite an increase over the last two decades, manufacturing value added remained low across the African continent, with around 68% of the manufacturing value added also concentrated in just five countries: Egypt, Nigeria, South Africa, Algeria, and Morocco. Over the past two decades, Sub-Saharan Africa stagnated at the low-level share of 1.8% in world merchandise exports [5].

It is argued that low-income but resource-rich countries can achieve structural change if they succeed in diversifying their economic portfolios into expanded baskets of high-value production, revenue sources, export bases, and employment [6]. While such a situation marks a starting point, an important analytical question is whether the mining and quarrying sector provides realistic leveraging opportunities for developing sectors with productivity. There is an ongoing debate on whether it is feasible and if there are mechanisms to approach and guide a process of managing revenues collected on the back of the mining and quarrying sector to transform and increase the productive capacity of low-income countries with the aim to ensure their long-term economic prosperity [7]. However, RRACs receive revenues estimated to be on average 2.6 times lower than the extractive resource rent [8]. The lack of positive economic impact that is proportionate to the richness in minerals is compounded by the growing dependence of many RRACs on the extractive sector.

This paper analyses the historical inter-sectoral linkages between the mining and quarrying sector and other economic sectors in two RRACs: Tanzania and Botswana. These two countries have unique and generalisable features that are crucial for robust research findings, which provide a comparative perspective to understand other contexts. Tanzania is a lower-middle income economy that has resource wealth from metallic, industrial, and construction minerals, and gemstones. Despite this, it is relatively 'new' in terms of fully developing (at a large scale) its extractive industry, with gold as its predominant sector. Industrial minerals and building materials are less exploited, though there is a history of mining and quarrying activities at small-scale. Limited maturity and poor infrastructure and human capital are factors that distinguish Tanzania from Botswana but also make it relatable to several other RRACs.

Botswana is an upper-middle income economy with resource wealth that is predominantly focused on diamonds, but it has more years of mining experience with more reliance on the minerals sector than Tanzania. The country is land-locked with a population of about 2.3 million [9], which has implications for industrial policy differing from that of Tanzania and other more populous countries with sea access. Botswana is one of the RRACs that is praised for its relative success in resource-based development mainly through the utilisation of diamond revenues for public sector investments. Botswana offers aspects that are comparable to Tanzania and other RRACs, and it allows a good comparative analysis with an opportunity to potentially draw lessons.

Analysing existing inter-linkages provides a useful tool to understand, for example, if and how the increased productivity levels typically experienced by the service sectors (e.g., trade, business, transport, and communication) contribute to the development of domestic value chains and stimulate investments in manufacturing [10]. The analysis in this paper is framed from an economic transformation rationale that pivots inter-sectoral linkages as a pathway to diversification and structural change rather than an end goal by itself. This rationale is premised on mining-based economic development not only seen in the narrow sense of building supply chains, but to also account for more broadly conceived inter-sectoral linkages and diversification inputs, such as the development of technical capability, technology, infrastructure, and institutional capacity [11]. Framing linkage building along these lines enables us to understand not just, for example, the types of inputs that local suppliers provide to the mining and quarrying sector, but also

the impact of local procurement on the broader economy, providing a stimulus for other economic sectors and potentially inducing structural change.

Specifically, this paper addresses three research questions: (i) Does the mining and quarrying sector inter-link with other economic sectors in Tanzania and Botswana, and if so, which economic sectors does the sector interact with most? (ii) What is the extent of the sector's interdependence with other *key* economic sectors? (iii) What do the inter-sectoral linkages of the sector imply for potential drivers of economic diversification? The paper proceeds as follows: Section 2 provides a brief profile of the Tanzanian and Botswana mining and quarrying sectors vis-à-vis their economies. Section 3 presents the methodology and modelling framework for the data analysis. Section 4 discusses the results and key findings. Section 5 analyses the results from the viewpoint of exploring the potential for economic diversification. Section 6 concludes and provides some recommendations for future research.

2. Mining and the Economies of Tanzania and Botswana

Starting with Tanzania, its sub-soil is rich in (1) metallic minerals, such as gold, iron ore, silver, copper, platinum, nickel and tin; (2) industrial minerals, such as kaolin, phosphate, lime, gypsum, diatomite, bentonite, vermiculite, salt and sand; (3) construction materials, such as stone aggregates and sand; (4) gemstones, such as diamonds, tanzanite, ruby, garnet, emerald, alexandrite and sapphire; and (5) energy minerals, such as coal, natural gas (off-shore, near-shore and onshore), and uranium [12]. Tanzania is the fourth largest gold producer in Africa and the largest producer of Tanzanite. Mining has been the leading investment sector, which, in 2017, accounted for 40% of the total (USD 5419.1 million) accumulated FDI stock, and hosted the largest share (compared to other economic sectors) of FDI inflows from South Africa, which is one of the top sources [13].

In 2020, the sector accounted for about 7% of Tanzania's GDP, employing more than 310,000 people [14]. The Tanzanian extractive sector, which includes minerals, metals, petroleum, and gas, accounted for 42% of the USD 7.71 billion worth in total exports in 2020, with shares of gold (26.9%), precious metal ores (3.93%), and unrefined copper (3.38%). Figure 1 shows that the services and agriculture sectors also have important shares in total exports. Although the mining sector has a huge economic potential, its contribution to government revenues has been less significant, contributing a mere 3% in 2016 [15]. In 2018/2019, the government collected revenues of around USD 183 billion from mining and approximately USD 77 from the oil and gas sectors [14]. This is despite the report by the Tanzanian Mining Commission [16] of a steady increase in government revenues from mining, a 154% increase in 2019/20 compared to the revenues collected in 2015/16.

The very significant investments in the mining sector in Tanzania have not translated into structural change This is attributed to the government's excessive emphasis on reforming the mineral taxation regime to generate more mining revenues, with no attention paid to the need for integrating the mining sector into the local economy [17]. The economy remains heavily reliant on agriculture, despite some increase in the value added from manufacturing, construction, and services (trade, government, and transport). Furthermore, de Vries et al. [18] noted a slow increase in mining's value added for the past decade.

With the intent to maximise the mining sector's contributions to the economy, the Tanzanian government pursued various regulatory reforms mainly by introducing more stringent fiscal and local content policies [19]. In 2021, the government drafted a local content implementation strategy, setting out short-, medium- and long-term targets and plans; providing a roadmap for implementing local content initiatives; identifying key stakeholders and their roles and responsibilities; and laying out a monitoring and evaluation framework. A serious concern is that policy changes in Tanzania continue to be undermined by a lack of coordination and counterproductive state interventions in the economy [20]. Conditions have, however, improved since the change of presidency in 2021, with increased investor confidence in the country's overall mining regulations and administration [21]. The National Economic Empowerment Council (NEEC) has been

mandated to coordinate the implementation and monitoring of this strategy. This is a complex and challenging task, as it involves coordinating and aligning various government and non-government entities, each driven by their own varied interests and capacities.

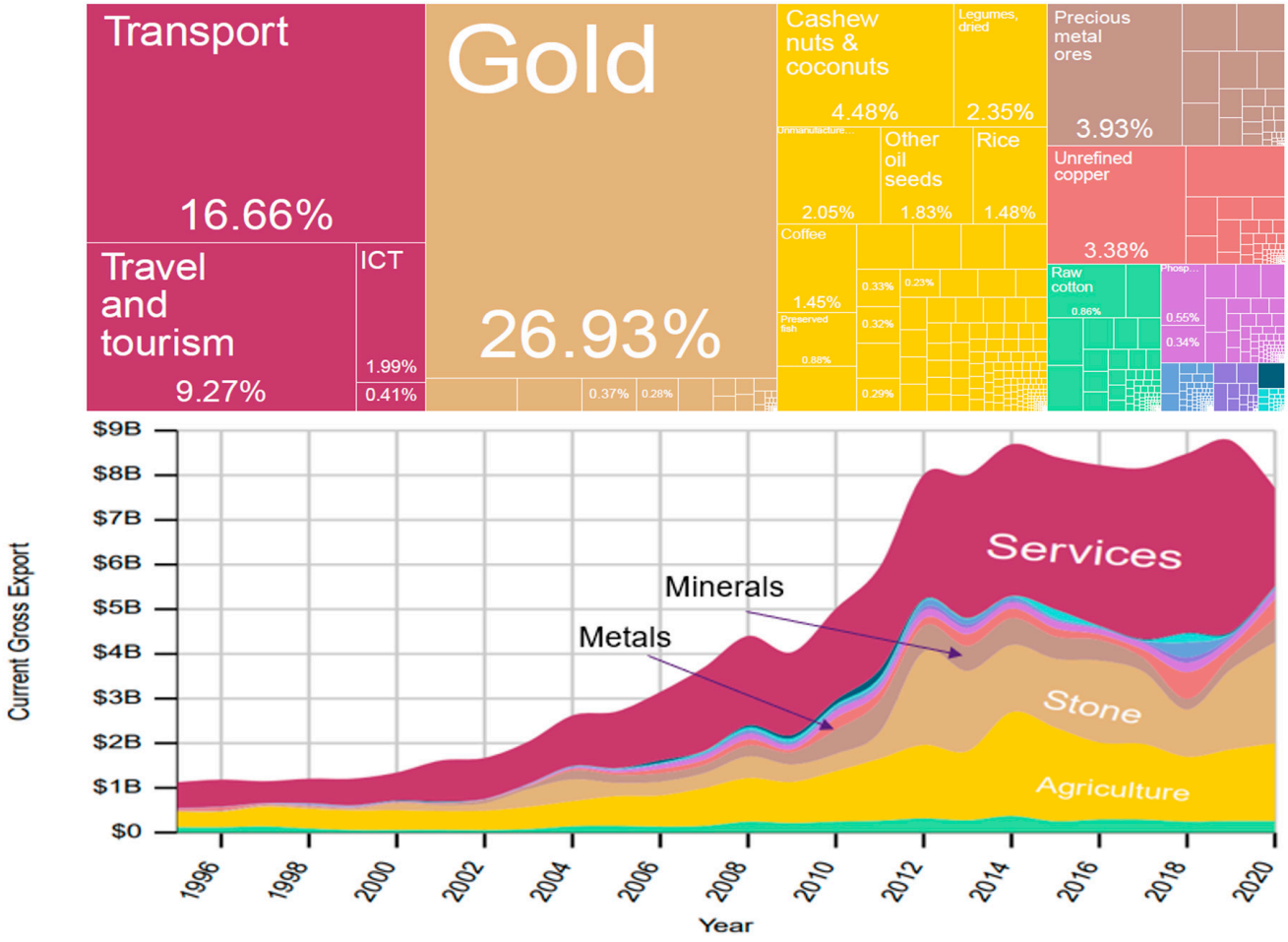


Figure 1. Composition of Tanzania's exports in 2020 and trend over 1996–2020. Source: Atlas of Economic Complexity.

Meanwhile, diamonds have dominated Botswana's mining sector and its economy for decades. As shown in Figure 2, diamonds accounted for 76.76% of the total USD 4.07 billion valued exports in Botswana in 2020, followed by travel and tourism (5.18%), ICT (93.96%), insulated electrical wire (1.64%), and Bovine (1.12%). Other minerals, including soda ash and other industrial and construction minerals, as well as copper, gold, and coal, also contribute to GDP and other macroeconomic indicators to a much lesser extent. The sector's value added to GDP has been decreasing since 2008. There was a steady decline in mineral rent as a percentage of GDP since its peak of 6.5% in 2007 to 0.33% in 2020 [5]. This decline coincided with an increase in value added from trade and government services and also business services [18]. The construction sector, financial services, and manufacturing sectors have also increased their value added. Nonetheless, mining still continues to be an important sector, contributing to one fifth of GDP, one third of total government revenue, and more than 85% of national foreign exchange earnings [22].

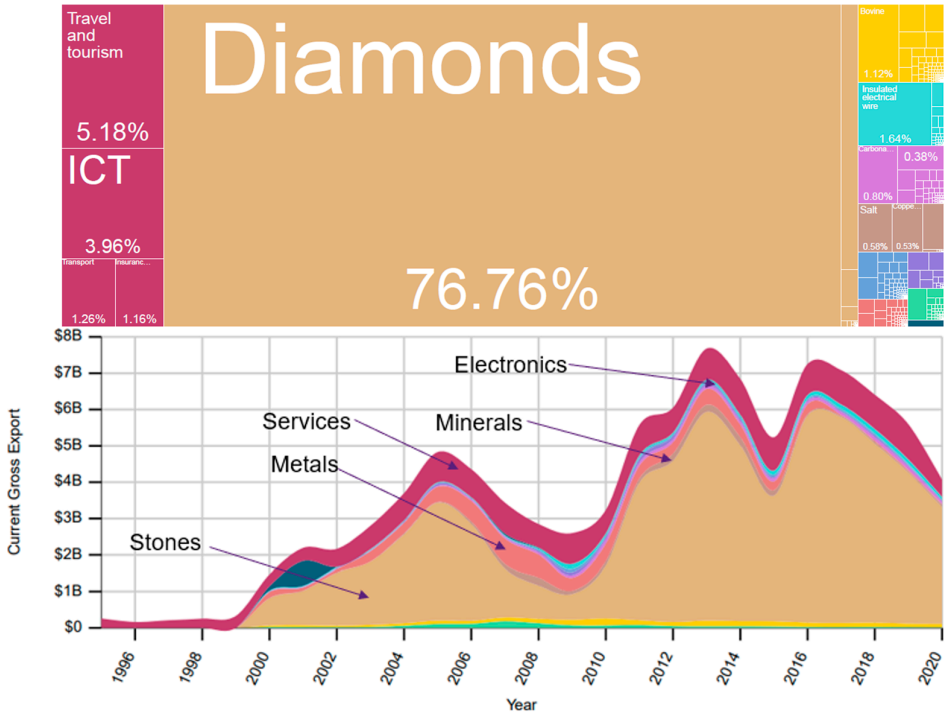


Figure 2. Composition of Botswana's exports in 2020. Source: Atlas of Economic Complexity.

After many decades of strong reliance on diamond mining, the declining share of government revenues sourced from this sub-sector and the prospect of depleting diamond reserves could pose a threat to the country's economy. This is more so because little effect has been registered on the diversification of the economy [23]. While the service sector's increasing value addition to GDP could be signalling a positive development towards diversification, its limited impact on technological change and productivity implies limited diversification towards manufacturing [24]. In fact, Botswana's prudent management of mining revenues mainly resulted in boosting government-provided services, such as education and health, but has had limited effect on other productive sectors that are perceived to be more directly conducive to structural transformation. The country's bid to diversify faces the challenge of unfavourable geo-location, i.e., it is far from other main global markets with no sea outlet, has a less competitive industrial sector, has human capital and ecological constraints, and has scarce water resources [25].

One way the government made efforts to leverage mining beyond revenue collection is through the establishment of the Diamond Trading Company Botswana (DTCB) in 2008. DTCB's objective is to increase diamond beneficiation by empowering local cutting and polishing industries. However, this effort has had little effect as, in 2016, Botswana accounted for only 2% of the world's polished diamonds, despite being the second largest producer of diamonds and contributing a share of 24% to the global production value [26]. Other recent efforts to facilitate economic diversification have included the formulation of a National ITC and E-commerce Strategy aimed at supporting local businesses through the transfer of digital content and information and flow of goods and services via engagement with large global markets [27]. Policy and academic debates continue to discuss the question of whether Botswana has been and will be successful in achieving a more diversified economy on the back of its successful and generally well-managed and governed mining industry.

3. Methodology

The previous section underlined that in Tanzania and Botswana, most of the rise in value added from sectors other than mining has been driven by the service sector, especially trade, government services, and general business services, but also financial and other auxiliary services. Second, the respective construction sectors have also shown increases,

especially over the past five to ten years. Investigating whether and how the mining and quarrying sector interlinks with these sectors in both countries offers a first step towards a better understanding of potential pathways to economic diversification.

We apply a national-level sectoral input–output (IO) model to analyse the linkages between mining sub-sectors as well as between mining and other sectors of the economies of both Tanzania and Botswana. In principle, IO models enable analysts to observe the reallocation of factors of production in the production and consumption patterns across different sectors. In this paper, we employ the Hypothetical Extraction Method (HEM), which is one of the IO models that has evolved over the years.

The logic of the HEM is based on hypothetically extracting (or nullifying) one of the sectors in an economy to understand that sector's impact on the overall economic output. The HEM enables us to estimate the direct, indirect, and induced effects of the extracted sector on other economic sectors and the national economy. Since the early modelling by Paelinck et al. [28], the HEM has been widely applied and refined [29–33]. In this paper, we apply the Partial Hypothetical Extraction Method (P-HEM) based on Dietzenbacher and van der Linden [33] and distinctly measure the backward linkages (BL) and forward linkages (FL) based on, respectively, the Leontief and the Gosh models. Rather than hypothetically nullifying a sector in its entirety, which seems too excessive, partial extraction enables us to explore a sector's strength in relation to backward and forward linkages with other economic sectors and the overall economy.

In P-HEM, inputs (backward linkages) and outputs (forward linkages) are extracted separately rather than extracted both at the same time. This helps us to estimate a percentage decrease in the total economic activity (or total output) of the respective sectors following partial extraction of a sector. So, backward linkage values are generated using P-HEM by extracting only the columns of the production linkage values of the extracted sector to indicate that the sector in consideration no longer demands domestic intermediate inputs—in other words, it indicates the extent of its dependency on domestic inputs. The application of the HEM has a limitation that it cannot determine the strength of a sector's backward and forward links with the rest of the economy without considering the impact of a shift in output. To improve the analysis, we first isolate and examine the sectors that are highly linked with the mining and quarrying sector to determine the degree of inter-sectoral linkages. We then zoom out to consider the broader economy of both Tanzanian and Botswanan to explore further how the identified *key* inter-linking sectors function and how they could be developed to support structural change.

3.1. HEM Model to Measure Inter-Sectoral Linkages

HEM model specification is based on the standard IO equation $X = \Lambda x + d$, where $X = x_m$ stands for the production vector of gross output of n sectors, $d = d_m$ represents the vector of final demand, and $\Lambda = \alpha_{mk}\ \forall m, k = 1, 2, 3, \ldots, n$ is the technology matrix (also known as input–output coefficient or direct input coefficient) required as an input for the production of one unit of sector $m's$ output. Measurement of the total (direct and indirect) backward linkages (BL) of the sector using the Leontief model, expressed as $x = (I - \Lambda)^{-1}d$, yields a row vector of total output multipliers $b' = \varepsilon' L$ where L is the Leontief inverse or the total requirement matrix $(I - \Lambda)^{-1}$, ε denotes the summation vector of ones, and I is identity matrix. The element l_{mk} of the Leontief inverse represents the amount of output of sector m that is needed to meet the one unit of final demand in industry k.

Using logic similar to the Leontief model, the Ghosh model, which is used to measure direct and indirect (or total) forward linkages (FL), is expressed as $x' = v'(I - \mathrm{B})^{-1}$, where x' refers to total input, v' is a row with total primary inputs, and B is the output coefficient matrix. Therefore, $G = (g_{mk})_{m,k} = (I - \mathrm{B})^{-1}$ represents the Ghosh inverse matrix. The Ghosh model solution yields a column vector of total input multipliers $f = G\epsilon$. The Ghosh input multipliers need to be interpreted as the change in output (input) of sectors due to a unit change in the exogenous price of primary input of sector m [33].

The *total backward* and *total forward linkages* are delivered by, respectively:

$$BL(t)_m = \sum_{m=1}^{n} l_{mk} \text{ and } FL(t)_m = \sum_{m=1}^{n} g_{mk} \quad (1)$$

where t refers to total (direct and indirect) linkages of sector m.

The basic IO method only accounts for effects on final demand and primary input. As we also need to account for effects on intermediate output change, a hypothetical extraction approach is deployed to isolate or exogenously specify the elements of the sector measured to generate a relatively accurate measure of economic linkages. We apply the P-HEM using the closed-form analytical expressions derived in Temurshoev and Oosterhaven [32], which considers the application by Dietzenbacher and van der Linden [33].

Partial extraction of sector m means that the column of input matrix Λ and the row of output matrix B are nullified to measure the backward and forward linkages, respectively, of sector m. The post-extraction new input coefficient matrix is defined as $\widetilde{\Lambda}_c$ with zeros in column m and new output coefficient matrix as $\widetilde{B}_r$ with zero in row m. Then, the change in backward linkages brought about by the P-HEM of sector m can be estimated in absolute terms using the Leontief Model as $\varepsilon' x - \varepsilon' \widetilde{x}_c$, where $\widetilde{x}_c = (I - \widetilde{\Lambda}_c)^{-1} d$. Using the Ghosh model, the absolute change in forward linkages resulting from partial extraction of sector m is given by $x'\varepsilon - (\widetilde{x}_r)'\varepsilon$, where $(\widetilde{x}_r)' = v'(I - \widetilde{B}_r)^{-1}$. We apply normalisation per unit of output to remove the size of sector when determining the magnitude of impact extraction. The normalised backward and forward linkages of the partial extraction of sector m are thus given by

$$LPE_m = \frac{\varepsilon' x - \varepsilon' \widetilde{x}_c}{x_m} \times 100 \text{ and } GSE_m = \frac{x'\varepsilon - \left(\widetilde{x}_r\right)'\varepsilon}{x_m} \times 100 \quad (2)$$

where, for simplicity, the term LPE (Leontief Power of Extraction) refers to Leontief IO indices resulting from the P-HEM; and the GSE (Ghosh Sensitivity of Extraction) refers to the Ghosh IO indices.

After partially extracting each of the sectors, we then apply normalisation relative to the average to identify the economic sectors designated as *key* sectors. We classify sectors according to the intensity of their backward and forward linkages for the analysis that follows. According to Miller and Lahr [34], an index value of 1 (unity) is considered as the average of the relative linkage of all sectors in a normalised form. As a result, and consistent with Hirschman's [35] early assertion, sectors that have above average (>1) inter-sectoral input (backward) and output (forward) linkages with the rest of the economic sectors are considered *key* (important) to the broader economy (or specific sector).

3.2. Data Description

For computation of inter-sectoral linkages disaggregated by backward and forward linkages, we used 12 IO tables for Botswana and Tanzania that cover the period 2005–2016. Analysing this time-series data enables us to measure trends and changes in inter-sectoral linkages over time. We sourced data from the UNCTAD-Eora global supply chain database [36]. It consists of a multi-region input–output table (MRIO) that provides a time series of high-resolution IO tables for 190 countries. These tables are based on the common International Standard Industrial Classification (ISIC), which contains 25 sectors (listed in Appendix A). UNCTAD-EORA MRIO tables are compiled from various data sources, including I–O tables from national statistics offices, UN National Accounts, UN Comtrade and Service trade International Trade databases, and OECD [37]. For countries with less developed statistical systems, UNCTAD-EORA is heavily dependent on imputation methods to make up for the data gaps that are common in those countries [38]. Therefore, statistics for nations such

as Botswana and Tanzania with limited capacity to gather and preserve trustworthy data should be used with caution.

Another important limitation pertains to the issue that the 25 sectors in the UNCTAD-EORA tables are highly aggregated, and this makes it difficult to discern specific sector linkages. For example, the mining and quarrying sector (M&Q hereafter), which we coded as sector 'D', comprises the mining of metals and non-metals, including coal, quarrying, as well as the extraction of crude petroleum and natural gas. Given this situation and the need to understand whether strong inter-sectoral linkages relate to one or more of the mining sub-sectors (metals, non-metals, or petroleum), we consulted, where possible, the literature and relevant policy documents to substantiate our analysis.

4. Results and Discussions

We begin our analysis by first identifying the sectors that, from a linkages point of view, are *key* to the overall economy. Second, shifting focus towards M&Q, we pinpoint those sectors that closely inter-link with this sector. Third, we zoom in for an in-depth examination of the identified significant inter-sectoral linkages by conducting P-HEM analyses on those sectors that were found to be *key* to M&Q. For Tanzania, we identified eight such sectors, and for Botswana, six sectors.

4.1. Tanzania

We first conducted a P-HEM analysis on the Tanzanian economy, partially extracting each economic sector to understand their respective importance for the economy from the perspective of production linkages. This exercise resulted in 13 sectors showing as *key* to the Tanzanian economy over the period 2005–2016. These sectors are depicted in Figure 3A. Next, we conducted a P-HEM analysis by partially extracting M&Q to identify the *key* sectors with which M&Q has the most backward and forward linkages. This resulted in six sectors that are *key* to M&Q (D). They include Construction (G); 'The manufacture of petroleum, chemical, and non-metallic mineral products' (E04); 'The manufacture of metal products' (E05); 'The manufacture of electrical and machinery products' (E06); 'Electricity, gas, and water supply' (F); and 'Transport services' (I). These sectors are shown in Figure 3B. The sectors that show as *key* to both the Tanzanian economy and M&Q are 'The manufacture of petroleum, chemical, and non-metallic mineral products' (E04); 'The manufacture of electrical and machinery' (E06); Construction (G); and 'Transport services' (I). Notably, the very high levels of backward and forward linkages of M&Q with itself (shown by the high values of LPE and GSE in Figure 3B) could be interpreted as indicating that the Tanzanian mining sector largely operates as an enclave.

Figure 4 shows that all the sectors that are *key* to M&Q (D) are also the top six sectors from the perspective of backward linkages. This means that they are the primary suppliers of inputs to M&Q. Additionally, from the perspective of backward linkages, 'Financial intermediation and business activities' (J02) features as highly linked to M&Q. Except for 'Electricity, gas, and water supply' (F) and 'Financial intermediation and business activities' (J02), all the mentioned sectors are also among the 13 sectors that show an increasing trend of backward linkages with M&Q over the 12-year period of consideration. The 13 sectors are shown in the upper side of the 'LPE Trend'-headed left-hand diagram that is part of Figure 4. The changes in the inter-sectoral backward linkages with Transport (I) and Construction (G) over 2005–2016 are also displayed in Figure 5A,B. Large increases in M&Q's linkages with Construction and Transport occurred in the early 2010's.

Regarding forward linkages with M&Q (D), the right-hand diagram of Figure 4 indicates that Recycling (E09); Transport (I); 'Electricity, gas, and water supply' (F); 'Hotels and restaurants' (H04); and 'The manufacture of petroleum, chemical and non-metallic mineral products' (E04) are the top five ranked downstream sectors. The forward linkages with these sectors are likely to be through the sale of M&Q's natural gas and coal. The diagram under the heading 'GSE Trend' further demonstrates that, over the 12-year period of consideration, an increasing trend of forward linkages is observed between all 24 sectors

included in our analysis and M&Q. Recycling (E09) is among the top four sectors, which also includes 'Private households' (J05), 'Maintenance and repairs' (H01), and 'Textiles and apparels' (E02), which had the highest rising forward linkages trend, as depicted in Figure 5. Most of the large increases occurred in the early- to mid-2010s, and this could be linked to the usage of natural gas by these sectors.

When all economic sectors are considered, there is an increasing trend in forward linkages and a decreasing trend in backward linkages of M&Q with the overall Tanzania economy. This could potentially be reflecting the domestic utilisation of increasingly more coal, petroleum, and construction materials rather than an increase in mineral processing taking place in Tanzania. Indeed, the government's push for establishing processing plants in the country, as set out in the revised Mining Act 2018 [19], is an indication that there has not been much mineral processing in the country.

The next three sub-sections focus on the manufacturing, services, and construction sectors that showed as *key* to M&Q.

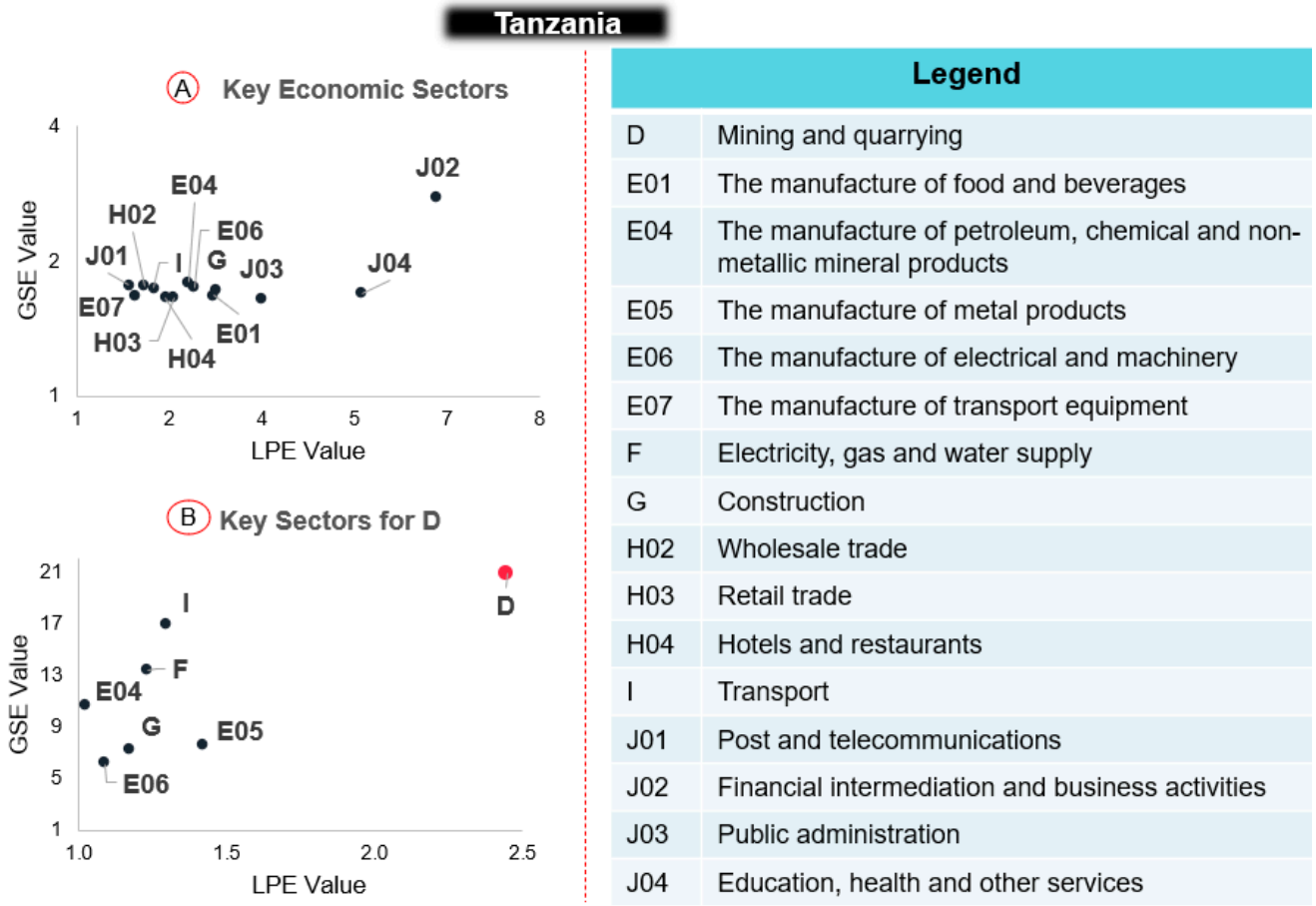


Figure 3. (**A**) Most-linked economic sectors; (**B**) sectors most linked with M&Q (D, denoted by red circle) (2005–2016). Note: GSE refers to Ghosh Sensitivity of Extraction (level of forward linkages) and LPE is Leontief Power of Extraction (level of backward linkages). There are thirteen *Key* sectors to the economy and six *Key* sectors to M&Q. *Key* sectors are sectors with high (>1) GSE value and high (>1) LPE value.

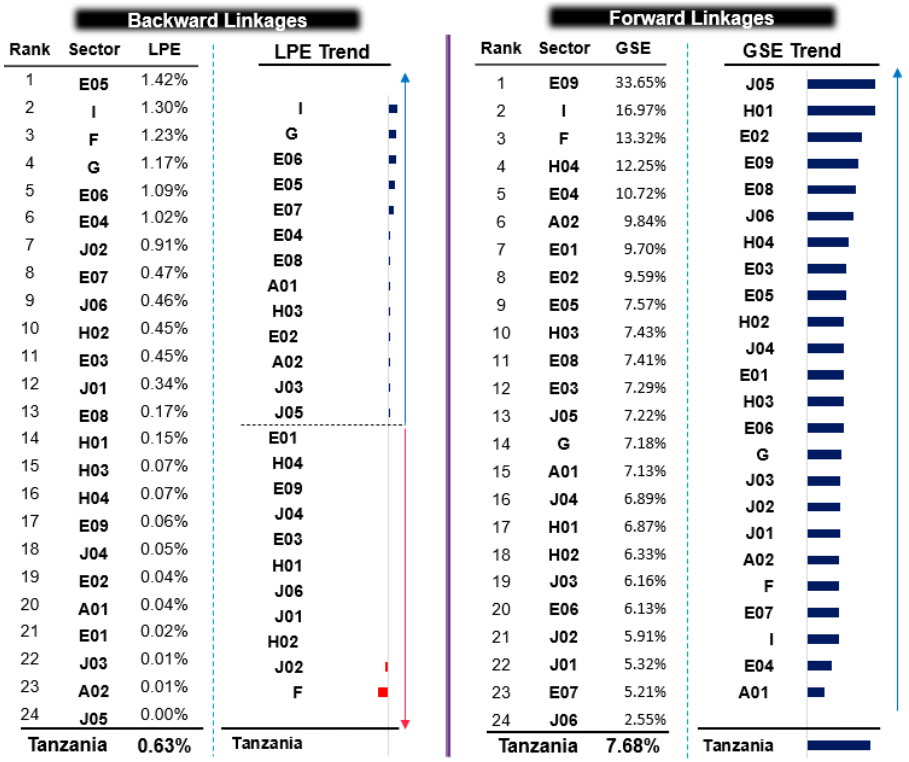


Figure 4. Ranking and trends of inter-sectoral BL (LPE) and FL (GSE) of the Tanzanian M&Q (2005–2016). Note: The values indicate a percentage decrease in total economic output of the respective sectors following partial extraction of M&Q. So, if we consider the LPE values in the left diagram (the backward linkages), it means only the columns are extracted to indicate the extent of the M&Q's dependency on domestic inputs. Blue arrows indicate increasing trend and red arrows decreasing trend.

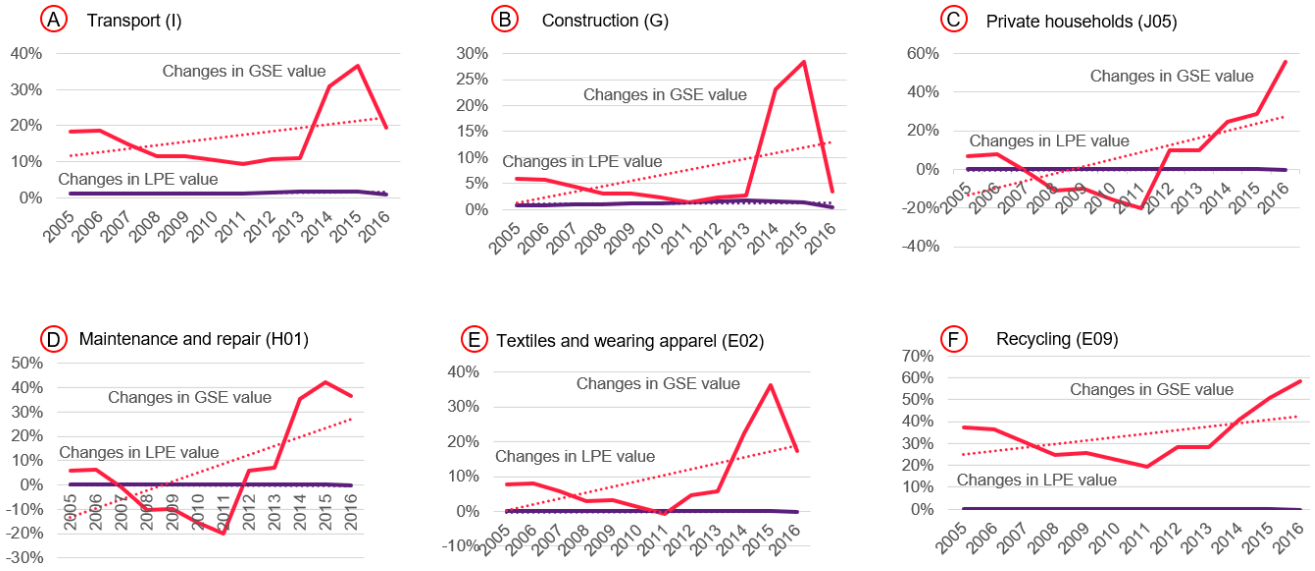


Figure 5. Changes in inter-sectoral BL (LPE) and FL (GSE) of the Tanzanian M&Q with selected sectors (2005–2016). Note: The values indicate a percentage decrease in total economic output of the respective sectors following partial extraction of M&Q. Purple lines indicate BL (LPE) and red lines FL (GSE), dotted lines are trends.

4.1.1. Manufacturing Sectors

Of the sectors identified above to be *key* to M&Q (D), the manufacturing sectors include 'The manufacture of petroleum, chemical and non-metallic mineral products' (E04); 'The manufacture of metal products' (E05); and 'The manufacture of electrical and machinery' (E06). Included in this analysis is also Recycling (E09), which shows strong forward linkages with M&Q.

To understand whether M&Q is one of the *key* sectors to these manufacturing sectors, we conducted a separate P-HEM, partially extracting each of those manufacturing sectors. Figure 6 presents the results for each sector from the perspective of backward linkages, forward linkages, or both in the 12-year period considered. We found that M&Q is listed as the top supplier of inputs to 'The manufacture of petroleum, chemical and non-metallic mineral products' (E04), and it would experience a 14.5% reduction in its output if this manufacturing sector were partially extracted (shown in Figure 6B). M&Q is also the fourth largest receiver of inputs from 'The manufacture of petroleum, chemical and non-metallic mineral products' (E04) (shown in Figure 6A). This is not surprising given that Tanzania produces non-metallic minerals (including construction and chemical minerals), natural gas, and coal, which are largely processed and consumed domestically [39,40].

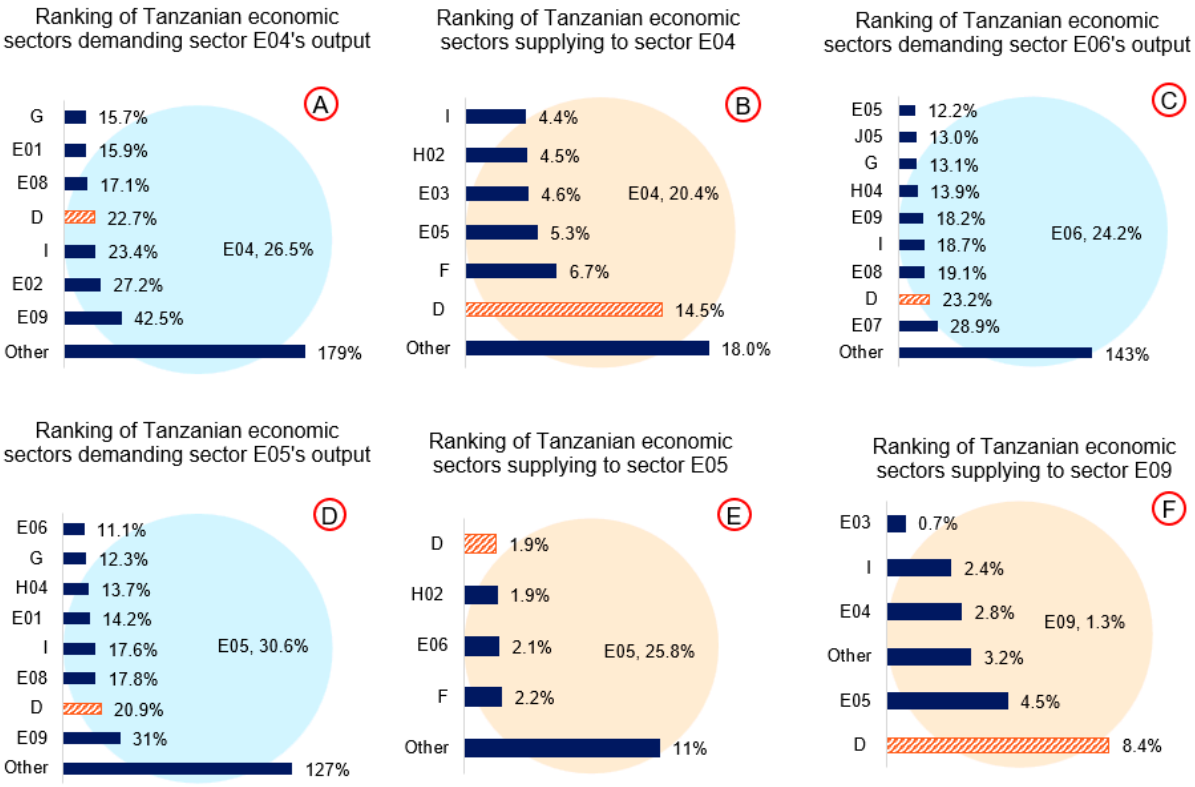


Figure 6. Ranking of Tanzanian economic sectors by their linkages to the selected manufacturing sectors. Note: P-HEM was conducted on each of the four sectors, with the pale blue and yellow circles indicating linkage values of each of these extracted sectors with themselves. Columns indicate the linkage values of the other sectors with the extracted sector. Sectors E04 (The manufacture of petroleum, chemical and non-metallic mineral products), E05 (The manufacture of metal products), E06 (The manufacture of electrical and machinery), E09 (Recycling), and D(M&Q).

Recalling from Figure 4 that 'The manufacture of metal products' (E05) is the top-ranked sector in terms of providing inputs to M&Q (i.e., M&Q's backward linkages), Figure 6D correspondingly shows that M&Q is the second largest destination for the outputs of 'The manufacture of metal products' (E05). M&Q would face a 20.9% drop in output if this manufacturing sector were partially extracted. However, the ranking of 'Wholesale

trade' (H02) as the third top supplier to 'The manufacture of metal products' (E05) (see Figure 6E) implies that some of the metal products that are supplied to sectors such as M&Q are imported and/or that their intermediate inputs are imported. Correspondingly, trade statistics indicates that imports of steel products grew significantly over the period 2001–2017 [41]. For example, Tanzania imported an average of USD 23 million worth of mechanical shovels, excavators and shovel loaders; USD 11 million in tools, interchangeable, rock drilling or earth-boring tools; and USD 3.3 million in cast iron, tubes, pipes and hollow profiles per year over the period 2005–2016 [42].

From a forward linkages perspective, the result that shows M&Q as one of the main providers of inputs to 'The manufacture of metal products' (E05), albeit at a small scale, could reflect not iron ore but the energy component (coal, crude petroleum, and natural gas) of M&Q that is needed to produce metal products. This is explained by the absence of iron-ore mining in the country and, therefore, the reliance of domestic steel manufacturing on imported steel billets or scrap steel. Nevertheless, there has been an increase in domestic steel production and the use of scrap metals, some of which is probably sourced from M&Q [41].

The results showing significant linkages of M&Q with Recycling (E09) could imply that some of the scrap metals are sourced from M&Q. As shown in Figure 4, Recycling is the first-ranked destination for M&Q's outputs over the period being considered. M&Q is also the largest supplier of inputs (including metal and non-metal waste and scrap) to Recycling (see Figure 6F). This suggests that, much more than minerals, it is metal and non-metal scraps and wastes that get processed in Tanzania. Baya and Jangu [43] have estimated that the large-scale mining sector produces about 2.5 million tonnes of mining waste per year, including hazardous chemicals such as mercury and cyanide. Although there are no data tracing the destination of waste (particularly metallic) in Tanzania, various industries, including the steel factories in the country, are believed to be making use of metal scraps collected from mining and other industries.

Figure 6C demonstrates that M&Q (D) is, on average over the 12-year period, the second-largest destination for domestic output sales from 'The manufacture of electrical and machinery' (E06) including pumps, compressors, bearings, gears. Again, some of the technology and capital-intensive products (e.g., machinery) may be imported before being supplied to M&Q. This is because manufacturing in Tanzania still relies on basic technologies and skills [44]. From a forward linkages perspective, M&Q is not one of the main suppliers of inputs to 'The manufacture of electrical and machinery' (E06), including pumps, compressors, bearings, and gears, although it may indirectly contribute to electrical and machinery production through 'The manufacture of metal products' (E05) and 'The manufacture of petroleum, chemical and non-metallic mineral products' (E04), which are the first- and third-ranked sectors in the list of suppliers to 'The manufacture of electrical and machinery' (E06), including pumps, compressors, bearings, and gears. This corresponds to the low ranking of the latter among M&Q's forward linked sectors in Figure 4.

4.1.2. Construction Sector

Figure 4 shows that (on average over the 12-year period) Construction (G) features as the fourth-largest sector from which M&Q (D) procures domestic inputs. This is a testament to the typically significant investments that occur during the construction phase of mining projects. From Construction's perspective, M&Q is the highly ranking buyer of its outputs (see Figure 7A). In terms of supplying inputs to Construction, M&Q does not feature as one of the major direct suppliers (see Figure 7B). However, M&Q supplies indirect inputs through 'The manufacture of metal products' (E05) and 'The manufacture of petroleum, chemical and non-metallic mineral products' (E04), which have been identified as the first and second largest suppliers to Construction. Despite growth in the manufacturing and supply of local construction materials, including cement, reinforcement steel, concrete, paints, and roofing materials, Tanzania is a net importer of construction materials and

machinery. Its Construction suffers from issues related to the availability and quality of locally sourced and imported construction materials [45].

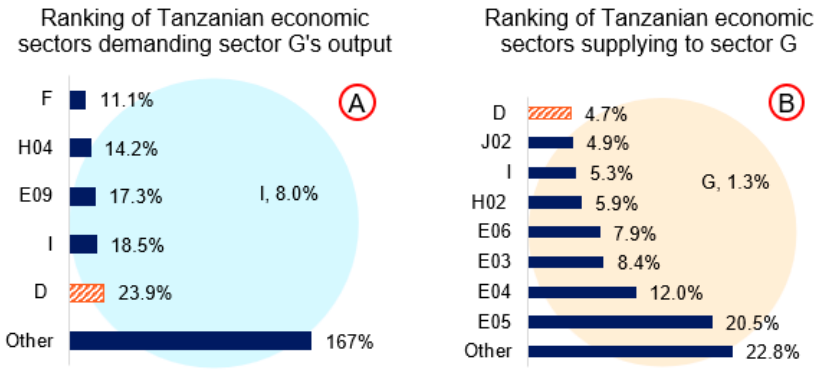


Figure 7. Ranking of Tanzanian economic sectors by their linkages to Construction. Note: P-HEM was conducted on Construction, with the pale blue and yellow circles indicating linkage values of Construction with itself. Sectors G (Construction) and D (M&Q). Columns indicate the linkage values of the other sectors with the extracted sector.

4.1.3. Service Sectors

Recall from Figure 4 that Transport (I) ranks as the second-largest provider of domestic inputs to M&Q over the 12-year period. Figure 8A also lists M&Q second in terms of demanding outputs from Transport. These service outputs include transport (by land, water, and air), storage, communication, travel agencies, etc. This type of linkage is evident in the value chain in which the movement of mineral products takes place, such as semi-processed gold transported to gold refineries [46]. Similarly, such linkages are present when bulk minerals such as coal from mines in the southern part of Tanzania are transported to other industries such as the cement factories in Tanga. Also from Figure 4, 'Electricity, gas, and water supply' (F) ranks as the third top supplier of inputs to M&Q. M&Q also ranks as the number one destination for sales of outputs from 'Electricity, gas, and water supply' (see Figure 8C).

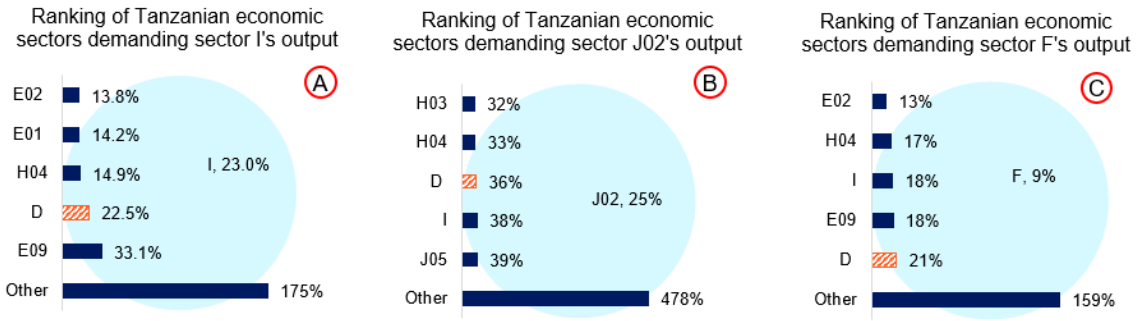


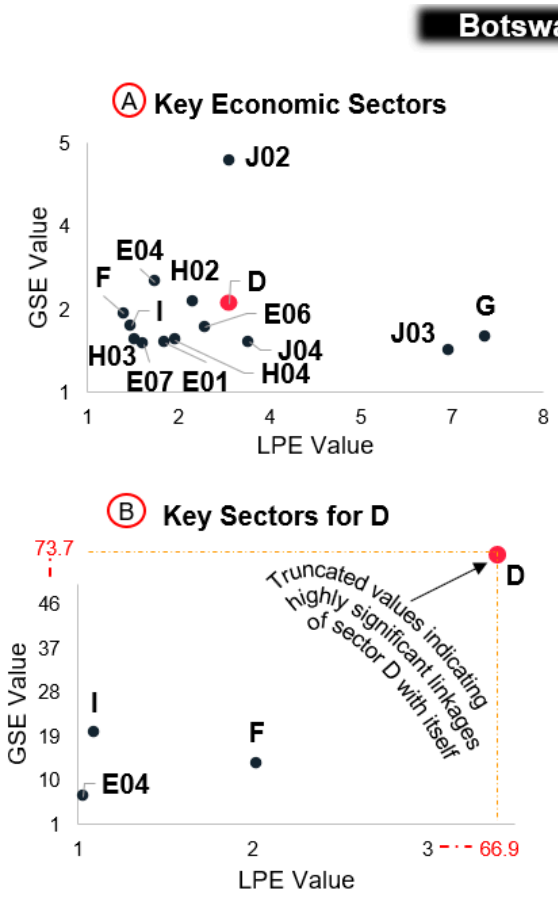
Figure 8. Ranking of Tanzanian economic sectors by their linkages to the selected services sectors. Note: P-HEM was conducted on each of the three sectors, with the pale blue circle indicating linkage values of each of these extracted sectors with themselves. Sectors I (Transport), J02 (Electricity, Gas and Water Supply), F (Electricity, Gas and Water Supply) and D (M&Q). Columns indicate the linkage values of the other sectors with the extracted sector.

'Financial intermediation and business activities' (J02) is also one of the main suppliers of inputs to M&Q (D), with M&Q ranking third on the list of destinations for the outputs of 'Financial intermediation and business activities' (Figure 8B). These outputs include financial intermediation, legal, accounting, packaging, building cleaning, other business activities, data processing, R&D, and other related services. However, most of the financial services are likely to be provided by foreign banks and financial service providers via

the Bank of Tanzania, which causes the results to appear as significant linkages of M&Q with the Tanzanian financial services. The underpinning reason for this result is that the Banking and Financial Institutions Act, 2006 does not provide for a specific definition of what constitutes a "Tanzanian bank". Instead, it requires all transactions involving foreign banks to be made through the Bank of Tanzania [47], and therefore, all transactions are captured as Tanzanian services.

4.2. Botswana

The P-HEM analysis of the Botswanan economy resulted in 14 sectors showing as *key* to the economy over the period 2005–2016 (Figure 9A). In a second step, we again conducted a P-HEM analysis by partially extracting M&Q and identifying the *key* sectors with which M&Q has the most backward and forward linkages (Figure 9B). M&Q features as relatively strongly linked with some manufacturing and services sectors. This finding corresponds with that of Koitsiwe and Adachi [48], who applied the Granger Causality Test and Vector Autoregressive Approach to determine inter-sectoral linkages. Specifically, three sectors show as *key* to M&Q, including 'The manufacture of petroleum, chemical and non-metallic mineral products' (E04); 'Electricity, gas, and water supply' (F); and 'Transport services' (I). All these three sectors are also among the *key* sectors to the Botswanan economy. As in the Tanzania case, M&Q's very high levels of backward and forward linkages with itself (as shown by the high values of LPE and GSE in Figure 9B) can be interpreted as an indication of the enclave nature of M&Q in Botswana.



Legend	
D	The mining and quarrying
E01	The manufacture of food and beverages
E04	The manufacture of petroleum, chemical and non-metallic mineral products
E06	The manufacture of electrical and machinery
E07	The manufacture of transport equipment
F	Electricity, gas and water supply
G	Construction
H02	Wholesale trade
H03	Retail trade
H04	Hotels and restaurants
I	Transport
J02	Financial intermediation and business activities
J03	Public administration
J04	Education, health and other services

Figure 9. (**A**) Most linked economic sectors; (**B**) sectors most linked with M&Q (D, denoted by red circle) (2005–2016). Note: GSE refers to Ghosh Sensitivity of Extraction (level of forward linkages), and LPE is Leontief Power of Extraction (level of backward linkages). There are 14 *Key* sectors to the economy and three *Key* sectors to M&Q. *Key* sectors are sectors with high (>1) GSE value and high (>1) LPE value.

Figure 10 demonstrates that 'Electricity, gas, and water supply' (F); 'Transport services' (I); 'The manufacture of petroleum, chemical and non-metallic mineral products' (E04); and 'Financial intermediation and business activities' (J02) are the top four providers of inputs to M&Q (D). While Koitsiwe and Adachi [48] found only forward linkages, our results indicate that M&Q has some level of backward linkages with the overall economy, although forward linkages are more significant. The difference in results arises because the definition of M&Q used by Koitsiwe and Adachi includes only diamonds, copper-nickel, gold, and soda ash. Whereas our broader definition of M&Q and our inclusion of 'Electricity, gas, and water supply' and 'Transport' services, which were excluded from Koitsiwe and Adachi's study, explain the finding of backward linkages with the overall economy. We elaborate on this further below. The left-hand diagram of Figure 10 shows that all the sectors in our analysis except 'Education, health, and other services' (J04) and 'Public administration' (J03) have had a decreasing trend of backward linkages with M&Q over the 12-year period of consideration. As shown in Figure 11, the decline in Transport occurred throughout 2005–2016, whereas most of the decline in 'Electricity, gas and water' happened since 2009, despite some fluctuations in both cases.

With respect to M&Q's forward linkages, Recycling (E09), Fishing (A02), Transport (I), 'Private households' (J05), and Agriculture (A01) are the top five destinations of outputs from M&Q. These strong forward linkages can likely be explained by the energy sub-sectors (coal, crude petroleum, and natural gas) included in our definition of M&Q. In landlocked Botswana, the use of these energy sources in the fishing industry refers to fisheries along the Okavango Delta and some major dams as well as some aquaculture.

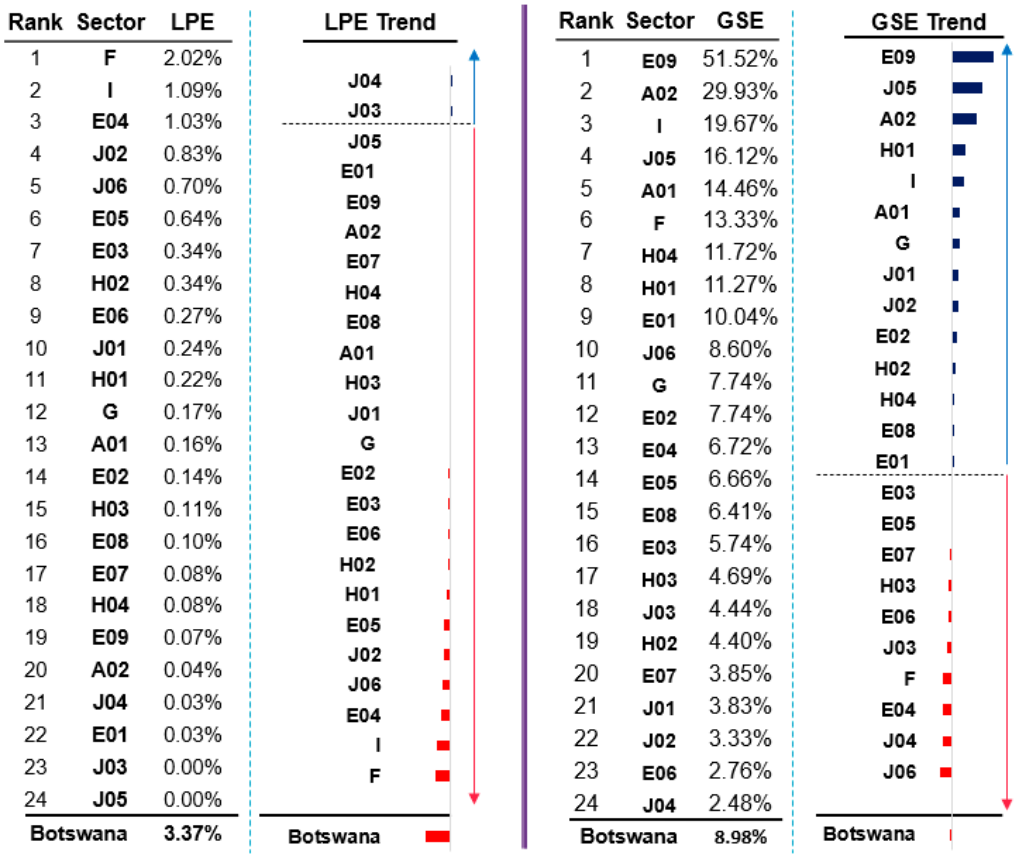


Figure 10. Ranking and trends of inter-sectoral BL and FL of the Botswanan M&Q (2005–2016). Note: The values indicate a percentage decrease in total economic output of the respective sectors following partial extraction of M&Q. Blue arrows indicate increasing trend and red arrows decreasing trend.

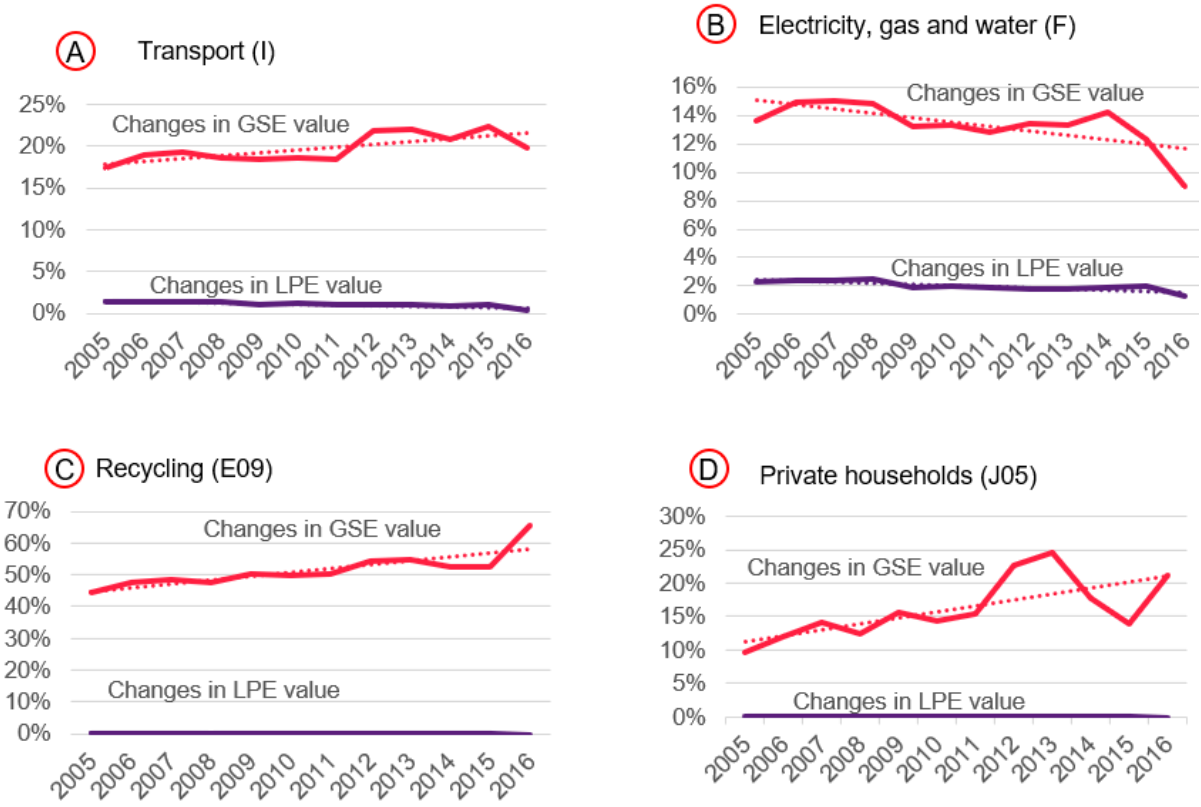


Figure 11. Changes in inter-sectoral BL (LPE) and FL (GSE) of the Botswanan M&Q with selected sectors (2005–2016). Note: The values indicate a percentage decrease in total economic output of the respective sectors following partial extraction of M&Q. Purple lines indicate BL (LPE) and red lines FL (GSE), dotted lines are trends.

The right-hand diagram of Figure 10 indicates that 14 sectors show an increasing trend of forward linkages with M&Q, and the remaining 10 demonstrate a decreasing trend. All the top five sectors that M&Q has forward linkages with have had an increasing trend of forward linkages. As shown in Figure 11, Recycling (E09) and 'Private households' (J05) are the top two sectors with the highest increasing trend over the period of consideration. Recycling had seen a nearly steady increase throughout 2005–2016, which could be due to the continued supply of M&Q's scrap metals and waste balancing the negative effect of domestic coal supply and use. The changes in forward linkages with 'Private households' fluctuated, reflecting the impact of M&Q's boom and the slowdown of households' use of coal and to some extent salt from Botswana ash (Botash) over 2005–2016. When all economic sectors are considered, both backward and forward linkages of M&Q show a decreasing trend, with M&Q's backward linkages experiencing a more pronounced decreasing trend than its forward linkages with the overall Botswanan economy.

The next two sub-sections focus on the manufacturing and services sectors that showed as *key* to M&Q.

4.2.1. Manufacturing Sectors

The manufacturing sectors listed as *key* to M&Q (D) are 'The manufacture of petroleum, chemical and non-metallic mineral products' (E04); 'The manufacture of metal products' (E05); and Recycling (E09). Figure 12 presents the results of P-HEM analyses for each of these sectors as measured on average over the 2005–2016 period. We found that 'The manufacture of petroleum, chemical and non-metallic mineral products' (E04) is not only among the top three suppliers of inputs to M&Q, as shown in Figure 10, but it also relies on M&Q as the second-ranked destination for its outputs (see Figure 12A). On the other hand, M&Q is the top-ranked provider of inputs to 'The manufacture of petroleum, chemical

and non-metallic mineral products' (E04), i.e., if this manufacturing sector were partially extracted, M&Q would experience around a 13.5% reduction in output (Figure 12B). Such a scenario would mainly affect the non-metallic minerals, such as soda ash, salt, and coal, for which production in 2016 was estimated to amount to 280,457 tonnes, 399,837 tonnes, and 1.87 million tonnes, respectively [26].

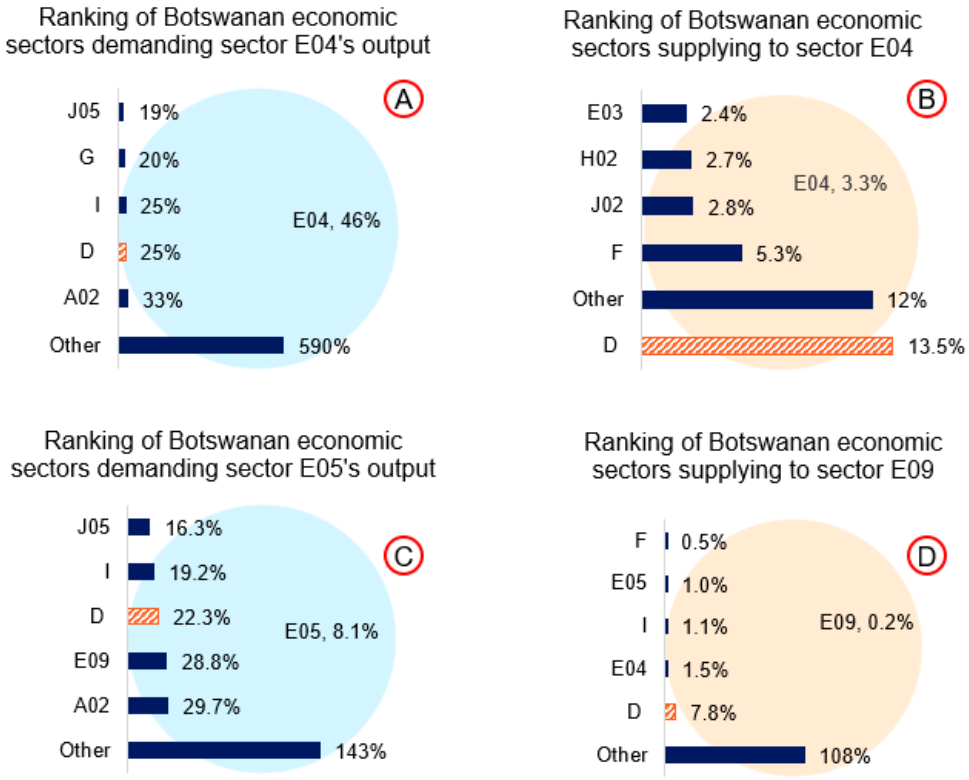


Figure 12. Ranking of Botswanan economic sectors by their linkages to the selected manufacturing sectors. Note: P-HEM conducted on each of the three sectors, with the pale blue and yellow circles indicating linkage values of these extracted sectors with themselves. Columns indicate the linkage values of the other sectors with the extracted sector. Sectors E04 (The manufacture of petroleum, chemical and non-metallic mineral products), E05 (The manufacture of metal products), and E09 (Recycling).

Figure 12C shows that M&Q is the third top destination for outputs of 'The manufacture of metal products' (E05), meaning that M&Q would experience around a 22% reduction in output if 'The manufacture of metal products' were partially extracted. As Botswana is not known for any production of iron-ore or steel, M&Q may be procuring imported metal products from domestic businesses. For example, Botswana imported an average of USD 612,513 worth of expanded metal (more than 90% from South Africa); USD 20.3 million worth of mechanical shovels, excavators and shovel loaders; USD 10.6 million in cast iron, tubes, pipes and hollow profiles; USD 3.7 million in tools, interchangeable, rock drilling or earth-boring tools; and USD 1.9 million in coal or rock cutters and tunnelling machinery per year over the period 2005–2016 [42]. As with the Tanzania case, there were significant forward linkages of M&Q with Recycling (E09), as can be seen in Figure 12D. However, this result mainly reflects the purchase of metal waste by local collectors who then export most metal waste and scrap to South Africa, apart from a very small domestic processing of scrap metals [49].

4.2.2. Service Sectors

The three services sectors that stand out for their linkages with M&Q (D) include Transport (I), 'Financial intermediation and business activities' (J02), and 'Electricity, gas,

and water supply' (F). The results of our P-HEM analysis for each of these sectors are presented in Figure 13. Recalling from Figure 10, Transport ranks in the top three sectors linked with M&Q both from a backward and forward linkage standpoint. According to the results of the P-HEM of Transport, M&Q is the top third destination for Transport's outputs (Figure 13A). For example, the Morupule coal mine uses Botswana railways as well as roads and trucks to transport coal domestically (particularly to Botash in Sowa Town and Makoro bricks near Palapye) and to South Africa. Similarly, Botash uses road and rail transport to move soda ash and salt domestically and to South Africa as well as to other countries in the region.

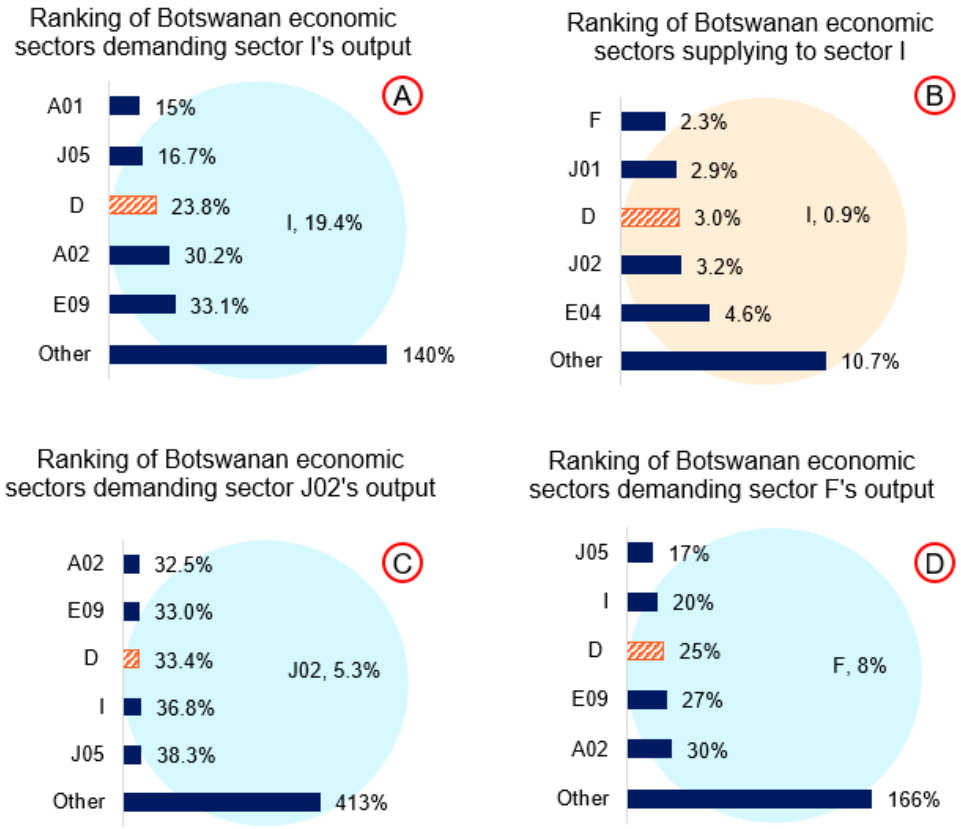


Figure 13. Ranking of Botswanan economic sectors by their linkages to the selected services sectors. Note: P-HEM conducted on each of the three sectors, with the pale blue and yellow circles indicating linkage values of these extracted sectors with themselves. Columns indicate the linkage values of the other sectors with the extracted sector. Sectors I (Transport), J02 (Financial intermediation and business activities), and F (Electricity, gas and water supply).

Regarding forward linkages, M&Q appears as the top third source of inputs for Transport (Figure 13B). This result is mainly referring to the energy component of our definition for M&Q. Specifically, coal is used to generate electricity, which in turn makes up about 5% (95% being petroleum) of the energy need in the Botswanan transport sector [50].

Recalling again from Figure 10, we identified 'Electricity, gas, and water supply' (F) as the top-ranking provider of inputs to M&Q. The P-HEM of 'Electricity, gas, and water supply' reveals that M&Q features as the top third destination for this sector's outputs (Figure 13D). The Morupule thermal power station near Palapye is a coal-fired power station that services a significant portion of the country's power generation [51]. The Morupule coal mine, in addition to being a major provider of coal for the station, also relies on this power station for its electricity and other power needs. While Botash uses coal to generate some of its own electricity, its major electricity power is sourced from the national grid provided by the Botswana Power Corporation.

Figure 13C indicates that M&Q is one of the top three buyers of outputs from 'Financial intermediation and business activities'. As shown in Figure 10, among M&Q's top four procurement items are outputs from 'Financial intermediation and business activities'. These include financial intermediation, legal, accounting, packaging, building cleaning, other business activities, data processing, R&D, and other related services. Since all the licensed commercial banks are majority foreign owned [52], these financial services are delivered primarily by South African banks that operate in Botswana. There is perhaps an economic reasoning behind the dominance of South African banks in Botswana, which may not necessarily mean that Botswana might be missing on the leveraging of mining linkages through financial services so long as these banks create value addition through investments in Botswana.

5. Potential for Economic Diversification

The potential for achieving economic diversification in Botswana and Tanzania hinges on the development of infrastructure, innovative technology, and technical skills as well as institutional strength. Apart from increasing efforts to utilise government revenues from mining to support economic diversification, the potentially promising linkages of M&Q with some of the identified *key* sectors could catalyse pathways to economic diversification.

5.1. Mineral Utilisation for Physical Infrastructure

In the manufacturing sector, 'The manufacture of petroleum, chemical and non-metallic mineral products' and 'Recycling' stand out in both Tanzania and Botswana, especially in terms of M&Q's forward linkages (M&Q supplying outputs to these sectors). This linkage is more likely determined by the energy resources, of which both countries have a great potential to further exploit beyond current production. RRACs are best served to strategize around their economic priorities, of which energy security is one. As such, they must find ways to develop and utilise their abundant resources, including the scarcely exploited coal and natural gas. This is crucial for the development of infrastructure, which is sorely needed to power their industrialisation. At the same time, both countries and the broader RRACs may explore, economic feasibility permitting, ways to enter the market of cleaner energy development.

In the case of Botswana, the strong forward linkages of M&Q with 'The manufacture of petroleum, chemical and non-metallic mineral products' may also be determined by the production of soda ash and salt. With the second largest reserves globally, Botswana is one of only two producers of soda ash in Africa and the fourth largest globally, producing on average 250,000 tonnes of soda ash and 440,000 tonnes of salt per year [53]. However, all its soda ash is exported to South Africa (66% of total) and Zimbabwe (20%), where it is used to make container and flat glasses, polymers, silica, detergent, and other chemicals [54]. Botswana then imports glass products from these countries through local agents such as PG glass Botswana (pty) ltd. Given such a significant potential in this commodity, Botswana could possibly (if cost and competitive advantage were to be achieved) capture the massive outflow of value addition by scaling up the mining of soda ash and salt and investing in glass, polymer and chemicals manufacturing in the country, with the aim of serving the domestic, regional, and international markets. This, in turn, could induce and increase the productivity of other industries, thus contributing to economic diversification.

There is likely at least a two- or three-decade window for Botswana to develop and utilise its abundant coal resources to develop its energy and other infrastructures. In the meantime, investments can be made to develop technology to not only extract coal and establish a high-efficiency low-emissions plan, but also to gradually develop and adopt cleaner energy sources. There are, however, uncertainties around the potential for coal as a major economic driver, and it is believed to be inadequate for replacing diamonds as the economy's main sector [55]. Given the unfavourable geographic and demographic status of the country, it may be best for Botswana to channel mineral and revenue utilisation to develop its infrastructure and business architecture to support tourism and agroindustry.

In the case of Tanzania, the pathway for exploiting opportunities for economic diversification via linkages with the manufacturing sector can potentially be through (1) the mining development of non-metallic and construction minerals and natural gas; (2) the development of non-metallic and metallic product manufacturing; and (3) the strengthening of linkages all the way through to the construction sector. Tanzania is endowed with abundant reserves of industrial and construction minerals, which it has yet to exploit at scale. These include aggregates and dimension stones (marble and granites), sand, graphite, and other industrial minerals [56]. Non-metallic products, chemicals, and metal works were among the sub-sectors that have shown growth and were identified in Tanzania's Integrated Industrial Development Strategy 2025 [57].

Some of the strong linkage results with 'The manufacture of petroleum, chemical and non-metallic mineral products' may relate to utilization of domestic limestone, clay, sand, and gypsum. Although these are currently produced far below the potential reserves, they are used in the production of cement and other industrial products. For example, Tanga (Simba) Cement PLC, Maweni Limestone Limited, and Dangote Cement PLC are major cement-producing factories that utilise local resources. The Dangote Cement plant in Mtwara, for instance, is not only utilising 500 million tonnes of limestone reserves that could last for 149 years, but also is poised to add value using the Mtwara port to transport cement across the country and offshore [58]. Furthermore, the plant has already started processing and utilising natural gas, having also secured a 9.98-square-kilometre area in the Ngaka coal fields to boost its production inputs [59]. Through such domestic utilisation of mineral and energy resources, cement production and the manufacturing of other non-metallic and chemical products provide a major pathway to economic diversification. With the climate risk associated with, especially, the use of coal in mind, this potential also relies on technology developments and the minerals needed going forward as part of the energy transition effort.

In addition to non-metallic products, metallic products such as steel could potentially be explored in Tanzania. There is an opportunity for both countries, but more so for Tanzania, to explore the potential for developing a recycling industry to take advantage of the significant metal and non-metal waste and scrap generated by mining and other industries. While there are no data or mechanism to discern the sources of metal scraps, Tanzania is said to possess large surpluses of scrap, which the foundries and steel mills have not been able to utilize fully [60]. The development of a sustainable and innovative recycling practice has many advantages, including the recovery of valuable resources, especially through the "decoupling of technology metal from major metal sources"; the continued supply of metals; employment potential, especially in collection and pre-processing; and the reduction in the environmental impacts via minimizing toxic metals that enter the environment and, thus, reducing the burden that the mining sector imposes on the environment, alternative use of water and land, and the emission of carbon dioxide [61].

While an advanced mechanism of metal waste collection and recycling adds to the production of metallic products, Tanzania is believed to have iron ore reserves that it could exploit. The largest deposit is found in the Liganga iron ore mine with 126 million tonnes of proven reserves [62]. Recycled metal and iron ore that can be produced in Tanzania could exponentially enhance steel and metal production, which already responded to the expansion of the construction sector over the last few decades with increases from 190,000 tonnes of raw steel and 129,555 tonnes of rolled products in 2014 to 300,000 mt and 224,402 mt, respectively, in 2018 [40]. It would be crucial to clearly target the industrial demands for infrastructure, machinery and equipment that could support the development and growth of Tanzania's manufacturing sector. This entails the competitive development of, for example, manufacturing sub-sectors of iron and steel, machineries, chemicals, and cement and other non-metallic products.

By utilising a reliable source of energy combined with maximum mineral utilisation, Tanzania could competitively develop metallic and non-metallic products to crucially support the construction of infrastructure and commercial and public buildings, which in

turn could propagate various economic sectors through efficiency gains and an improved logistics infrastructure. In 2016, Tanzania banned coal imports, which caused a decline in cement production to an extent that some companies were forced to suspend their operations, citing the poor quality, unreliable supply, and relatively higher prices of locally produced coal [59]. Nevertheless, the huge reserves of natural gas in Tanzania constitute a major opportunity for the production of metallic and non-metallic products. The development of natural gas extraction has, however, faced some delay, and there are issues that could undermine the massive transformative potential, which include the excessive cost and long timeframe of developing gas projects, coupled with the lack of coordination by the various government authorities involved in decision making, planning, and regulatory challenges that are endemic in countries such as Tanzania [20].

5.2. Leveraging to Develop Local Businesses

The findings in this paper also identified *key* service sectors that have strong linkages with the M&Qs of both Tanzania and Botswana. A special emphasis can be made on 'Financial intermediation and business activities,' which could further benefit laterally through the development of innovative financial instruments and efficiencies that could, in turn, have ripple effects across other economic sectors. As mentioned above, the use of locally based South African banks in Botswana may be economically plausible so long as there is local value addition created. The Tanzanian local content regulation [63] that requires businesses to keep an account with and transact through a Tanzania-based bank with at least 20% Tanzanian equity shareholding might potentially increase the likelihood of reaping the linkage opportunities between the Tanzanian M&Q and financial service providers. How such linkages between the M&Q and 'Financial intermediation and business activities' can be developed and can support economic diversification merit further research. But one area could be that banks can develop their technical and professional capabilities through the provision of services to the sector.

Furthermore, M&Q's strong backward linkages with Transport and 'Electricity, gas, and water supply' have the potential to create important business opportunities, business skills, opportunities for learning by doing, and financial gains that could be utilised to develop other economic activities. One issue that is identified in M&Q's procurement of transport services as well as metallic products is that intermediate and final products appear to be sourced locally but are largely imported in both Tanzania and Botswana.

In Botswana, large transport companies that are involved in the Botswana mines' in-and-outward transportation haulage services are either South African owned or use Botswana-registered vehicles operating from South Africa [64]. This is because the Morupule Coal Mine (MCM) and Minergy as well as Botash sell at mine gate, meaning that clients arrange transport services themselves. Thus, there is no legal obligation for the use of local transport services; cross-border clients, such as South African cement and other industries in the Minergy case, may find it economical to use transport service providers from South Africa. Tanzania has an opportunity to create important linkages through the transport of bulk minerals such as coal and iron ore once the mining of these commodities is further developed. However, it would be difficult to realize such an opportunity unless the practice of the so-called fronting is addressed. Such behavior can be addressed through regulations that do not hinge local content on ownership as well as by investing in the development of genuine local supplier capacity.

Joint ventures could be encouraged between local businesses and foreign providers of goods and services. However, it is often difficult for international businesses with a reputation, brand, and legal compliance to risk abandoning their brand and working with local businesses that have capacity and credibility issues. This shows that there is discrepancy in possibilities and expectations between government and the private sector. There is a need for a constructive dialogue and a relationship between the public and the private sector to work towards a shared goal. In addition, governments and mining companies have a role in the development of local supplier capacity. Mining companies are

generally viewed as being more effective in developing local business supplier capacity. However, a middle ground must be found that incorporates the respective positions of the mining and quarrying companies and host governments.

6. Concluding Remarks

Some of the linkage pathways that are identified in this paper have the potential to leverage mining and quarrying to induce structural change by contributing to the diversification of the Tanzanian and Botswanan economies. There are similarities in both countries in terms of the sector's linkage pathways with the manufacture of petroleum, chemical and non-metallic mineral products; recycling of metal and non-metal scrap and waste; and transport, financial and energy and water services. However, given their respective endowments, opportunities for economic diversification via the manufacturing linkage pathways differ between the two countries.

Botswana, being endowed with soda ash, salt, and coal resources, could prioritize scaling up the mining of these commodities and developing physical infrastructure and local manufacturing capacity for glass, polymers, and chemicals to feed various related domestic industries as well as supply into regional and international markets. For Tanzania, the underexploited vast resources of natural gas; non-metallic minerals such as sand, aggregates and dimension stone, limestone, gypsum, and graphite; as well as iron ore and metal scraps, provide an opportunity for economic diversification. Specifically, the construction sector can be targeted as a key linkage pathway, utilizing large-scale cement production and developing iron ore mining and the recycling of metal scrap to scale up the manufacturing of metallic and non-metallic products. However, this and the overall efforts of leveraging the sector for economic diversification largely pivots on economic integration that could be created at regional, sub-regional and continental levels. The African Continental Free Trade Agreement (AfCFTA) is an important step to unlocking such integration; however, there is a long way to go before achieving the full potential.

One key determinant for the linkage pathways in both Tanzania and Botswana is the availability of abundant natural gas and coal, respectively, as energy sources, which have been crucial in the mining of raw materials for and manufacturing of soda ash, cement, and steel, among other metal and non-metal products. These resources can be exploited at a large scale to generate the energy needed. The global push for phasing out coal to reduce carbon emissions, however, could negatively affect the prospect of scaling up coal to support the identified linkage pathways. At a global level, the mining and construction sectors have commenced shifting towards developing and piloting carbon-limiting technologies that could in due course outcompete carbon-intensive technologies. Another key determinant for linkage-based economic diversification is how both countries maximize the financial, technological, and skill gains generated through the backward linkages of the mining and quarrying sector with the transport, financial and energy and water services. The question remains how these gains, as well as the government revenues from the increased mining of the relevant minerals, are effectively generated and utilized to support the main linkage pathways for economic diversification. There is, therefore, a scope for future research to explore inter-sectoral linkages by measuring other components of the value chain, including revenues, business multipliers, and changes in factor inputs and investments over multiple years. Specific sectors that the analysis identified as key could also be analysed in-depth to understand their role in economic transformation through the utilisation of diversification inputs.

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Appendix A

	Code	Economic Sectors
1	**A01**	Agriculture
2	**A02**	Fishing
3	**D**	Mining and Quarrying
4	**E01**	Food & Beverages
5	**E02**	Textiles and Wearing Apparel
6	**E03**	Wood and Paper
7	**E04**	Petroleum, Chemical and Non-Metallic Mineral Products
8	**E05**	Metal Products
9	**E06**	Electrical and Machinery
10	**E07**	Transport Equipment
11	**E08**	Other Manufacturing
12	**E09**	Recycling
13	**F**	Electricity, Gas and Water
14	**G**	Construction
15	**H01**	Maintenance and Repair
16	**H02**	Wholesale Trade
17	**H03**	Retail Trade
18	**H04**	Hotels and Restaurants
19	**I**	Transport
20	**J01**	Post and Telecommunications
21	**J02**	Financial Intermediation and Business Activities
22	**J03**	Public Administration
23	**J04**	Education, Health and Other Services
24	**J05**	Private Households
25	**J06**	Others

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