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The Commodity Dependence Trap

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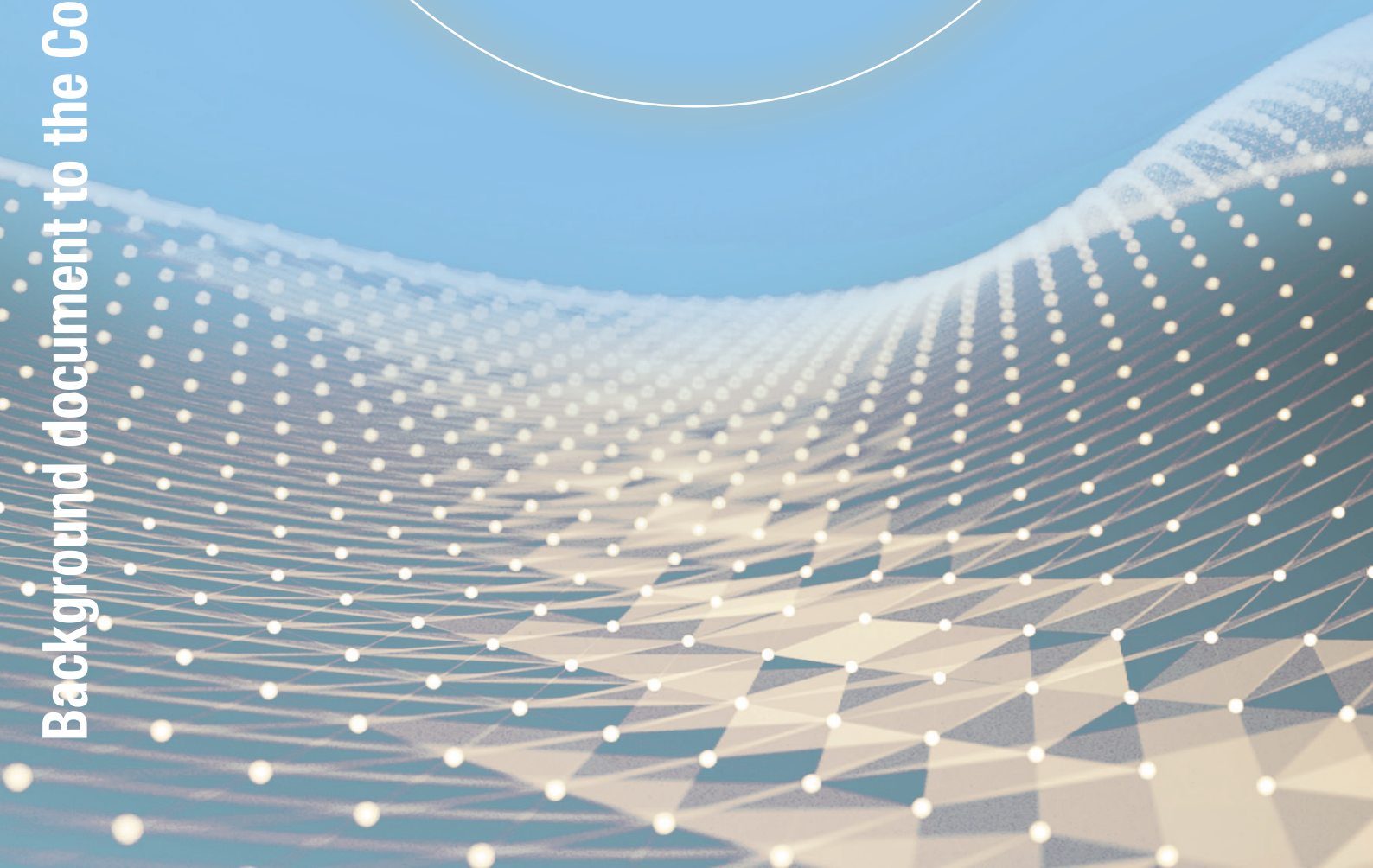

Abstract

This paper explores the hypothesis that commodity dependent countries, particularly developing countries among them, are trapped into the state of commodity dependence. It analyses the degree to which countries move between three states, namely no dependence, commodity dependence, and strong commodity dependence. Trapping implies that once countries are in either of the two states of dependence, they have difficulty getting out of them. This exposes them, for a very long time, to a multitude of challenges associated with commodity dependence, limiting their capacity to meet their development objectives, including the Sustainable Development Goals (SDGs). Empirical analysis confirms that commodity-dependent countries are trapped in the two states of commodity dependence. Identification of the correlates of commodity dependence suggests some avenues for addressing this issue. Most particularly, there is suggestive evidence that improving technological capabilities of trapped countries could help them to escape out of commodity dependence. Escaping from the commodity dependence trap will require strong political will and a long-term development vision.

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Disclaimer

1. Introduction

Commodity dependence, defined as the state characterizing countries that derive at least 60 per cent of their merchandise export earnings from the commodity sector, has been shown to be associated with several challenges.[1] These include economic challenges such as negative terms of trade; unpredictable export revenues due to high commodity export price volatility; macroeconomic instability (van der Ploeg and Poelhekke, 2009) manifesting itself through high trade deficits, unstable exchange rates, budget deficits, and high indebtedness; microeconomic challenges such as low firm profitability and declining household incomes in commodity-dependent developing countries (CDDCs) (UNCTAD and FAO, 2017). Commodity dependence is also associated with political instability resulting from the contest over the control of rents generated by natural resources (Collier and Hoeffler, 2004). Moreover, commodity dependence amplifies the negative effects of climate change on CDDCs (UNCTAD, 2019a). There is also a nascent literature associating commodity dependence with high illicit financial flows, particularly in the extractive sector (Lemaître, 2019; UNCTAD, 2016).

In addition, dependence on commodities is associated with poor governance and social development. For instance, a higher share of point-source natural resources—fuels and minerals—tends to have a negative effect on the quality of institutions (Bulte et al., 2005) and on governance (Isham et al., 2005). Furthermore, commodity dependence is linked to both lower social development (Carmignani and Avom, 2010) and lower human development (Nkurunziza et al., 2017). Also, a higher share of commodities in exports is linked to lower non-resource export diversification (Bahar and Santos, 2018). It has also been established that commodity dependence is associated with lower aggregate labour productivity (Csordas, 2018).

The negative association between commodity dependence and economic performance has been amply discussed in the last four editions of the Commodities and Development Report series. This paper analyses the extent to which CDDCs are trapped into their state of commodity dependence. It documents the persistence of dependence and explores some potential drivers of the phenomenon. Identifying the correlates of commodity dependence could inform policies seeking to enable CDDCs break with commodity dependence.

More specifically, this paper uses transition analysis based on a stochastic (or transition) matrix to measure mobility across three states, namely non-commodity dependence, a state that characterize countries that derive less than 60 per cent of their merchandise exports from the commodity sector; commodity dependence for countries deriving between 60 per cent and 80 per cent of merchandise export earnings from the commodity sector; and strong commodity dependence for the countries deriving more than 80 per cent of their merchandise export earnings from the commodity sector. Elements of the transition matrix measure the probability that, on average over the sample period, countries move from one state to another. Given that this analysis is based on a relatively short sample period, the transition matrix characterizes short-term mobility.

After the analysis of short-term mobility, the focus shifts to the derivation of long-term or steady-state distribution of countries in the three states. This is particularly important as it could be argued that short-term mobility might be due to some phenomenon unrelated with commodity dependence, or simply volatility of the values used to compute mobility. The steady-state distribution, in contrast, provides information on the stability of the allocation of countries in the three states when all short-terms movements have ended. Using information from the eigenvector characterizing the dynamics of commodity dependence, the analysis also estimates the half-life of the transition matrix, suggesting how long it takes a country to cover half of the difference between its positions in the short term and in equilibrium.

Empirical results show that commodity-dependent countries are indeed trapped in the state of dependence. The implication is that if they do nothing, they will remain commodity-dependent and continue to suffer from the negative consequences of dependence highlighted above. Moreover, given that the sample distribution is almost the same as the equilibrium distribution, strong action is needed to change the status quo. Most particularly, strengthening technological

[1] The 60 per cent threshold was determined econometrically using a quantile regression of human development on several variables, including the share of commodity exports over total merchandise exports, in value terms. For details, see Nkurunziza et al. (2015).

capabilities of commodity-dependent countries is highlighted as one key avenue for enabling CDDCs to move away from commodity dependence.

Section 2 illustrates cases of countries trapped in commodity dependence by briefly presenting the cases of Zambia and Nigeria. The case of Costa Rica is used to illustrate a country that was able to escape from its commodity dependence. Section 3 discusses the methodology used to measure mobility, both in the short term and the long-term. It also presents empirical results of mobility. Section 4 identifies correlates of commodity dependence, with a focus on indicators of technology, using a simple econometric probit model. Section 5 concludes.

2. The commodity dependence trap: a tale of three country trajectories

The concept of commodity dependence trap in this Report is used to characterize three different outcomes. The first is a situation where a country is commodity dependent in the reference period and remains dependent over a long period. Zambia illustrates this case. The second situation, illustrated by Nigeria, relates to a country where export diversification characterizes its initial conditions but over time becomes export dependent. The third case is that of a country that is initially commodity dependent but, over time, diversifies its export sector and moves out of export dependence. Costa Rica exemplifies this case. Using data from The Atlas of Economic Complexity,[2] the trajectories of the three countries over the period from 1965 to 2018, representing more than half a century, reveals three different trajectories that summarize most developing countries' experiences.[3]

In 1965, copper ore and concentrate, and copper alloys, represented 85 per cent of Zambia's net merchandise exports. Twenty years later in 1985, the composition of Zambia's export basket had hardly improved, with copper and copper alloys, refined or not, unwrought; representing 77 per cent of the country's merchandise exports. By 2005, merchandise exports were still dominated by copper-based raw materials, accounting for about 60 per cent of the total. In 2018, Zambia's export concentration around copper had worsened, increasing to almost to 80 per cent of total merchandise exports (Figure 1(a)).

Whereas Zambia has remained dependent on the same commodity over more than half a century, Nigeria was relatively diversified in 1965 but became more dependent on one commodity over time. In 1965, even though Nigerian exports were dominated by primary commodities, the export basket was diversified with cocoa beans, groundnuts, and palm nuts and kernels, representing 15 per cent, 13 per cent, and 10 per cent, respectively, of total merchandise exports. The country also exported palm oil, groundnut oil, and tin and tin alloys, unwrought. Crude petroleum and refined petroleum accounted for 15 per cent and 10 per cent, respectively, of total merchandise exports. Twenty years later in 1985, the country was exporting almost a single commodity, crude petroleum, which accounted for 97 per cent of total merchandise exports. In 2005, at 92 per cent of total merchandise exports, crude petroleum was still by far the major export of Nigeria. By 2018, the picture had changed only slightly, crude petroleum still accounting for 81 per cent of total merchandise exports (petroleum gases represented 12 per cent).

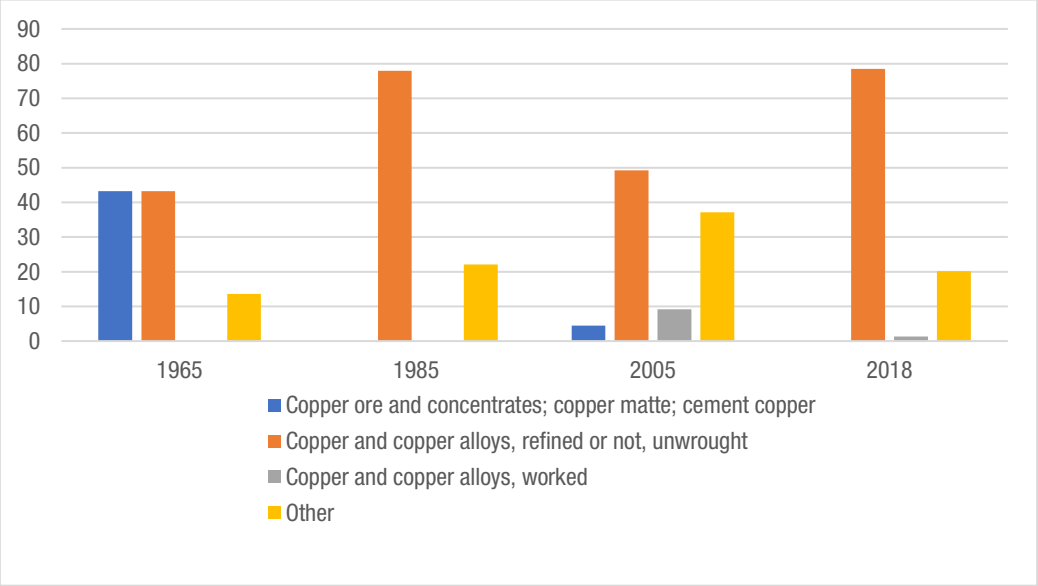
Costa Rica followed a different, more successful trajectory. In 1965, Costa Rica's export base was dominated by coffee and bananas, representing about 68 per cent of total net merchandise export earnings (Figure 1(c)). Overall, food commodities represented 83 per cent of total merchandise exports. Twenty years later, in 1985, these two commodities were still the country's dominant exports, accounting for 61 per cent of total merchandise exports. Even though food commodities made up 76 per cent of total merchandise exports, there was a nascent manufacturing sector, which contributed about 15 per cent to total merchandise exports against only 7 per cent 20 years earlier. Thereafter, the country embarked on a diversification drive to the extent that by 2005, the country's export basket had dramatically changed. In 2005, the main exports were electronic microcircuits, with a share of 26 per cent, followed by parts of and accessories for machines, with a share of 15 per cent. Machinery and vehicles accounted for 48 per cent of total

[2] https://atlas.cid.harvard.edu/

[3] To access disaggregated data from before 1995, the SITC4 classification system was used. Export shares are calculated using gross trade flows. Data in figures 1(a) and 1(b) are derived using the 4-digit level of disaggregation. However, in the discussion, sectoral level data at 1 digit is also used to show more aggregated information.

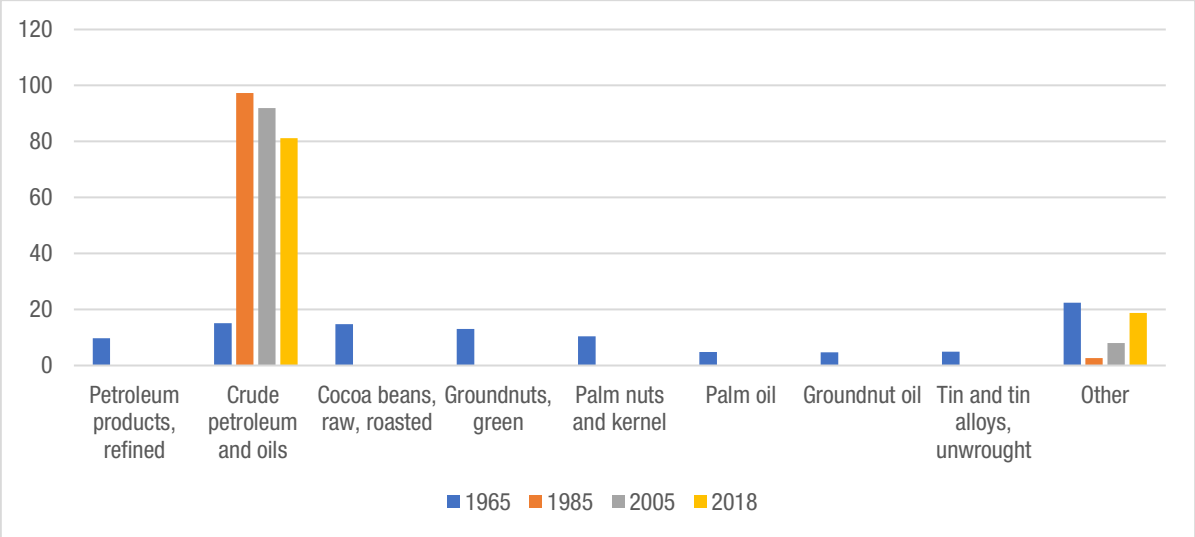
merchandise exports, and the share of the food sector had dropped to only 24 per cent of the total. By 2018, other sectors that had developed include the medical instruments and appliances, and orthopedic instruments. Interestingly, the traditional food sector remained important, as banana and fruits represented an important share of exports. This contrasts with the case of Nigeria, suggesting that diversification is not about adopting new products, while abandoning traditional ones.

Figure 1 (a): Zambia's main merchandise exports in 1965, 1985, 2005 and 2018
(percentage of total merchandise exports)



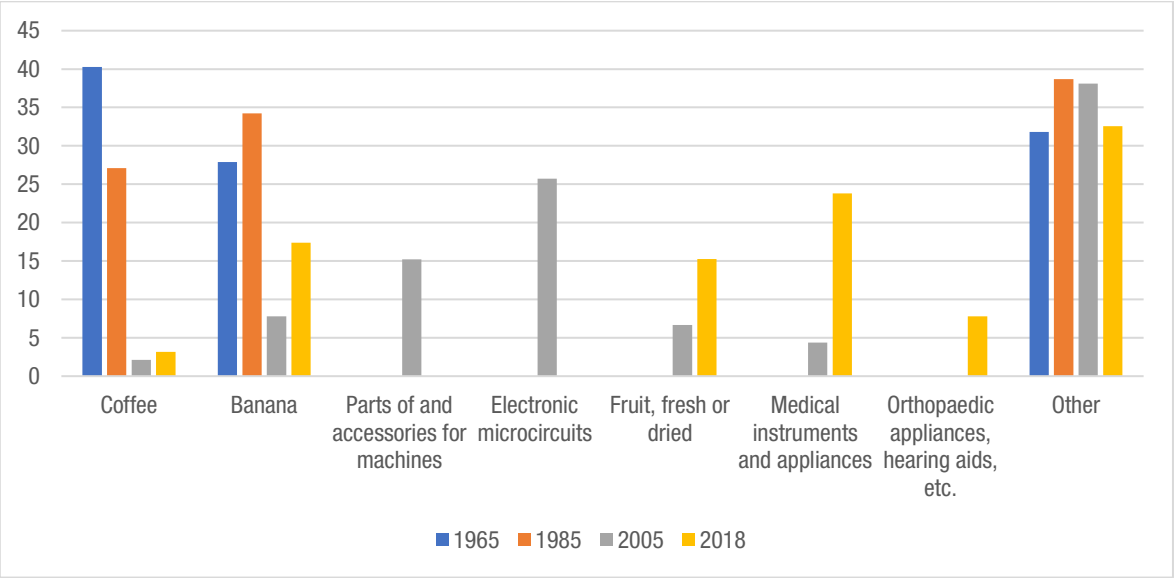
Source: Author based on:
https://atlas.cid.harvard.edu/explore?country=247&product=undefined&year=2018&productClass=SITC&tradeFlow=Net&target=Product&partner=undefined&startYear=undefined (accessed 11 May 2021).

Figure 1(b): Nigeria's main merchandise exports in 1965, 1985, 2005 and 2018
(percentage of total merchandise exports)



Source: Author, based on data from:
https://atlas.cid.harvard.edu/explore?country=159&product=undefined&year=2018&productClass=SITC&tradeFlow=Net&target=Product&partner=undefined&startYear=undefined (accessed 11 May 2021).

Figure 1(c): Costa Rica's main merchandise exports in 1965, 1985, 2005 and 2018
(percentage of total merchandise exports)



Source: Author based on data from https://atlas.cid.harvard.edu/explore?country=52&product=undefined&year=2018&productClass=SITC&tradeFlow=Net&target=Product&partner=undefined&startYear=undefined (accessed 11 May 2021).

The reconfiguration of exports in 2018 shows the food sector regaining importance, mainly because there were more food commodities exported. The most important ones, in addition to bananas, were fruit, fresh or dried, including avocadoes, pineapples and mangoes; edible products or preparations; fruit and vegetable juices; fruit, prepared or preserved; bakery products; etc. This illustrates that diversification is not just about adding value to primary commodities or only producing more sophisticated goods. While Costa Rica diversified into more sophisticated goods, it also increased the number of products exported within the commodities sector. This highlights the point that even when a country remains commodity dependent, it is better off relying on a larger basket of products, as was Nigeria in 1965. Currently, as a price taker, Nigeria's total reliance on exports from the energy sector exposes it much more to the vagaries of international commodity markets.

Zambia, Nigeria, and Costa Rica illustrate three different trajectories of commodity dependence. Costa Rica illustrates a successful case of export dynamism, from a highly concentrated base to more product and sectoral diversification. The country owes its success to a combination of factors, including a visionary leadership, macroeconomic stability, openness to foreign direct investment, proximity to a large export market—the United States—health and education policies that fostered human capital development, etc. (UNCTAD and FAO, 2017). Zambia and Nigeria, in contrast, are two different illustrations of the commodity dependence trap. For more than half a century, Zambia has not been able to transform its economy in such a way that the country eases its dependence on copper exports. Nigeria, in turn, had the opportunity to maintain a relatively diversified export sector or even develop it further. Instead, commodity dependence worsened over time.

There is literature claiming that economies more reliant on point-source natural resources may be more prone to the natural resource curse than those relying on diffuse and sparsely distributed agricultural commodities. One major channel may be that point-source natural resources are more prone to predation by not only incumbent politicians but also rebels. The latter my capture them either at their extraction site or at any choke point when they are moved for export, causing instability and economic decline (Collier and Hoeffler, 2004). This might help explain the contrast between Costa Rica and Nigeria.

However, the negative relationship between point-source natural resources and the resource curse might not be generalized (Alexeev and Conrad, 2011). Indeed, when revenues from natural resources are used to develop other sectors and hence contribute to diversifying the economy, CDDCs avoid the natural resource curse. Indonesia, for

example, derived 71.5 per cent of its merchandise export earnings from the oil and gas sector in 1980. Fifteen years later in 1995, the contribution of the fossil fuels sector to total merchandise exports had been reduced to less than a third of the value in 1980, with only 22.2 per cent. This was the result of massive investment of revenues from the fossil fuels sector into non-commodity sectors, diversifying the economy. By 2018, oil and gas accounted for 10 per cent of total merchandise export earnings. The economy had diversified its exports into products such as coal, coke and briquettes; iron and steel; road vehicles; vegetable oils and fats; metalliferous ores and metal scrap; apparel and clothing; electric machinery; etc.[4]

The discussion of the three country cases above, as well as that of Indonesia, leads to one of the main questions addressed in this paper: when observed over a long enough period, an initially commodity dependent country may move out of commodity dependence. Costa Rica, and Indonesia to some extent, illustrate this case. Zambia and Nigeria, in contrast, seem to be trapped in a state of commodity dependence. The next section presents the methodology used to measure mobility, followed by empirical results. Given that most developing countries, which constitute a large share of the sample, are commodity dependent, knowledge of the likelihood that a country can escape from dependence may inform policy towards structural transformation and export diversification. Before calling on CDDCs to diversify their economies, it would be important to first understand why they have not done so for such a long time. Better understanding of the factors behind commodity dependence might lead to rethinking diversification policies.

3. Measuring mobility across commodity dependence states

Observed at any specific time, any country can be classified in one of the three states defined above: it may be not commodity-dependent, commodity-dependent, or strongly commodity-dependent. Allowing for a relatively long period of time, countries may move across the three states. After all, the old debate about the need for CDDCs to diversify their economies implies moving from the commodity-dependent (and strongly commodity-dependent) to the non-commodity dependent state. Costa Rica achieved this over several decades. However, many CDDCs remain commodity-dependent even when they are observed over a period spanning half a century, as Zambia and Nigeria illustrate. These countries seem to be trapped.[5]

Mobility is analyzed with a transition matrix. It is a tool used to determine the probability that a country in a reference period remains in its state or moves to some other state after some time. A period is the unit of time used to analyze mobility. It varies according to the phenomenon under analysis. For example, a generation is used as the time unit in studies of intergenerational income mobility. Studies of cross-country growth adopt five or ten years as their time unit of observation (Kremer et al., 2001). In this chapter, countries are observed over a period spanning 24 years corresponding with 23 potential annual transitions, from 1995 to 2018. The analysis of commodity dependence dynamics requires a relatively long period of observation given that the economic transformation process leading to export diversification takes decades, as illustrated by the case of Costa Rica. Analysis is limited to 24 years because detailed data on commodity dependence and some of its potential correlates are only available since 1995.

Formally, a transition matrix shows probabilities that a country moves from state i to state j between time t and time $t+\tau$, with τ representing one unit of time. In the empirical analysis below, the unit of observation is one year but mobility is aggregated over a 24-year period. If empirical results show that the probability of escaping commodity dependence is small, policy action should be towards making this transition faster and easier. Whether the adoption of modern technologies, such as those associated with the Third and Fourth Technological revolutions, can help these

[4] Based on data from The Atlas of Economic Complexity, accessed on 18 January 2021; https://atlas.cid.harvard.edu/explore?country=103&product=undefined&year=2018&productClass=SITC&target=Product&partner=undefined&startYear=undefined

[5] Strictly speaking, the statistical concept of a trapping state in the analysis of dynamic systems means that once a country is in this state, it is impossible for it to move to any other state (Robert and Casella, 1999). In this chapter, unless otherwise specified, the concept is used to represent situations of very slow mobility with probability close—but not equal—to zero.

countries to hasten their transformation towards more diversified economies is briefly explored towards the end of this paper.

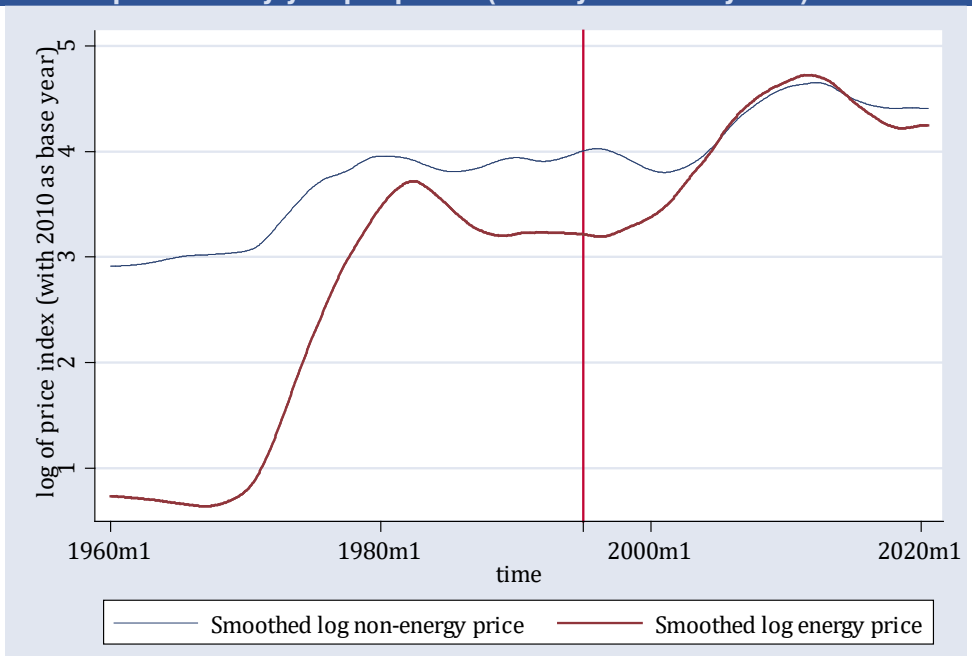
The transition matrix is represented as follows:

$$\begin{pmatrix} p_{11} & p_{12} & p_{13} \\ p_{21} & p_{22} & p_{23} \\ p_{31} & p_{32} & p_{33} \end{pmatrix} \quad (1)$$

where $p_{11}$is the proportion of countries that are non-commodity dependent in periods t and remain non-commodity dependent in period $t + \tau$. Note that proportions are also interpreted as probabilities. Hence, p_{12} is the probability that a non-commodity dependent country in the reference period becomes commodity dependent in the next period. As for p_{13} it indicates the probability that a non-commodity dependent country in the reference period becomes strongly commodity dependent in the next period. Elements along the diagonal measure persistence, namely the probability that a country remains in the same state between two time periods, with p_{22} and p_{33} referring to commodity dependence and strong commodity dependence states, respectively. p_{21} and $p_{23}$are probabilities that a commodity-dependent country becomes non-commodity dependent, and strongly commodity dependent, respectively. p_{31} and p_{32} are probabilities that a strongly commodity dependent country becomes non-commodity dependent, and commodity dependent, respectively.

The sample period is from 1995 to 2018, with 4 944 observations or country-years (24 years for each of the 206 countries and territories). The 24-year period captures different phases of the commodity price cycle. Between 1995 and 2002, commodities prices were low, corresponding with a declining phase of the price cycle that had started in the early 1980s (Figure 2). The period between 2003 and 2011 was characterized by a commodity price boom with commodities prices increasing manyfold over a few years. After 2011, commodities prices have been declining, even though they have remained higher than their level before the commodity boom of the 2000s. Indeed, before presenting empirical results of mobility, it is worth discussing first the behaviour of the commodity price trend, considering that commodity dependence may be a function of prices, in the short term. For example, during the last commodity price boom, the number of CDDCs increased from 110 in 2005 to 118 at the end of the boom in 2011. Thereafter, the number declined (Nkurunziza et al., 2017).

Figure 2: Commodities prices: a sixty-year perspective (January 1960 to July 2020)



Source: Author based on World Bank commodity price index, using 2010 as base year

Note: Data smoothing by local polynomial. Vertical line is 1995m1, start of sample used in empirical analysis.

Decomposing commodities into energy and non-energy groups, figure 2 illustrates commonalities and differences in the behaviour of both groups. The major common factor is that prices follow the same long-term trend. Prices have tended to increase, stabilize, and decline at the same time. This finding implies that over a long enough period, the markets for energy and non-energy commodities are fundamentally affected by the same major factors. This strong correlation suggests that while diversification within the wider commodity sector may help, to some extent, to contain some of the negative consequences of price changes, only diversification out of the commodity sector could be an answer to the deleterious effects of commodity dependence. In other words, even though some types of commodities might face idiosyncratic challenges—e.g., climate change may have a much stronger impact on agricultural commodities than on minerals, ores and metals—the major challenges facing the commodity sector are the same.

One major difference between the two types of commodities, as illustrated by figure 2, is the amplitude of price changes. Energy commodities experience much stronger price changes than non-energy commodities. For example, because of the commodity price boom of the 1970s, the energy price index increased by more than 1 350 per cent, from 3.4 to 49.50 between January 1973 and December 1980. Over the same period, the non-energy commodity price index increased by barely 114 per cent, from 27.07 to 57.87. Unequal increases in prices were again recorded during the commodity boom of the 2000s, with energy prices increasing by 552 per cent between January 2002 and July 2008 while non-energy prices increased by 189 per cent over the same period. Energy markets have also been characterized by sudden and drastic price drops, shattering exporting countries' economies.

High price volatility is indeed an intrinsic characteristic of energy markets. Recently, energy prices dropped by more than half in just six months. In June 2014, the energy price index stood at 131.48, but it had fallen to 63.10 by January 2015, less than half its value six months earlier. Countries that had planned spending based on an oil price of US$112 in June 2014 faced the challenge of substantially cutting their budgets to adapt to a price that had reached US$45 by 13 January 2015. The brutal effect of commodity dependence was strongly felt by oil-export dependent countries across the world, including Angola, The Bolivarian Republic of Venezuela, The Islamic Republic of Iran, Nigeria, and Saudi Arabia. Commodity dependence is harmful not only because price shocks are destabilizing but also the relatively short periods of high commodities prices are followed by much longer periods of depressed prices, as illustrated by figure 2. This background information may help to understand why commodity dependence might manifest itself differently depending on the type of commodity a country depends on. Econometric results seem to confirm this hypothesis (UNCTAD, 2019b).

The empirical transition matrix in Table 1 summarizes aggregate mobility of 206 economies, both developed and developing, which represents almost all the countries and territories in the world.

Table 1. Commodity dependence: mobility across three states (1995-2018)

	Non-Com. Dep.	Com. Dep.	Strongly Com. Dep.
Non-Commodity Dependent	0.95	0.04	0.01
Commodity Dependent	0.13	0.75	0.12
Strongly Commodity Dependent	0.01	0.07	0.92
Average share of countries	0.50	0.18	0.32

Source: Computed by the author based on UNCTADStat data.

Table 1 provides three sets of information. First, the last row shows the average proportion of countries in each of the three states after mobility has ended. On average, over the sample period, half of the countries were in the Non-commodity dependent state. The other half was in the Strongly dependent state (32 per cent of the full sample) and in the Commodity dependent state (18 per cent of the sample). This summary information suggests that while a widespread characteristic, commodity dependence—and its strong version—only affect half of the countries in the sample. Second, all elements of the transition matrix are non-zero, even though some are small, implying that there is indeed mobility across all states.

The third set of information relates to values of the transition matrix, interpreted as probabilities. Starting with the two extreme values of the diagonal: there is evidence of limited mobility from the non-commodity dependent and strong commodity dependent groups. During the sample period, 95 per cent of non-commodity dependent countries remained within this group. The proportion of strongly dependent countries that did not move out of the category is 92 per cent. Another way of interpreting these findings is that the probabilities that a non-commodity dependent country becomes commodity dependent or strongly commodity dependent are 0.04 and 0.01, respectively. Similarly, the likelihood that a strongly commodity dependent country becomes non-commodity dependent over the 24-year period is very small. But there is a 7 per cent chance that such a country improves from strong commodity dependence to just commodity dependence. Even though this might be considered as an improvement, this information needs to be put in context because both commodity dependent and strongly commodity dependent countries face the same challenges with just higher severity for the latter group.

The value in the middle of the diagonal suggests an almost equal probability that a commodity dependent country becomes non-commodity dependent (probability of 0.13) or strongly commodity dependent (probability of 0.12). On average, three-quarters of commodity-dependent countries remain in the same state, over the sample period. This result suggests that a priori, while some countries graduate into the non-commodity dependence category, an almost equal number fall into the worse state of strong commodity dependence. The implication is that relatively few countries can escape from the commodity dependence trap.

One important question is whether a period of 24 years of observation is long enough to properly capture the transition processes occurring across all commodity dependence states. In other words, could transitions captured in table 1 be the result of short-term phenomena that would subside over time? Indeed, commodity dependence states might be correlated with commodity price cycles that could be longer than the 24-year sample period. Hence, it is important to analyze the evolution of commodity prices over a longer time span to ensure that what is captured by the transition matrix may be considered as representing a general pattern of mobility.

To probe the stability of the pattern of mobility based on the sample period 1995-2018, it is important to determine whether the distribution does not change over time. To answer this question, the steady-state or ergodic probability distribution is computed as follows, based on the transition matrix in table 1.[6]

$$\begin{bmatrix}\pi_1\\ \pi_2\\ \pi_3\end{bmatrix} = \begin{bmatrix}(p_{11}-1) & p_{21} & p_{31}\\ p_{12} & (p_{22}-1) & p_{32}\\ 1 & 1 & 1\end{bmatrix} X \begin{bmatrix}0\\0\\1\end{bmatrix} \quad (2)$$

It is also useful to calculate the speed of convergence to steady state. It is based on the asymptotic half-life of convergence, or the number of years required to halve the norm of the difference between the current and ergodic distributions. The speed of convergence is given by:

$$h = -\frac{\ln 2}{ln\,|\lambda_2|} \quad (3)$$

where h is the speed of convergence and λ_2 is the second highest eigenvalue of the transition matrix. The value of h in equation (3) is the half-life of the system represented by the transition matrix. The vector of ergodic probabilities and their associated eigenvalues are presented in table 2.

Table 2: Ergodic probability distribution and associated eigenvalues

	Non-Com. Dep.	Com. Dep.	Strongly Com. Dep.
Ergodic probability distribution	0.51	0.17	0.32
Eigenvalues (λ_s)	1.00	0.92	0.69

Source: UNCTAD Secretariat based on equations (2) and (3)

[6] For the derivation of the matrix in (2), see Nkurunziza (2015)

Interestingly, the steady-state distribution is almost the same as the distribution shown in Table 1, when the analysis is limited to the period 1995-2018. There are small changes in the proportions of countries in the non-commodity dependent and the commodity-dependent categories, from 0.50 to 0.51, and from 0.18 to 0.17, respectively. This finding suggests that commodity dependence as characterized by data in the sample depicts a system in equilibrium. This is consistent with the examples of Zambia and Nigeria showing that for close to 60 years, the countries have remained not only dependent but also on the same commodity. The finding confirms that commodity-dependent and strongly commodity-dependent countries are indeed in a trap.

Another way of ascertaining the difficulty of emerging out of the dependence trap is to use the information provided by the eigenvector. Based on equation (3), with h = 8.27, and if no action is taken to accelerate mobility, it would take the average commodity dependent country 190 years[7] to cover half of the difference between its current share of commodities in total merchandise exports and that of the average non-commodity dependent country. This result illustrates the challenge facing CDDCs. Commodity dependence will not disappear on its own. Unless they take strong action to change the status quo, CDDCs will remain commodity-dependent for the coming centuries. This seems to be the trajectory that Zambia and Nigeria, and most other CDDCs, have embarked on.

Given the discussion above, this report posits that technology could be among the disruptive factors that could help CDDCs to change their trajectory towards more diversified economies. Costa Rica's experience shows that an economy can indeed be transformed into a more diversified production and export system. Success requires time, strong political will, and a long-term realistic development vision, coupled with an ambitious but reasonable implementation strategy (UNCTAD and FAO, 2017).

The remainder of the paper is devoted to an econometric analysis of commodity dependence. Even though it might be difficult to comprehensively model the causes of commodity dependence given its complexity, determining some of its correlates may provide potential entry points towards economic structural transformation and diversification.

4. Correlates of commodity dependence

Correlates of commodity dependence are identified using available data. Most particularly, given the specific interest in technology, this section estimates simple probit econometric models regressing commodity dependence on several indicators of technology, and other control variables.

4.1 Discussion of the variables

Five indicators of technology are used.[8] First, the share of a country's population using internet captures the deployment of Information and Communication Technologies (ICT) within an economy. Internet provides greater access to information, reduces labour costs, and allows far greater connectivity between people, firms, and other economic agents, ultimately leading to higher productivity.

The second variable is the speed of the internet. It captures the quality of ICT deployed in a country. Indeed, productivity improvements result from not only accessing the internet but also internet connections that work well and at speeds facilitating transactions without interruption. Internet creates so many opportunities that it is has become a vital economic resource in modern societies. Internet permeates economic and social life that it is now at the root of the digital divide (Aydin, 2021) between those who have access to it and those who do not.

Third, high-skill employment as a percentage of the working population is an indicator that measures the quality of human resources available in a country. Indeed, measures such as the employment-to-population ratio do not account for the fact that many jobs particularly in developing countries are low skilled and contribute little to export and economic structural transformation. High-skill employment, on the other hand, is associated with technological innovations that CDDCs might need to adopt to create new products and reduce their strong dependence on commodity exports.

[7] This is 8.27*23 transitions. The number of transitions covers the period from 1995 to 2018.
[8] Information on the technology indicators used here was compiled by our UNCTAD colleague Clovis Freire Junior; thanks to him for kindly sharing the data.

Fourth, the number of scientific publications on the frontier technologies (R&D publications) is considered as a good proxy of technological activities taking place within an economy. The higher the number, the more technologically advanced is an economy.

Fifth, high technology manufactures exports as a percentage share of total merchandise trade measures the share of technologically sophisticated goods that are exported by a country. Primary commodities being less sophisticated exports, moving out of the commodity dependence trap implies that CDDCs need to upgrade their productive systems to produce manufactured goods and services that are more sophisticated.

All five technology indicators show the capacity of a country to produce and export goods and services with a high technology content, unlike commodities that embed a low level of technology. Put differently, countries displaying high levels of technology indicators are not dependent on the commodity sector for their exports. Technology and innovation enable them to diversify exports into high-value goods and services that are less prone to negative shocks that afflict primary commodities. Therefore, improving technology and innovation in CDDCs is expected to help them diversify into high-value exports and increase as well as stabilize export earnings.

In addition to technology and innovation indicators, other control variables, all sourced from UNCTAD, are included as correlates of commodity dependence (Table 3).[9] These are the shares of fuels, minerals, and agriculture exports in total exports. These are expected to capture the fact that commodity dependence may be a function of the type of the major commodity exported by a country, as discussed earlier (see also UNCTAD, 2019b). High shares of energy and minerals in total merchandise exports tend to be associated with strong commodity dependence. In developing countries, energy and minerals sectors concentrate the bulk of investment, particularly foreign direct investment, translating in highly concentrated economic activity. Similarly, sectoral allocation of employment may potentially be related to commodity dependence if the best of a country's human resources is concentrated in the production of the export commodity. Another way of analyzing dependence is to probe the sectoral contribution to value-added in an economy. High value-added shares indicate the importance of a sector to an economy. For example, in CDDCs, value-added is generally generated in low-tech and low-skilled primary and services sectors, suggesting that exports will also tend to be low-skilled and low-tech, which is the case for commodities. Finally, a Least Developed Country (LDC) dummy variable is introduced to proxy for three dimensions of a country's level of development. This dummy captures a country's income level, its human assets, and its economic vulnerability.[10] The LDC status implies that a country faces development problems that may add to the negative effect of commodity dependence, making development even more challenging. Such countries require more attention than non-LDCs (Gore and Kozul-Wright, 2011). In this chapter, the variable LDC takes value 1 if a country is an LDC and zero otherwise.

There are two important facts to keep in mind when using information in Table 3. First, the variables representing shares of different types of commodities in total merchandise exports show mean values that are substantially different from medians, suggesting the presence of potential outliers. Nevertheless, for consistency, all variables expressed as shares are used without transformation. To check if outliers might have an important effect on econometric results, we ran models where the variables mentioned above were transformed in log. The results (not included) are qualitatively comparable to those of the variables in shares, but with smaller coefficients and standard errors.

The second fact relates to coverage of technology indicators. Technology variables cover only a few years, between 2015 and 2018, and slightly less countries. Hence, econometric models in Table 4 use only the latest few years of the sample for which data is available.[11] Despite this reduction in the sample size, there is no reason to consider that the relationship between technology and commodity dependence was different before the period 2015-2018. It is assumed that the period covered is representative of the full sample period. In any case, these indicators seem to reflect the

[9] A detailed discussion of many of these variables and why they matter for commodity dependence and economic structural transformation is found in Chapter 2.

[10] See https://unctad.org/press-material/ldc-what-least-developed-country. See also UNCTAD (2017). The Least Developed Countries Report: Transformational Energy Access. What are the least developed countries? (United Nations publication, Sales No. E.17.II.D.6, New York and Geneva), pp. v and vi.

[11] Some variables such as internet speed and R&D publications cover only two years.

expected relationship between commodity dependence and technological development, as shown by econometric results.

Table 3: Descriptive statistics of the variables included in the econometric model

Variable	Mean	Median	Observations
Dummy commodity dependence	0.52	1.00	4944
Share of fuels exports in total merchandise exports	0.17	0.05	4675
Share of minerals exports in total merchandise exports	0.08	0.02	4764
Share of agriculture exports in total merchandise exports	0.26	0.18	4770
Share of employment in industry	19.67	20.14	4392
Share of employment in services	50.42	52.02	4392
Share of value-added in agriculture	12.58	8.38	4378
Share of value-added in industry	26.60	24.81	4366
Share of value-added in services	53.25	53.56	4188
Dummy variable for LDC status	0.23	0.00	4944
Internet users (share of population)	0.52	0.55	474
Internet speed, Mbps (mean download speed)	0.50	0.46	316
High-skill employment (% working population)	0.39	0.37	474
R&D publications (# scientific publications on frontier technologies)	0.40	0.38	316
High-tech manufacturing (% total merchandise trade)	0.56	0.56	474

Source: Author based on data from the International Labour Organization, International Telecommunication Union and the UNCTADstat database.

4.2 Empirical results

To explore the relationship between technology and commodity dependence, a probit model of commodity dependence is estimated, using the technology and innovation indicators discussed above as correlates, and other control variables (Table 4). Considering the data limitations discussed above, the objective of the econometric analysis is to explore how technology and innovation correlate with commodity dependence, not to establish a causality relationship; this would require a more thorough analysis necessitating more data. Indeed, there could be different sources of endogeneity in the model that are not specifically discussed, which could potentially distort a causality analysis. Moreover, the limitations with respect to coverage of the technology variables does not allow a full-fledged panel data analysis that could help to address some of the potential econometric issues. Despite this, identifying what technological indicators are relevant correlates of commodity dependence would be useful enough to justify a deeper analysis of the relationship between commodity dependence and technology and innovation, the focus of the Commodities and Development Report 2021 entitled “Escaping from the commodity dependence trap through technology and innovation.”

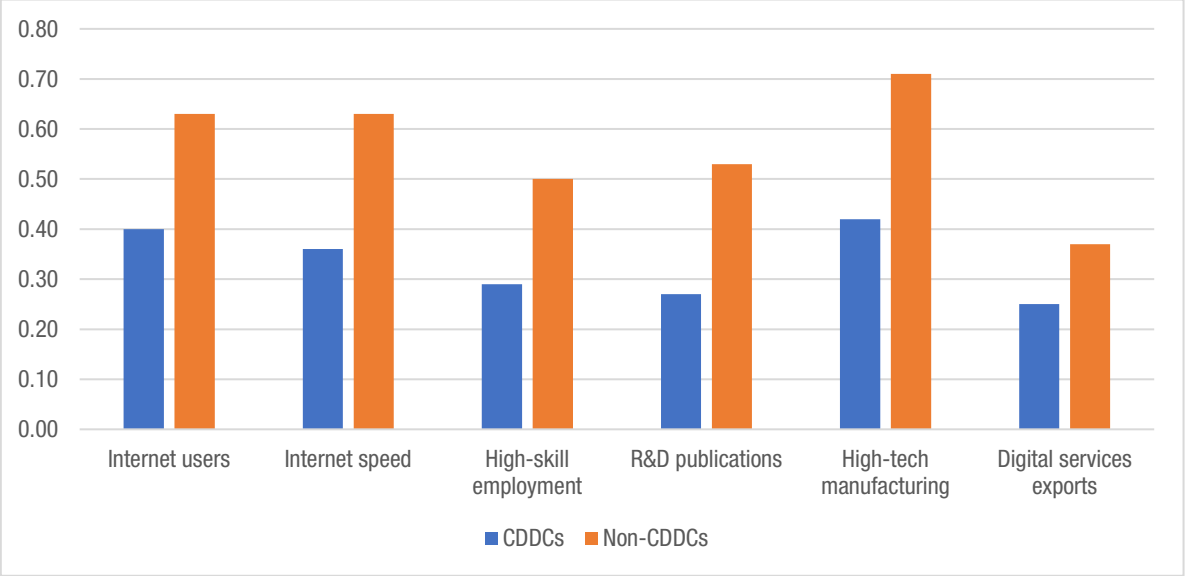
Econometric results summarized in table 4 suggest a number of interesting findings regarding commodity dependence and its correlates. First, coefficients of all the technology variables have negative signs and are highly significant. This suggests that the odds of commodity dependence are strongly associated with low levels of technology. In other words, countries with higher technological capabilities are less likely to be commodity dependent. Figure 3 below illustrates the strong and negative correlation between commodity dependence and the level of technological development.

Table 4: Results of a probit model of commodity dependence and technology

Technology indicators	Internet Use	Internet Speed	High-skill Employment	R&D Publications	High-tech Manufacturing
Internet users	-1.97***				
	[0.59]				
Internet speed		-6.47***			
		[1.09]			
High-skill employment			-2.78***		
			[0.69]		
R&D publications				-1.84***	
				[0.57]	
High-tech manufacturing					-3.83***
					[0.92]
Digital services exports					
Control variables					
Share of fuels exports	7.90***	9.15***	7.32***	7.17***	6.61***
	[0.87]	[1.45]	[0.86]	[1.27]	[0.91]
Share of minerals exports	10.32***	11.47***	9.39***	10.65***	10.42***
	[1.86]	[2.44]	[1.62]	[2.57]	[1.91]
Share of agriculture exports	5.50***	5.19***	4.69***	5.05***	4.57***
	[0.83]	[1.39]	[0.84]	[1.24]	[0.88]
Share employment in industry	-0.03**	-0.07***	-0.04***	-0.03*	-0.04***
	[0.10]	[0.02]	[0.01]	[0.02]	[0.01]
Share employment in services	0.03***	0.04***	0.04***	0.02	0.03***
	[0.1]	[0.01]	[0.01]	[0.01]	[0.01]
Share of value-added: industry	-0.01	-0.05**	-0.04**	-0.02	-0.02
	[0.1]	[0.02]	[0.01]	[0.02]	[0.02]
Share of value-added: services	-0.04**	-0.08***	-0.06***	-0.05**	-0.05***
	[0.02]	[0.02]	[0.02]	[0.02]	[0.02]
LDC dummy	1.30***	0.58	1.04***	0.97**	1.02***
	[0.38]	[0.45]	[0.33]	[0.44]	[0.36]
Constant	-1.03	4.61***	0.71	0.82	1.51
	[0.96]	[1.64]	[0.86]	[1.07]	[1.02]
Number of observations	456	294	446	294	446
Pseudo R2	0.74	0.79	0.73	0.72	0.74
Log Pseudolikelihood	-82.87	-42.88	-83.96	-55.89	-78.99

Note: Bracketed numbers are White (1980) robust standard errors. 3, 2, and 1 star, correspond to 1, 5 and 10 percent significance level, respectively. The shares of employment and value added in agriculture are excluded to prevent perfect multicollinearity.

Figure 3: Technology indicators in CDDCs and in non-CDDCs (variables as defined above)



Source: Author based on the data discussed in Table 3

If the results were to be interpreted as representing causality relationships, they would suggest that by strengthening their technological capabilities, commodity dependent countries may reduce their vulnerabilities associated with commodity dependence. Indeed, improving the technological ecosystem of commodity-dependent countries would create opportunities through increasing production outside the commodity sector. Weak technologial ecosystems in CDDCs explain why this group of countries has the least sophisticated and low-value product basket. Acquiring technological capabilities and adopting institutions that foster innovation and technological development would reduce CDDCs dependence on commodities and its deleterious effects on economic development.

Econometric results also show a systematically positive and statistically significant relationship between commodity dependence and export shares of the three types of commodites. All three positive signs suggest that commodity dependence is not limited to some type of commodity a country depends on. However, the fact that coefficients have unequal sizes, with the variable on agricultural exports having the lowest size and that on minerals exports having the largest, suggests that the odds of commodity dependence are not uniform across commodity types. In fact, the coefficient on minerals exports is about twice that on agriculture exports across all models. Therefore, even though the state of commodity dependence is associated with all three types of commodities, the correlation is strongest for countries dependent on exports of minerals. The implication might be that the issue of commodity dependence is more entrenched in minerals exporting countries and, to a great extent, fuels export-dependent countries. One explanation could be that extractives (monerals, ores and metals; and fuels) in CDDCs are generally enclave sectors dominated by foreign firms that have little incentive to create domestic linkages with non-commodity sectors (Hansen, 2013). As value addition to primary commodities takes place outside producing countries, they do not benefit from value creation and its attendant advantages, including income generation, job creation, and tax revenue, along the value chain.

The negative sign and statistical significance of the variable share of employment in industry in all models suggests that the development of the industrial sector would be a relevant way of addressing the commodity dependence issue. Indeed, industrial production, even when it uses commodities as inputs contributes to product and economic diversification. In contrast, the positive sign and statistical significance of the coefficients on the share of employment in the services sector suggests that moving labour to the services sector may reinforce commodity dependence.

Finally, the systematically positive sign and statistical significance of the LDC dummy in all but one model is an indication that LDCs are more affected by commodity dependence than other countries. If the relationship were to be interpreted as causal, that would mean that other things being equal, the odds of being commodity dependent are between 2.7 and

5.0 times higher for an LDC than for a non-LDC.[12] That is, the odds of being commodity dependent is 174 per cent to 400 per cent higher for an LDC. The positive sign and strong correlation between commodity dependence and the LDC dummy variable is an indication that commodity dependence is positively correlated with other vulnerabilities embedded in the LDC variable as discused above.

5. Conclusion

The main objective of this chapter was to document the level of commodity dependence and determine whether countries are trapped in a state of commodity dependence. The next step was to identify the correlates of commodity dependence in order to determine possible pathways out of the dependence trap.

Empirical analysis confirmed that commodity dependent countries are indeed trapped into the state of dependence. The probability that a strongly commodity-dependent and commodity-dependent country becomes non commodity dependent is low, as shown in Table 1. Moreover, the fact that the short-term distribution of countries in the three states is almost the same as the ergodic distribution suggests that the current distribution is an equilibrium. The implication is that only strong action will change the status quo. Otherwise, trapped countries might remain trapped for several centuries, as the examples of Zambia and Nigeria seem to indicate.

With respect to the results of the econometric model, the main message is that technology seems to potentially enable trapped countries to become non commodity dependent. However, this process of change appears particularly challenging for countries dependent on extractives. In this regard, fostering the development of a technology ecosystem in CDDCs that encourages production of more sophisticated goods would be a relevant policy action. Defeating commodity dependence will require that CDDCs put in place the right physical and institutional infrastructure that allows this technology ecosystem to thrive.

The message about the potential role technology can play in enabling commodity-dependent countries to escape from their dependence trap is key to the Commodities and Development Report 2021 for which this paper provides background analysis.

[12] These values are based on the smallest and the largest coefficients (models with R&D publications and Internet use, respectively). Given that the coefficients cannot be interpreted as elasticities, the values are obtained as $e^{coefficient}$, meaning $e^{1.01} \approx 2.74$ and $e^{1.62} \approx 5.05$.

References

Alexeev, M. and Conrad, R. 2011. "The natural resource curse and economic transition" *Economic Systems* 35 (4), 445-461

Aydin, M. 2021. "Does the digital divide matter? Factors and conditions that promote ICT literacy" *Telematics and Informatics*, Volume 58 (May). https://doi.org/10.1016/j.tele.2020.101536

Bahar, D., and Santos, M. A. 2018. "One more resource curse: Dutch disease and export concentration" Journal of Development Economics 132, 102-114.

Bulte, E., Damania, R., & Deacon, R. 2005. "Resource intensity, institutions, and development" World Development 33(7), 1029-1044

Carmignani, F., & Avom, D. 2010. "The social development effects of primary commodity export dependence". Ecological Economics, 70(2), 317-330.

Collier, Paul and Hoeffler, Anke. 2004. "Greed and grievance in civil war". *Oxford Economic Papers* 56, 563-595

Csordas, S. 2018. "Commodity exports and labour productivity in the long run" Applied Economics Letters 25(6), 362-365.

Gore, C. and Kozul-Wright, Z. 2011. "An overview of UNCTAD's Least Developed Countries Report 2010: Towards a New International Development Architecture for LDCs" *The European Journal of Development Research,* 23, 3–11

Hansen, M. W. 2013. From enclave to linkage economies? A review of the literature on linkages between extractive multinational corporations and local industry in Africa. DIIS Working Paper 2014:02. Copenhagen Business School.

Humphreys, Macartan, Sachs, Jeffrey and Stiglitz, Joseph. 2007. *Escaping the resource Curse*. New York, Columbia University Press.

Isham, J., Woolcock, M., Pritchett, L., and Busby, G. 2005. "The Varieties of Resource Experience: Natural Resource Export Structures and the Political Economy of Economic Growth" The World Bank Economic Review, 19(2), 141-174.

Kremer, M., Onatski, A. and Stock, J. 2001. "Searching for prosperity," *Carnegie-Rochester Conference Series on Public Policy*, 55, 275-303.

Lemaître, S. 2019. "Illicit financial flows within the extractive industries sector: a glance at how legal requirements can be manipulated and diverted" *Crime, Law and Social Change* 71, 107–128.

Nkurunziza, J. D. 2015. "The distribution of firm size in Africa's manufacturing sector and implications for industrial policy" *Journal of African Development,* 17 (2), 49-81.

Nkurunziza, J. D., Tsowou, K. and Cazzaniga, S. 2017. "Commodity dependence and human development." *African Development Review*, 29 (S1), 27-41

Robert, C. P., and G. Casella. 1999. Monte Carlo Statistical Methods. New York: Springer Verlag.

UNCTAD. 2019a. Commodities and Development Report 2019. *Commodity Dependence, Climate Change, and the Paris Agreement*. United Nations, Geneva.

UNCTAD. 2019b. Do Differences in the types of commodities exported matter for export concentration? Geneva. UNCTAD/DITC/COM/2019/4.

UNCTAD. 2018. Commodities At A Glance No. 10. *Special Issue on Coffee in East Africa*. United Nations. Geneva.

UNCTAD and FAO. 2017. Commodities and Development Report 2017. *Commodity Markets, Economic Growth and Development*. New York and Geneva.

UNCTAD. 2017. The Least Developed Countries Report: Transformational Energy Access. What are the least developed countries? United Nations publication, Sales No. E.17.II.D.6, New York and Geneva.

UNCTAD. 2016. Trade Misinvoicing in primary commodities in developing countries: the cases of Chile, Côte d'Ivoire, Nigeria, South Africa, and Zambia. United Nations. Geneva.

van der Ploeg, F., & Poelhekke, S. 2009. "Volatility and the natural resource curse" Oxford Economic Papers, 61(4), 727-760.

White, H. 1980. "A Heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity" *Econometrica*, 48, 817-838.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