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WIDER Working Paper 2017/12

Industries without smokestacks in Uganda and Rwanda

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January 2017

United Nations University World Institute for Development Economics Research
wider.unu.edu

Abstract: We use unique high-frequency Government of Uganda and Government of Rwanda tax administration datasets to map the characteristics of 'industries without smokestacks' in East Africa. First, we find firm size appears to be crucial for successful industries without smokestacks in services and agro-processing. Second, we find that firms do not need to be active in the external economy themselves to achieve high levels of productivity, but that strong links to external sector actors are more common among more productive firms. Third, all industries with high levels of labour productivity rely heavily on imported inputs, though this is more pronounced in the manufacturing sector. We then identify the role of cross-sector spillovers in economic performance. We find that all of the top ten most interconnected sectors of the economy are either in manufacturing or services. We show that growth in output and productivity in these sectors is a strong indicator of overall economic growth. Finally, we show that sales and employment spillovers from foreign direct investment are most likely to occur in the manufacturing sector.

Keywords: economic growth, industry, firm size, tax administration data, Uganda, Rwanda

Tables and Figures: all authors own work.

Acknowledgements: Many thanks to Richard Newfarmer, John Page, Finn Tarp, Phillip English as well as participants at UNU-WIDER Workshop in Helsinki for helpful comments and discussions. Thanks also to the tax authorities and IGC country offices in Rwanda and Uganda without whom this research would not have been possible. We acknowledge support from UNU-WIDER.

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This study has been prepared within the UNU-WIDER project on 'Industries without smokestacks', which is part of a larger research project on 'Jobs, poverty, and structural change in Africa'.

Information and requests: publications@wider.unu.edu

ISSN 1798-7237 ISBN 978-92-9256-236-6

Typescript prepared by the Authors.

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The Institute is funded through income from an endowment fund with additional contributions to its work programme from Denmark, Finland, Sweden, and the United Kingdom.

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1 Introduction

Consensus among many development economists and policy makers is that development of the manufacturing sector is requisite for wider economic development (Rodrik, 2016; Chang et al., 2016). However, in Africa the initial conditions for structural transformation driven by the manufacturing sector are largely absent (Newman et al., 2016), and after several decades of lack of growth of the sector, with government attempts of both protection and liberalization having largely failed to grow the nascent industries since the 1970s (Isaac et al., 2014; Söderbom and Kamarudeen, 2013), it is now time to reconsider.

This paper acknowledges that there are a new set of previously overlooked sectors with high potential for growth. These industries already exist in Sub-Saharan Africa in the service sector, agri-processing, and high value horticulture but have often been overlooked due to a lack of firm level data. But can these modern 'industries without smokestacks' really act as an engine of structural transformation in Africa? The purpose of this paper is to contribute to answer this question by exploiting a unique and novel firm-level dataset for Rwanda and Uganda.

Both Uganda and Rwanda can look back at two decades of successful export growth and diversification. While unprocessed commodities (mainly coffee and tea) and mineral exports (in the case of Rwanda) still dominate the export portfolio, the importance of resource-based value addition products, as well as services, has grown substantially in both countries. As shown in Figure 1, services now make up more than 40% of exports, compared to less than 25% twenty years ago. The regional integration of markets in the EAC, but also the two governments trade-friendly policies, have fuelled this structural transformation and borne fruit as exports have grown from 5% to 15% of GDP in the case of Rwanda, and from 12% to 20% of GDP in the case of Uganda over the past twenty years. Behind this stand a high number of new export entrepreneurs in both countries, supported by a growth of annual FDI inflows from 0.2% of GDP in Rwanda and 2% of GDP in Uganda in 1995 to 3.7% of GDP in 2014 in Rwanda and 4.2% of GDP in Uganda in 2014.

Figure 2 shows aggregate export volumes over the period 2005-2014 using Customs data. Both countries have seen year on year rapid growth in their exports. Exports to the East

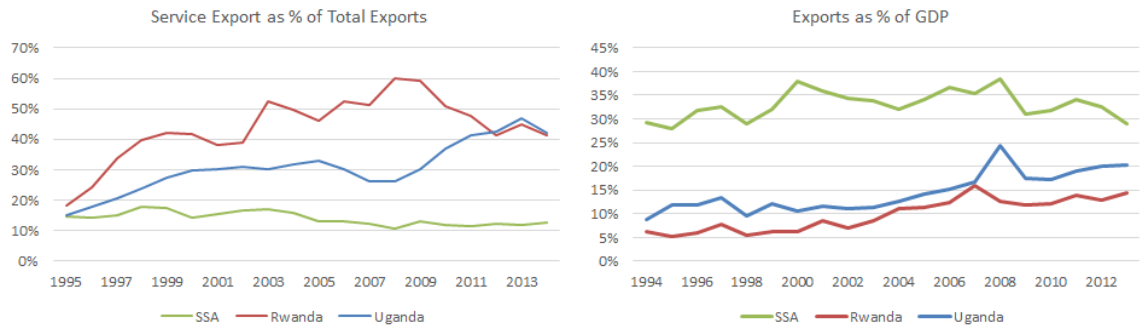

Figure 1: Rwandan and Ugandan goods and service export
Source: World Bank World Development Indicators, 2016

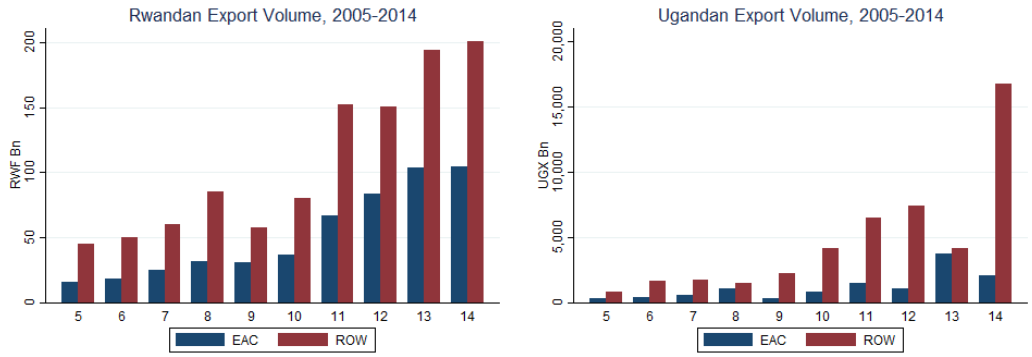

Figure 2: Rwandan and Ugandan export performance, EAC vs. rest of the world
Source: Ugandan and Rwandan Revenue Authorities

African Community (EAC) has made up a roughly constant share of total exports over this time in both countries, despite the deepining in intergration in EAC trade policy, illustrating that export growth has not led to an overreliance on regional markets.

Despite relatively strong export performance in both countries, pressures to grow exports to drive growth persist. The current account deficit averaged 8.5% of GDP over the last five years in Uganda and 9.5% of GDP in Rwanda (World Bank, 2016). But this seemingly difficult situation also offers opportunities. Commodity prices are at historic lows, and thus incentives to move away from dependence on unprocessed commodities for export earnings are greater than ever. What can Uganda and Rwanda do to build on first successes in the creation of service- heavy industries without smokestacks? To answer this question, a thorough understanding of firm experiences and the Ugandan and Rwandan export market is

a crucial pre-requisite. In this paper we use a unique dataset built from tax administration data from the Uganda Revenue Authority (URA) and the Rwanda Revenue Authority (RRA) to contribute to the filling of this gap.

Our dataset is unique in that it covers the full population of formal sector firms on a monthly basis and holds information on their characteristics, their business networks and behaviour that allow to study different industries at the micro level and compare their development over time, features that no survey dataset holds at a similar level of detail. We utilize the dataset to explore two directions of structural transformation: within sector productivity growth and the potential for across sector productivity spillover. First we study the distribution of labour productivity, firm size, participation in and connectedness to the external sector in order to uncover patterns across sectors and industries that allow us to understand what characterises high-productivity firms that could drive within-sector expansion. Second, we study across-firm spillovers for the different sectors, and to this end use the Ugandan data to analyze the number of connections firms have in the economy and explore correlations of output and productivity growth as a function of network distance. We then use the Rwandan data to study Foreign Direct Investment (FDI) as a second channel for across-firm learning.

Our results distill three main characteristics of high-productivity firms that have the potential to drive within-sector growth. First, we find that similar to their importance in the traditional manufacturing industries, firm size also appears to be of crucial importance for successful industries without smokestacks in services and agri-processing. Secondly, we find that firms do not need to be active in the external economy themselves to achieve high levels of productivity, but that strong links to external sector actors are more common than among less productive firms. Thirdly, all industries with high levels of labour producivity rely relatively heavily on imported inputs, though this is more pronounced in the manufacturing sector. This finding not only re-emphasizes the importance of a liberal trade regime to raise firm productivity, it also points to windows of opportunities for domestic companies that can aspire to substitute these inputs.

We find that service sectors make up six of the top ten most interconnected sectors of the economy in Uganda and five in Rwanda suggesting that services are vital to knitting the

economy together. We show that productivity growth in these sectors is strongly associated with the performance of the whole economy. Furthermore, we study the entry of FDI and its effect on firms with forward and backward linkages to these investments and find that FDI affects sales of firms supplying FDI firms positively across sectors, but only find a significant effect for the manufacturing sector.

The paper is structured in five main sections. The second section reviews the fundamentals of the dataset, and provides a description of the median and mean firm in the dataset, across sectors. The third section looks more closely at the distinctive features of industries without smokestacks, and gauges the potential for further within-sector expansion. The fourth section analyzes the potential of sector and firm-level spillover effects. The fifth section concludes.

2 The data

We use transactional level data from the Value-Added Tax (VAT), Pay-As-You-Earn[1] (PAYE) and Customs declarations submitted to tax authorities to study industries without smokestacks at the firm level in Uganda and Rwanda. The data covers the period 2010-2014/15, and covers the full population of formal enterprises in the economy.

We use the VAT declarations to extract information about firms' input and output use, as well as their supplier and client network. The data is unique in detail and goes much beyond the survey firm-level datasets available. One especially useful feature of the data is that sales transactions as declared in the VAT forms are listed including the tax identification number of the client, which allows us to map out networks of companies that do business with each other. We can then exploit the other datasets to supplement the network structure we have drawn up with details on firms' staffing (from PAYE), total output and input (from VAT) and the relationship with the external sector (from Customs).

The datasets cover only formal firms that report to the tax authorities. This is an acceptable limitation for our study, since we are interested in the type of high-productivity firms that interact with the external sector and are more likely to be formal. Because it is

[1]Pay-As-You-Earn is Personal Income Tax withheld by the employer.

more difficult to avoid customs duty than domestic tax, the coverage of the external sector of the economy in the dataset is much better than that of the domestic sector. As Table 1 shows, from the Ugandan dataset we learn that a total of 82,468 firms have reported exports or imports at some point over the five year period under study, while only 21,997 have reported VAT.[2] Some firms report VAT only at the aggregate level, so the VAT-part of the dataset contains transactional level information only for 12,148 firms in Uganda. The picture is similar with the Rwandan data. A further caveat to be noted is that part of the service sector trade, particularly professional services trade, is not recorded at border-crossings and is thus not represented in the datasets.

Table 1: The datasets cover three different tax heads

Name	Description	# of unique TIN		frequency
		Uganda	Rwanda	
Pay as you earn	# of workers and wages	15,738	21,210	monthly
Value Added Tax	Sales and purchases	21,997	33,576	monthly
Value Added Tax	- at transaction level	12,148	22,803	monthly
Customs	Cross-border transactions	82,468	41,631	continuous

All information in the declarations is self-reported and only in a subset of cases verified by audits, with the exception of customs where verification occurs more frequently. A recent IMF report estimated that the URA collects only 60% of the potential VAT (Hutton et al., 2014), and we expect similarly large compliance gaps in other tax heads and in Rwanda.[3] The report finds the highest level of tax avoidance in the service sector, particularly construction, hotels and restaurants, wholesale and retail trade. We therefore expect that our estimates of output, input and wages are biased downwards particularly for the service sector, although we do not anticipate this to alter results substantially. The next two subsections provide some descriptive statistics from both datasets.

[2]The Customs dataset also includes private individuals that export or import on a non-commercial basis. At least a fraction of the difference in numbers of taxpayers between VAT and Customs can be attributed to this.

[3]The compliance gap can be broken down into the collections gap, the amount assessed but not paid, and the assessment gap, the amount due but not declared. Our results are not impacted by the collections gap, but they are impacted by the assessment gap. Unfortunately, there are no estimates which fraction of the 60% compliance gap can be attributed to the assessment and collections gap, so we cannot accurately estimate the size of the bias introduced.

2.1 Description of the datasets

After cleaning, the Ugandan dataset contains information submitted by 100,428 firms over the period 2010 to 2015, and the Rwandan dataset contains information submitted by 65,193 firms submitted from 2009 to 2014. The numbers of actively declaring firms per year are lower, because some firms do not declare taxes for all tax heads, enter or exit the dataset, or do not submit returns on a monthly basis. In 2010 the datasets contained 29,274 and 18,714 actively declaring firms in Uganda and Rwanda, respectively. These numbers have since risen to 41,578 and 32,330 in 2014. The time period coincides with the move to electronic declaration systems for domestic taxes (2009 in Uganda, 2012 in Rwanda), which decreased tax reporting transaction costs for firms and helped the tax authorities expand the tax base.

In this study we use International Standard Industry Classification (ISIC)[4] codes to classify industries in five categories: agriculture, manufacturing, mining, 'other' and services. The standard ISIC at the most aggregate level groups agriculture, manufacturing and mining industries into single sectors, but splits the service sector into 16, which we combine into one sector for the purpose of this study. The 'other' sector includes two subsectors that do not count towards the private economy: extraterritorial organizations and public administration.

The service sector is the biggest in terms of number of firms covered, making up 80-93% of all declaring firms in the different datasets. This figure by itself does not accurately represent the sector's share of the economy; the mean service sector firm is considerably smaller both in terms of employees and output than firms in the other sectors. The manufacturing sector has the second highest number of firms in both datasets, making up 9-13% of firms in the Ugandan datasets and 4-9% of firms in the Rwandan datasets. The agriculture sector has approximately twice as many firms as the mining sector in all datasets, making up fractions of 1-3% of the datasets. Overall, the distribution of industries in our datasets is very close to the distribution of business as established by the Ugandan Bureau of Statistics in the 2010/11 Census of Business Establishments (COBE) and the 2014 Establishment

[4]International Standard Industrial Classification of economic activities (ISIC) is the standard classification unit used in the data. We use four digit sectors which yields disaggregated detail.

Census (EC) produced by the National Institute of Statistics of Rwanda, as shown in the last two columns of Table 2.

Table 2: Distribution of firms across industries in %, by dataset

	VAT		VATsales[5]		PAYE		ASYCUDA		Bus. Census	
	UGA	RWA	UGA	RWA	UGA	RWA	UGA	RWA	UGA	RWA
Agriculture	1.42	2.04	1.04	2.16	2.05	2.84	2.92	1.64	1.8	0.49
Manufacturing	9.27	4.27	12.72	3.94	11.30	5.12	12.99	8.64	6.9	6.96
Mining	0.52	0.84	0.6	1.09	0.72	1.2	0.66	1.11	0.2	0.18
Other	3.04	0.3	1.29	0.25	6.38	0.47	1.03	0.14	-	0.07
Services	85.76	92.55	84.35	92.57	79.54	90.36	82.39	88.46	91.1	92.3

While the datasets hold a wide array of variables, we focus our analysis on a sub-set of key variables for which we have enough observations to exploit overlap between the different datasources. More importantly, our analysis relies as much on the numerical variables as on the categorical variables and the connections between firms implied by transactions in the VAT declarations. Table 3 provides descriptive statistics for the main variables we use. The statistics are calculated after averaging values for each firm over each year so as to normalize the differing reporting patterns across firms and tax heads (Customs is reported on a continuous basis, VAT on a monthly and transaction basis), reduce variance stemming from seasonality and allow easy comparison of the numbers of observations. The variables were also winsorized[6] at the 5th and 95th percentile to reduce outliers stemming from errors in the database, such as missed or extra zeros, a common problem particularly in currency environments where the smallest notes are 1000 (Uganda) or 100 (Rwanda). All figures are presented in USD 2015 levels, unless stated otherwise.

Comparing firms across the two countries, Table 3 seems to show clearly that Ugandan firms are larger in terms of employees, output produced, inputs used, as well as export and import transaction volumes. But while it appears plausible that the larger economy features larger firms on average, we do not want to place too much weight on comparisons of absolute values across the two countries in our study. Using tax datasets, cross-country

[5]As previously noted the VAT dataset does not hold transaction level details for all returns, and thus the distribution of firms differs slightly when considering transaction rather than aggregate level VAT figures.

[6]Winsorizing does not discard any observations, rather it reduces extreme values in the distribution to the level of the specified cutoff percentile.

Table 3: Descriptive statistics for main variables used, in 2015 USD

Variable	Source	Obs	Year Mean	Std. Dev.	Median
Uganda					
Employees	PAYE	514,349	20	41	6
Wages	PAYE	514,349	1,452	1,591	830
Output	VAT	704,184	50,811	424,860	2,155
Input	VAT	704,184	26,322	232,351	914
Export	Customs	24,965	118,533	1,436,703	6,157
Import	Customs	342,459	27,087	278,316	3,425
Rwanda					
Employees	PAYE	571,877	15	40	3
Wages	PAYE	571,879	2,502	4,906	655
Output	VAT	364,270	28,219	128,261	1,998
Input	VAT	364,286	11,209	45,504	378
Export	Customs	18,541	39,192	209,343	1,903
Import	Customs	255,451	12,524	94,962	1,927

comparisons of absolute values are likely to be less acurate than within-country comparisons. This is because reporting regimes and tax enforcement among countries differ and might bias such comparisons, even when considering relatively similar and harmonised tax systems as Uganda's and Rwanda's.[7] When we draw cross-country comparisons, we therefore place more weight on relative values.

2.2 The median and mean firm across sectors

In this subsection we describe the median and mean firm across sectors, referring to figures presented in Table 4 and Table 9 in the Annex. Across sectors we confirm that variable distributions are fairly strongly skewed to the right, meaning that mean values are considerably larger than median values, and that there is a large number of small firms and a relatively small number of large firms.

Firms differs substantially across sectors and across the two countires in terms of size and transaction volumes. In Uganda, the largest firms in terms of employees are in the agricultural sector, with a median of 14 employees. This might sound surprising, given that most farming in Uganda is done by subsistence farmers that usually have no formal

[7] see Petersen (2010) for a comparison of the two tax systems.

employees and are not part of the formal economy. However, the agricultural firms that are part of this dataset can not be seen to represent the average farming business in the country, rather they represent the formal end of this largely informal value chain, including larger agro-processing firms. As such, the median output of agricultural firms in this dataset is much higher than that of the median Ugandan farmer. In fact, the median formal agricultural firm in the Ugandan dataset has the second highest output of all five sectors.

Table 4: Median firm by sector and variable, in 2015 USD[8].

Source:	PAYE		VAT		Customs	
	Employees	AvWage	Output	Input	Export	Import
Uganda	# of					
Agriculture	14	102	3,225	995	58,658	7,627
Manufacturing	12	88	5,030	3,602	15,566	22,441
Mining	8	132	1,229	2,187	11,875	17,477
Other	2	287	207	0	675	20,152
Services	6	121	2,163	947	5,047	7,743
Rwanda	# of					
Agriculture	4	104	1,445	0	205,366	9,038
Manufacturing	7	116	5,448	1,734	10,248	15,999
Mining	18	96	5,966	0	391,959	11,669
Other	24	172	5,176	895	4,607	3,693
Services	3	119	2,998	839	2,328	6,079

In Rwanda in contrast the largest firms in terms of employees are in the 'other' and mining sector, both sectors that also have high levels of median output. The median firm in the manufacturing sector in Rwanda has less employees, but in terms of output it is at the same level as the median mining firm. Nonetheless, the structure of the mining and manufacturing industries in Rwanda are quite distinct. Median and mean output in manufacturing lie much closer together than in mining, which illustrates the fact that the bulk of output in the mining sector in Rwanda is produced by a few large firms, whereas the manufacturing sector output is produced by a larger number of smaller, more homogeneous

[8]Note that the discussion in this section is based on the median of firms of non-missing observations of the variable under discussion, i.e. the median export is the median export of exporters, rather than the median export of all firms in the dataset. Since only a fraction of firms exports the median of all firms would be zero. Please see Table 9 for mean values by sector.

firms.

In the manufacturing sector in Uganda we find an industry structure very similar to the structure of the mining industry in Rwanda; a number of high volume manufacturers in Uganda pushes the mean output quite far away from the median manufacturer's output. The median manufacturing firm in Uganda has monthly output of USD 5,030, while the mean firm produces USD 214,565 per month. The manufacturing sector in Rwanda in comparison is much smaller (less than half the share of firms in the economy) and has smaller firms. The mean firm output there is only 30% of the value in Uganda.

Heterogeneity between firms and industries is most pronounced in export and import relations. In Uganda, the median exporter in the agricultural sector exports more than 7 times as much as the median importer in the sector imports. In Rwanda it is more than 22 times as much. This reflects the importance of the agricultural sector as a balancing weight for the otherwise weak external sector balance, particularly in Uganda - in no other sector does the median exporter export more than the median importer imports in this country. In Rwanda, exports are also strong in the mining sector, where the median exporter exports more than 33 times as much as the median importer imports. These imbalances also highlight the manufacturing sector's strong reliance on imports, which are crucial for the sectors' productivity and in turn the economy's sectoral diversity in both countries. A similar though less extreme relationship emerges when considering mean values, which again stems from the fact that on average exporters in both countries export larger volumes than importers import.

On average, only the agriculture sector has a positive external balance. Even so, service sector export statistics need to be read with caution. Professional services trade is starkly underrepresented in the customs datasets, because most service trade does not flow through customs. This limits the datasets' utility when comparing service sector trade with trade in goods and is one reason why in our analysis going forward we also place weight on analyzing firms that supply the external sector rather than solely firms that are active participants in the external sector themselves.

3 What does an industry without smokestacks look like in Uganda and Rwanda?

In this study we are interested in high-productivity sectors that have the potential to modernize the Ugandan and Rwandan economies, both through sector-level growth and economy-wide spillovers. Traditionally, only the manufacturing sector has been credited to have the potential to increase both sector level and economy-wide productivity. More recently there has been a shift of the mainstream focus towards non-traditional industries that can play a lead role in structural transformation, in recognition of the fact that many African countries do not feature the initial conditions necessary to become competitive in manufacturing, and in realization that new global opportunities have evolved in services trade and the participation in global value chains. These industries are called 'industries without smokestacks' as in the project that this paper contributes to, and it includes most prominently agro-processing, Information Technology (IT), transport and tourism. This section focuses on the first way these industries can lead to structural transformation: through sector-level growth. To identify industries that have growth potential, this subsection studies several important ingredients first at the sector and then at the industry level: labour productivity, connection to the external sector and direct participation in the external sector.

3.1 Sector level analysis

Table 5 presents sector level averages of labour productivity, connection to and participation in the external sector. Average labour productivity in Uganda is highest in the agricultural sector; almost 33% higher than in the manufacturing sector and 58% higher than in the services sector. In Rwanda the picture is different, here labour productivity is highest in mining, where it is 60% higher than in services and twice as high as in agriculture.

This difference in sectoral productivities between Uganda and Rwanda is especially interesting as it supports pre-existing anecdotal evidence on the respective countries comparative advantages and target sectors; industrial policy in Uganda has focused heavily on agricultural value chains such as maize and sugar, while Rwanda has focused on high value

services such as tourism (Daly et al., 2016).

It is important to note that particularly for the mining sector we expect that the labour productivity values presented here are biased upwards by the high capital intensity characteristic of this sector.[9]

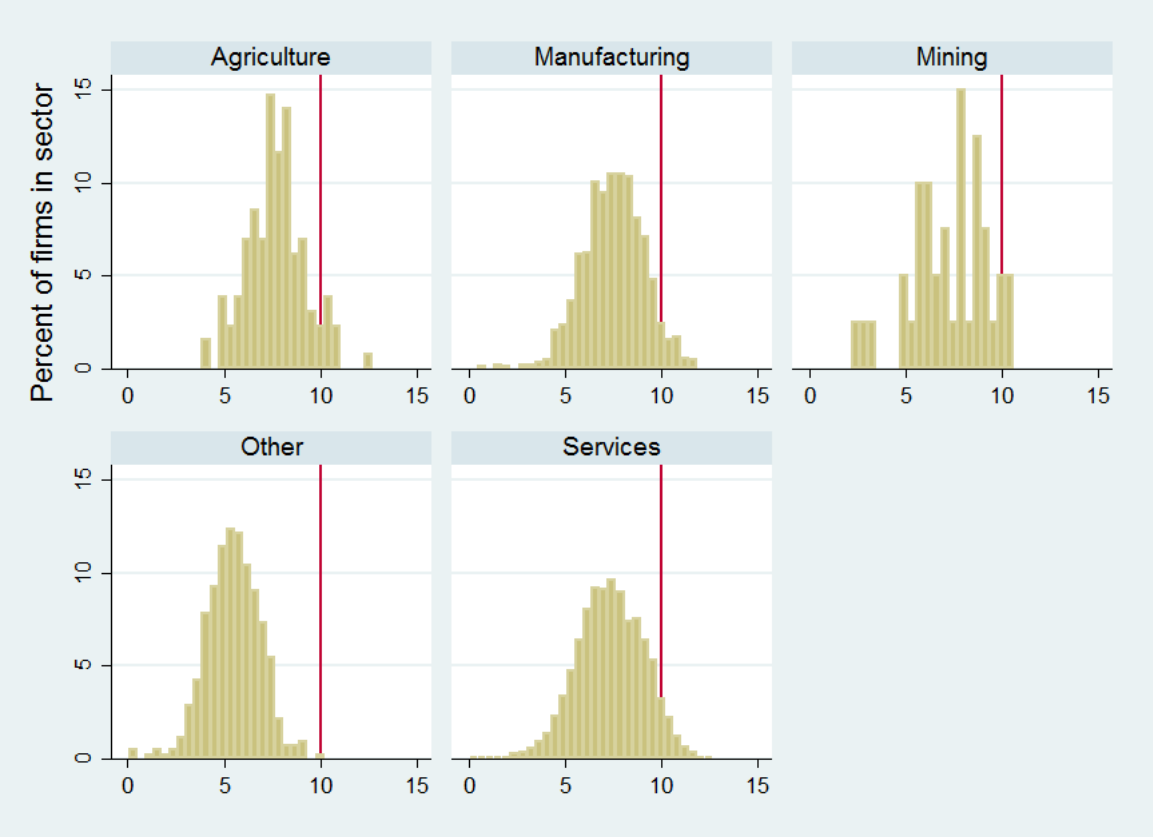

Figure 3: Histograms of output/worker across industries in Uganda, logarithmic scale of USD

Figure 3 shows the distribution of firms by labour productivity for Uganda and Figure 13 in the Annex shows the same for Rwanda. Similar to the distribution of firm size and transaction volume, across sectors labour productivity is considerably skewed to the right meaning that there are lots of unproductive firms clustered at the lower end of the distribution, and relatively few high-productivity firms on the other end[10]. The red vertical

[9]See Isaac and Othieno (2011), Hausmann et al. (2014) and Hausmann and Chauvin (2015) for analysis of Uganda and Rwanda's revealed comparative advantages, and opportunities for diversification.

[10]For legibility's sake the scale is logarithmic; otherwise cross-sector comparisons would be difficult. This means that an apparent normally distributed variable is actually considerably skewed to the right in absolute values.

line indicates outliers that have output/worker larger than USD 22,000. They make up about 5% of firms in Uganda, and are found particularly in the agriculture, manufacturing and services sectors. In Rwanda, the 95th percentile in the distribution of firms in terms of labour productivity starts at approx. USD 40,000, and includes also firms from the mining sector. These high-productivity firms are the firms we are most strongly interested in in this study, and whose characteristics we will compare and analyze across industries in the next subsection.

Table 5: Labor productivity, connection to and participation in the external sector

	Av(Output/ Worker)[11]	Export/ Import[12]	% are exporter	% export to EAC	% export to OECD	% supply exporter
Uganda						
Agriculture	10,802	2.46	0.21	0.08	0.13	0.10
Manufacturing	8,125	0.15	0.17	0.11	0.04	0.29
Mining	6,128	0.14	0.18	0.05	0.10	0.25
Other	569	0.02	0.03	0.00	0.02	0.04
Services	6,856	0.29	0.03	0.01	0.01	0.14
Rwanda						
Agriculture	8,166	3.20	0.12	0.06	0.08	0.02
Manufacturing	5,729	0.11	0.15	0.10	0.02	0.14
Mining	16,080	16.76	0.21	0.02	0.13	0.07
Other	942	0.05	0.05	0.02	0.00	0.02
Services	9,855	0.16	0.05	0.02	0.01	0.09

3.2 ISIC-level industry analysis

Table 10 and 11 in the Annex rank industries for both countries at the four digit ISIC level by labour productivity and report the top 30 ranks.[13] 17 out of the top 30 industries in Uganda, and 21 out of the top 30 in Rwanda are service industries. This clearly shows the vital importance of the service sector in raising productivity in the economy. In both Uganda (9 of top 30) and Rwanda (4 of top 30) traditional manufacturing still represents a high productivity sector. However, in Uganda three and in Rwanda one agricultural

[12]Output per worker is calculated on the yearly firm-level average, then averaged at the industry level.

[12]Export/ Imports is calculated by summing all exports in an industry and dividing by the sum of imports in the industry.

[13]For brevity reasons, we only focus on the top 30 sectors. We acknowledge that this is somewhat arbitrary and may miss some important sectors but believe this is necessary to keep the analysis succinct

industry broadly classified as agri-business have joined the high-productivity group.

3.2.1 Agriculture

Three agriculture industries in Uganda are among the top ten most productive industries in the economy in terms of labour productivity: Marine aquaculture, post-harvest crop activities, and marine fishing. All three are complex value chains that are service-heavy and produce products that are of comparatively high value-added. Neither industry features more than 15 companies, and on average the number of workers per company ranges between 22 and 103, so the industries are not very big and their employment creation impact as of now is limited. However, all three industries pay wages well above the sector average, suggesting that these industries could have positive skills-spillovers to connected industries. The industries dealing with aquaculture and fishing are on average larger in terms of output than in post-harvesting, yet all have higher output than the sector average, emphasizing the importance of scale. The proportion of firms in these industries that export directly is high, ranging from 27 to 67%, accounting for 35 to 65% of output. Most of their exports go to OECD markets, suggesting that firms in these industries manage to meet rigorous phyto-sanitary standards, an essential skill that other agri-business industries in both countries are still lacking. In Rwanda, the only agriculture industry that joined the top 30 industries with highest labour productivity is animal production. With 70 firms and an average of 168 workers the industry is relatively large, but mean output at USD 24,983 is lower than sector average. The industry's external sector connection is at sector average level. It appears that while the high-productivity industries of Ugandan agri-business have managed to join global value chains, Rwandan agri-business is still serving mainly the domestic market with the exception of coffee and tea. Regional value chain integration with high-productivity industries in Uganda could serve as a stepping stone towards joining global value chains.

3.2.2 Mining

The larger number of mining firms in Rwanda are small and informal, using artisanal mining methods. Unfortunately, our data only allows us to observe the formal side of this important sector, which is made up of large-scale firms that use modern techniques, have

access to capital and are highly productive.

Two of the top five most productive industries in Rwanda are in the mining sector, and these two industries make up 72% of the observations in the mining sector. Mining of metal ores is characterised by high labour productivity, high wages, and exports to the OECD. While integrated in a global value chain, the industry as a whole is still very small. The larger of the two is 'Other mining and quarrying' which includes quarrying of stones, sand, clay, mining of chemical and fertilizer mineral, extraction of peat and salt, as well as further unclassified mining and quarrying. Firms in this industry are large, with an average of 52 employees and USD 212,198 output, but the pay is lower than the economy-wide average, which shows that this sector relies heavily on productivity gains from capital equipment, rather than high-skilled labour. 16% of all companies in the industry are direct exporters, and 7% export to OECD economies. Clearly there is scope for within-industry learning to expand the percentage of directly exporting firms, and to increase the number of firms linked to OECD economies where higher value-added exports are demanded than in non-OECD markets. A market opportunity lies in the construction industry, which currently relies on a high percentage of imported construction materials that could be produced using raw materials from the domestic mining industry, especially given Rwanda's extraordinarily high transport costs, the heavy nature of construction materials, and the level of protection offered by the EAC Common External Tariff.

3.2.3 Manufacturing

The manufacturing industries that feature in the top 30 ranking of labour productivity in Uganda are, in decreasing order, producing building material such as cement, agricultural inputs such as fertilizers, beverages, plastic goods, pharmaceuticals, fats and oils, leather goods, as well as pumps. None of them features more than 25 companies, and the average number of workers reaches up to 80, bracketing the sector average of 38. The proportion of firms that is directly involved in the export market is considerably higher than in the rest of the sector; with the exception of one outlier all industries feature a share of at least 32% active exporters. Some industries have managed to penetrate the OECD market, testimony to their mastering of minimum standard requirements. Particularly notable in

this regard is the tanning and dressing of leather and fur products industry, in which five out of nine companies export to the OECD. Five out of nine companies also supply exporters. However, when considering volume of exports, it appears that most of the industries, except for the leather and fur industry, sell by far the biggest share of their output on the domestic market, while relying relatively heavily on imported inputs, even in comparison with sector averages. This shows that the value-addition potential differs relatively strongly among these industries, and that the fraction of firms that achieve high value addition is small. Given its success on the external market and relatively low reliance on imported inputs, the leather and fur industry can be singled out as a very promising infant industry to deserve closer attention by policy makers. While the cement industry has the highest labour productivity in the sector, we cannot proclaim it as the productivity miracle that it appears to be. Since it is a highly capital intensive industry, the high labour productivity value proxies the effect for capital, as well as the high degree of protection enjoyed, which gives companies in this industry market power and disincentive to become competitive globally (see Dihel et al. (2013) for more details on the cement industry in the EAC).

In Rwanda only three manufacturing industries made it into the top 30 ranking of labour productivity. In decreasing order they are manufacture of tobacco products, non-classified manufacturing, and manufacture of communication equipment. While the tobacco product industry is small in size, it has very high average output, and sells products both domestically, in the EAC and to the OECD market. Wages in this industry are high, which suggests a high degree of automation and the use of skilled labour to run machines, logistics and related high value added activities. However, the industry relies relatively strongly on imported inputs; its output is only 180% of its import. There might be a case to work with the companies in the industry and find ways of import substitution, which could also trigger cross-industry and cross-sectoral learning. The manufacture of communication equipment industry offers a different story. The industry does not seem to be adding much value in-country, having a high import/output ratio, and given its companies' very small sizes in terms of employees. Rather, the industry profits from Rwanda's location as a hub for re-exports to Burundi and Democratic Republic of the Congo (DRC). This emphasizes the importance of transport and logistics services in Rwanda.

3.2.4 Services

Service sector firms make up most of the top 30 industries in both countries. We find that these are in general made up of a large number of relatively small companies. Wages are mostly lower than in the top 30 agriculture and manufacturing industrires, with the exception of telecommunications, wholesale, air transport, specialized construction, holding companies and electricity services in Uganda, and other retail, reservation services, leasing of personal and household goods in Rwanda. None of the industries has an average staff number higher than 48 employees, which is on average considerably smaller than in the manufacturing and agriculture businesses in the top 30 (at least in Uganda), yet bigger than the sector average. The proportion of firms dealing directly in the external sector (at least as per the customs declarations)[14] are small and so are average export volumes, but the proportion of firms acting as direct supplier to exporters is higher than the sector average. Professional services play an important role in Uganda, with medical practices, holding companies and ICT featuring prominently.[15] In Rwanda, it is travel agency and tour operator activities, inland water transport and other reservation service and related activities that are to be singled out. They are the industries with the highest average wages in the sector, and examples for Rwanda's recent success in stimulating the travel and tourism market in the country.

3.2.5 Main results of ISIC-level industry analysis

Three main important patterns emerge from this analysis. Firstly, industries with high labour productivity feature on average larger firms in terms of output than the sector average. This suggests that scale is not only important in the manufacturing sector, but also 'industries without smokestacks' such as agri-business and the service sector. Secondly, highly productive firms do not need to be exporters, but they are connected to the external sector as suppliers more often than not. This is consistent with the notion that external sector firms require firms in their supply chain to be competitive enough to compete with

[14] Most service sector exports are not covered in customs declarations.

[15] See also Dihel et al. (2010) for a review of the state of professional services in the EAC and their role as pivotal inputs in other sectors.

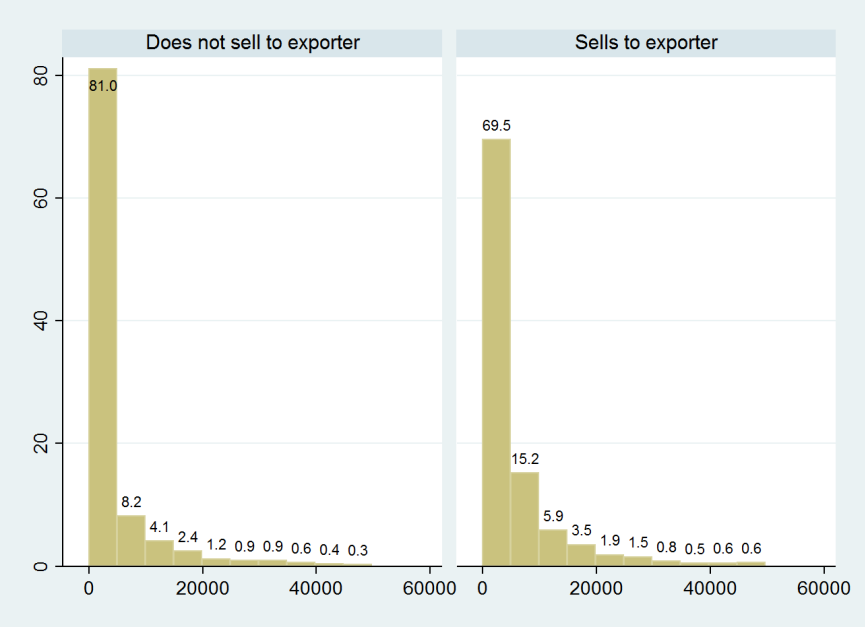

Figure 4: Output per workerin Uganda in 2015 USD, firms selling to exporters vs rest, trimmed at 50,000 for legibility.

other regional or global supply chains, and it is true for all sectors that made it into the top 30. Figure 4 nicely illustrates this using the economy-wide sample for Uganda.[16] Thirdly, all industries with high levels of labour producivity rely on imported inputs. This is particularly noticeable in the manufacturing sector and it highlights the importance of a liberal trade regime to raise firm productivity, but it also points to windows of opportunities for domestic companies that can aspire to substitute these inputs. It also suggests a positive impact of industries without smokestacks in improving external sector balance, at least relative to the manufacturing industry.

Considerable skills development will be required if domestic firms are to substitute the inputs that are essential in making the top 30 industries as productive as they are. This is closely related to section 4, which looks at the role of industries without smokestacks as important hubs in the economy that allow knowledge and productivity to spill from industry to industry and firm to firm. First, we briefly discuss the role of the Common External Tariff (CET) and the sensitive item list for industries in the top 30.

[16]Figure 13 in the Annex also shows that exporters also on average more productive than non-exporters.

3.3 High productivity industries and protection from international competition

Several of the industries that are part of the top 30 industries in terms of labour productivity benefit from the structure of the EAC CET and placement of their products on the sensitive item list. The CET groups products in three main bands: raw materials, intermediate inputs and finished products, with tariffs of 0%, 10% and 25% respectively, a structure designed to incentivise value-addition within the EAC. Given the reliance of the high-productivity industries on imported inputs highlighted in the previous subsection, it is eminent that the classification of goods into raw, intermediate and final is a crucial determinant of industries' productivity potential; misclassification can turn a measure intended to protect value-addition industries into a barrier hindering the industry to become productive.

Several industries enjoy tariff protection additional to the CET. At least two industries that feature in the top 30 most productive industries in terms of output per worker produce products that are part of the sensitive item list, which allows member countries to levy tariffs higher than the standard CET rates. The first is cement, which is protected by tariffs up to 55%. Given this high rate of protection, the small number of EAC companies active in this market and the high transport costs that obstruct full market integration, a negative side effect of the protective measure is that it gives companies in the industry market power. As mentioned in the previous subsection, this, together with the high capital intensity, explains why the industry appears productive in output/labour terms, while at the same time the price of cement is twice as high as on the international market. From the policy maker perspective it is not clear that such a high level of protection is warranted for this industry, given its crucial role as a provider of inputs for the construction industry.

A number of agro-processing products, particularly maize and products derived from it are also on the sensitive item list. Post-harvest crop activities is an industry with high labour productivity in Uganda, and maize is one of its main inputs. Given the high level of agricultural subsidies of maize on the global market, some higher level of protection allows EAC producers to compete on a more level playing field. Some companies in the industry

manage to compete on OECD markets, but maize and products derived from it are mostly sold within the EAC, with Kenya being by far the largest market. However, currently only a fraction of Ugandan and Rwandan maize exports to Kenya is made up of processed maize. Given its success in post-harvest activities for other products, Ugandan processors have a solid foundation to learn and compete with Kenyan processors, utilize their protection from international competition, and move up the regional value chain. An impediment to achieving higher value addition is the poor quality of raw maize as an input: Much of the Ugandan maize is of sub-standard quality, stemming from poor organization of the supply chain and poor information and skills of farmers (Daly et al., 2016). The Government of Uganda has rightly recognized its role in promoting quality, standards and the correction of market failures (Ministry of Trade, Industry and Cooperatives of the Republic of Uganda, 2015), but so far limited success has been achieved. This shows that trade policy needs to go beyond simple tariff measures, and industries that receive special protection, leading to muted international market signals and integration, also require special attention to their market failures.

4 Spillover effects of industries without smokestacks

Structural change remains one of the central pillars of development economics. The argument in favour of this approach rests on the assumption that a country's economy can be partitioned into low growth traditional sectors and high growth modern sectors. One rationale for this distinction is that modern sectors require better technology and higher skilled workers than more traditional sectors. This creates the opportunity for learning by doing and the space for substantial productivity growth. Another rationale is that the modern sectors provide higher potential for knowledge transfer from abroad given the simple observation than machines can be moved between countries much more easily than farming techniques (Rodrik, 2013).

Economic growth in this context, is simply a matter of equipping your economy with the skills and technologies to gradually replace old sectors with new modern sectors (McMillan et al., 2014). Equipped with higher-value factors of production, the economy can experience

virtuous cycles both within the modern sector and spilling-over to other more traditional sectors and consequently access higher growth paths. By contrast, traditional sectors can be characterised as more isolated with less spillovers to the rest of the economy. In this section, we identify two channels for these dynamic linkages in two different contexts in East Africa.

First, we look to identify the role of hub sectors, which knit together the rest of the economy. By combining Ugandan firm-level input-output data and firm-level production data, we correlate output and productivity across different sectors. Using this approach we identify whether there is something special about industries without smokestacks in their relationship to output and productivity of other connected sectors. Second, we look to identify output and productivity spillovers from foreign direct investment to other firms in the supply chain in Rwanda[17]. Here, we attempt to identify whether industries without smokestacks have greater capacity for sales and employment spillovers.

4.1 Output and Productivity spillovers

We first consider how central industries without smokestacks are to the rest of the Ugandan and Rwandan economies by looking at sectoral input-output linkages. We then consider the correlation of output and productivity between different sectors in Uganda.

In Figure 5 and Figure 6 we present a graphical representation of the sectoral input-output matrix for Uganda and Rwanda. Each node represents an industry classified at the ISIC four digit level. This partitions the Ugandan economy into 275 different industries and the Rwandan economy into 136 industries. Each edge shows a directed input-supply connection between the industries - i.e a flow of inputs from customer to supplier. An edge is only shown if trade between the two sectors exceeds 5 % of the sectors' total trade over the period. This restricts the analysis to only observe trade between sectors with substantial interactions. The spatial location of nodes is driven by a force directed layout known as ForceAtlas2. This layout works like a physical system: nodes repulse each other like charged particles, while edges attract their nodes, like springs. These forces create a movement that converges to a balanced state (Jacomy et al., 2014).

[17]Our dataset does not include disaggregated FDI flows for Uganda

Finally, nodes are coloured by sectoral groups (manufacturing, services, agriculture, mining), and scaled by the number of industries which are connected to each node. This helps the reader to observe hub sectors. An industry is considered to import (node coloured teal) if more than 5 % of its inputs are imported. An industry is considered to export (node coloured black) if more than 5 % of its sales are exported.

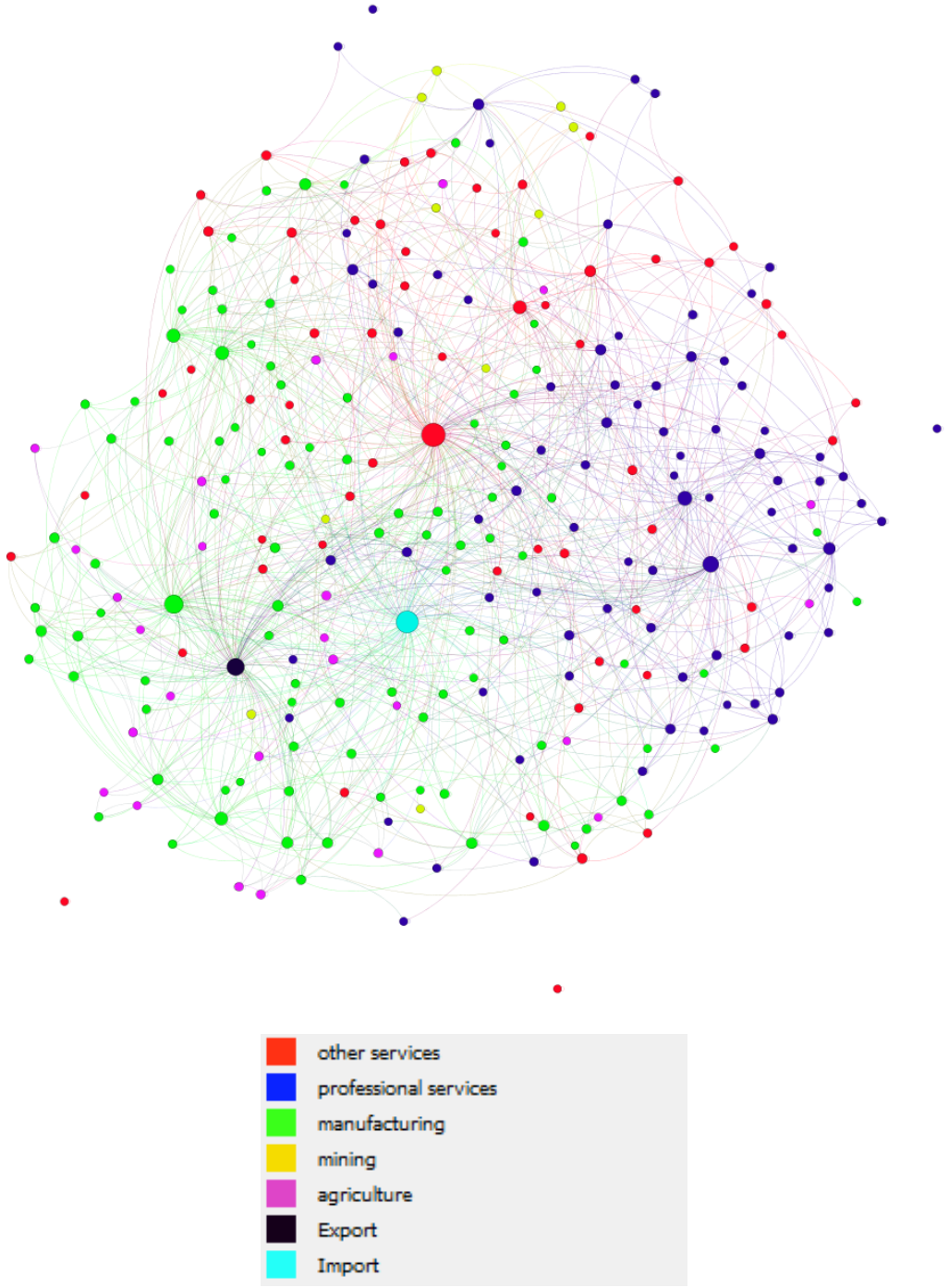

Figure 5: Graphical representation of Uganda sectoral input-output matrices for the years 2009-2015. Each node corresponds to an industry and each edge represents an input-supply relationship between two industries. Larger nodes represent more connections between the main industries, this helps to identify 'hub' industries. The layout of nodes is determined by ForceAtlas2 network layout algorithm. ForceAtlas2 is a force directed layout: it simulates a physical system in order to spatialize a network. Nodes repulse each other like charged particles, while edges attract their nodes, like springs. These forces create a movement that converges to a balanced state (Jacomy et al., 2014).

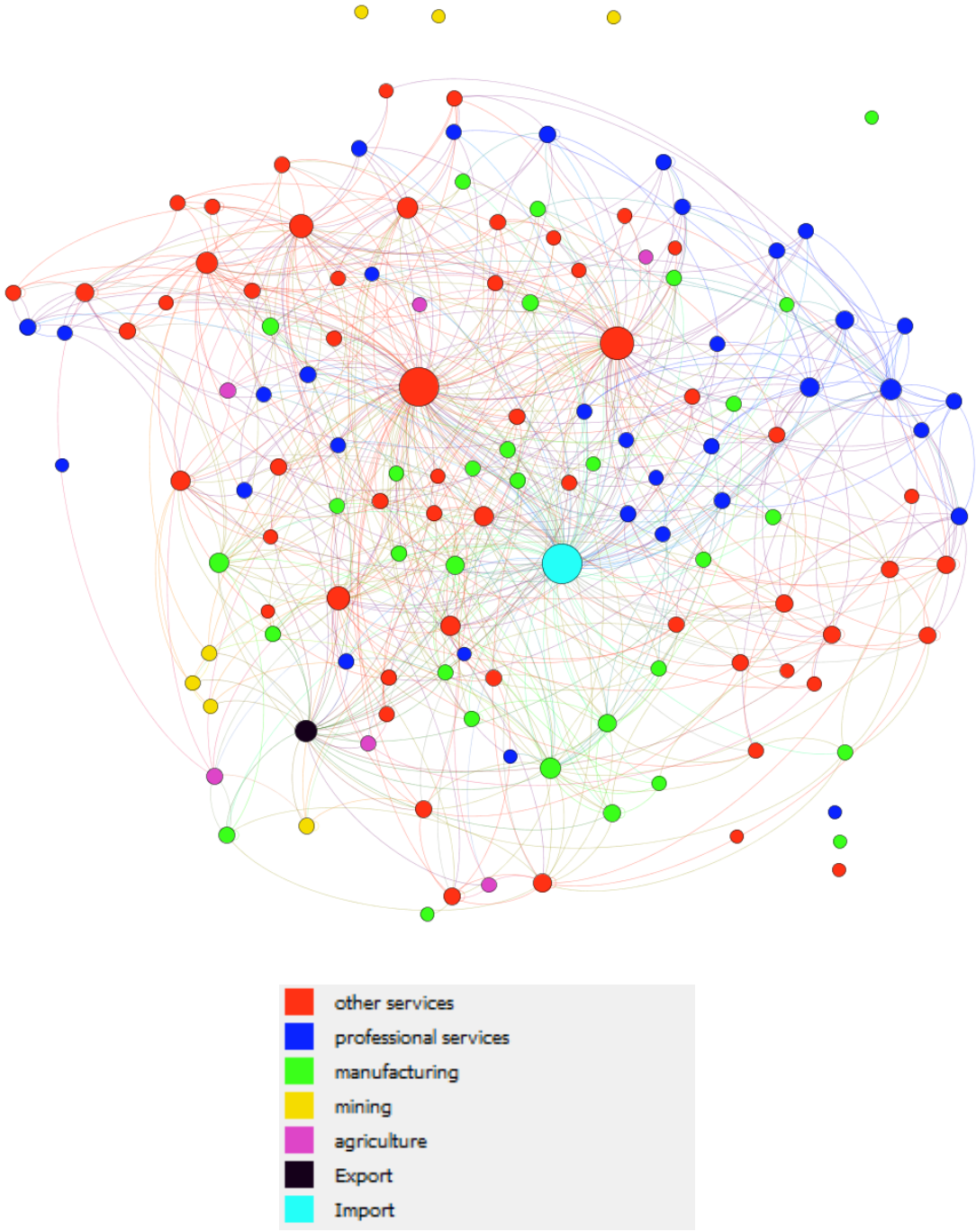

Figure 6: Graphical representation of Rwandan sectoral input-output matrices for the years 2013-2014. Each node corresponds to an industry and each edge represents an input-supply relationship between two industries. Larger nodes represent more connections between the main sectors, this helps to identify 'hub' industries. The layout of nodes is determined by ForceAtlas2 network layout algorithm. ForceAtlas2 is a force directed layout: it simulates a physical system in order to spatialize a network. Nodes repulse each other like charged particles, while edges attract their nodes, like springs. These forces create a movement that converges to a balanced state (Jacomy et al., 2014).

These graphs reveal some immediate and salient points about the Ugandan and Rwandan economies.

First, notice that in both Uganda and Rwanda some industries are far more interconnected to the rest of the economy than others. The average number of connections for each industry is just 3.8 in Uganda and 5.3 in Rwanda, suggesting most industries are relatively specialised with few linkages across the economy. However, as is clear in the graph, the top ten inter-connected industries have far more linkages across the economy. These industries can be classified as hubs which either provide inputs or serve as buyers to numerous other industries. This phenomenon is often referred to as the small world property of networks; despite most sectors being unconnected it only takes a few moves along the directed network to get from any one node to another. Indeed, the maximum distance in this network is just 11 steps in Uganda and 9 in Rwanda. This is important when we consider questions of output and productivity spillovers, and highlights the importance of hub sectors to spreading knowledge, output and productivity shocks.

Second, in both countries imports (coloured teal) and exports (coloured black) play a crucial role in the functioning of the economy. This can be observed in the large size and high centrality of these nodes. The role of imports is further emphasized in Figures 15 and 16 in the annex. In the graphs, node size is scaled by the proportion of the industries' inputs which are imported. Relative to Figures 5 and 6, it is clear to see that the manufacturing sector is far more reliant on imports than any other sector.

The top-ten industries are shown in Figure 7 and Figure 8. In both Uganda and Rwanda the top ten most interconnected sectors are remarkably similar. Immediately obvious is the presence of six service industries in the top ten in Uganda, and eight in Rwanda. This includes construction services, telecommunication services, accounting services, and cargo handling services. These are essential inputs to all other sectors, without which, other sectors could not function. This supports the notion of service industries serving as essential inputs into the production process. For instance, we know that employing a cargo handling service is a necessary requirement for exporting. Consequently, we might expect a larger impact from a productivity increase in cargo handling, than from other more specialised industries.

The remaining most interconnected industries are from the manufacturing sector. This is consistent with manufacturing industries purchasing inputs from numerous other sectors of the economy. Together, this confirms the opening hypothesis that the manufacturing and service sectors are distinct in their interconnectivity to the rest of the economy.

Much smaller in size are the mining and agricultural sectors which are also relatively unconnected to the rest of the economy. Firms in the mining sector primiarily trade with other mining firms or with general service support firms such as transport and logistics. This is consistent with the specialised nature of the mining sector and supports a long held belief that mining companies work in silos. In the agricultural sector linkages are often with the manufacturing sector. This is consistent with the manufacturing sectors' purchase of agricultural produce such as maize converted into flour.

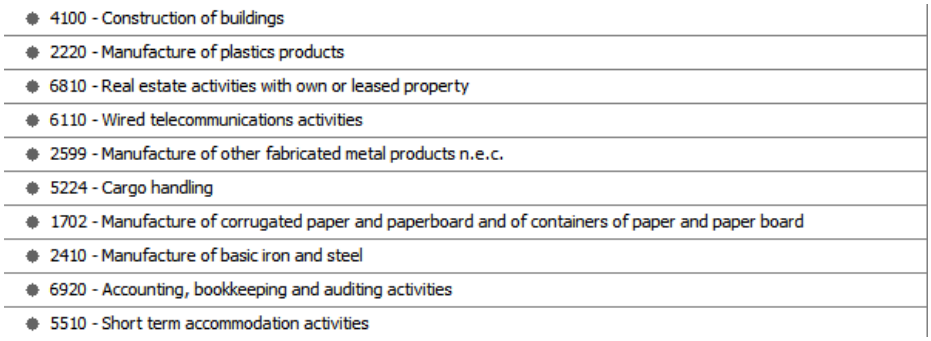

Figure 7: Ugandan sectors with most connections

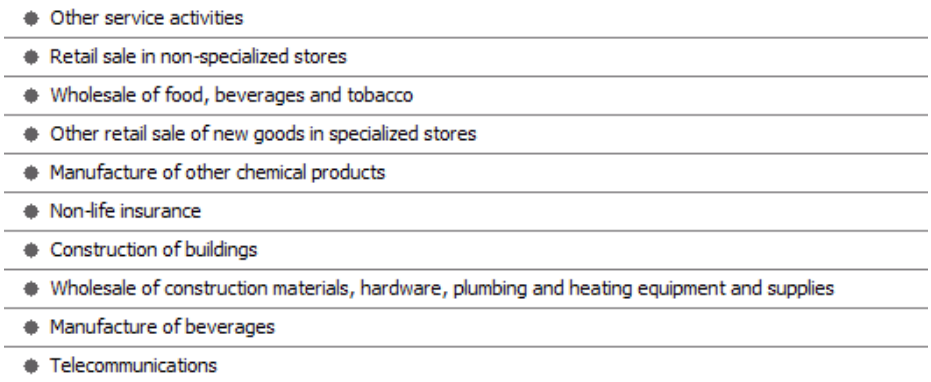

Figure 8: Rwandan sectors with most connections

4.1.1 Co-movement of output and productivity

We now turn to the question of co-movement of output and productivity across sectors. So far, we have observed that some industries are more interconnected than others, and that this varies by the type of sector. We add to this the observation that industries which are connected are likely to be highly correlated in terms of output and productivity. This is due to (a) covariate shocks across similar sectors and (b) idiosyncratic shocks with propagate through the supply-network (Acemoglu et al., 2012). Due to these factors, we would expect a high correlation of output and productivity between industries which trade heavily with one another. However, industries which are more isolated or further apart should have a smaller correlation. Indeed, we would expect this effect to decay with network distance.

To test this hypothesis following Carvalho (2014), we calculate average output growth in all 275 ISIC 4-digit industries between 2009 and 2015. We then calculate the pairwise correlation in output growth between each of the 275 industries. Finally, we take an average of these correlations across different network distances and disaggregate the results by sectoral groups.

Results are shown in Figure 9. The vertical axis displays the average pairwise correlation in output while the horizontal axis displays the network distance between the industries. The average correlation between industries which are distance one apart (i.e. sectors that are directly trading) is 0.38. However, as network distance decreases, so does the correlation in output growth. This is consistent with results in Carvalho (2014) for the USA. We can interpret this result as saying that (a) the network structure of the economy matters for economic growth and (b) that more connected industries are likely to influence economic growth more than isolated industries.

Some industries see a faster decay in correlation to others. This is evident in the agricultural sectoral group which decays very quickly with network distance. Whereas the manufacturing sector decays much less quickly. This is also consistent with Figure 4 which showed the agricultural sector was relatively unconnected.

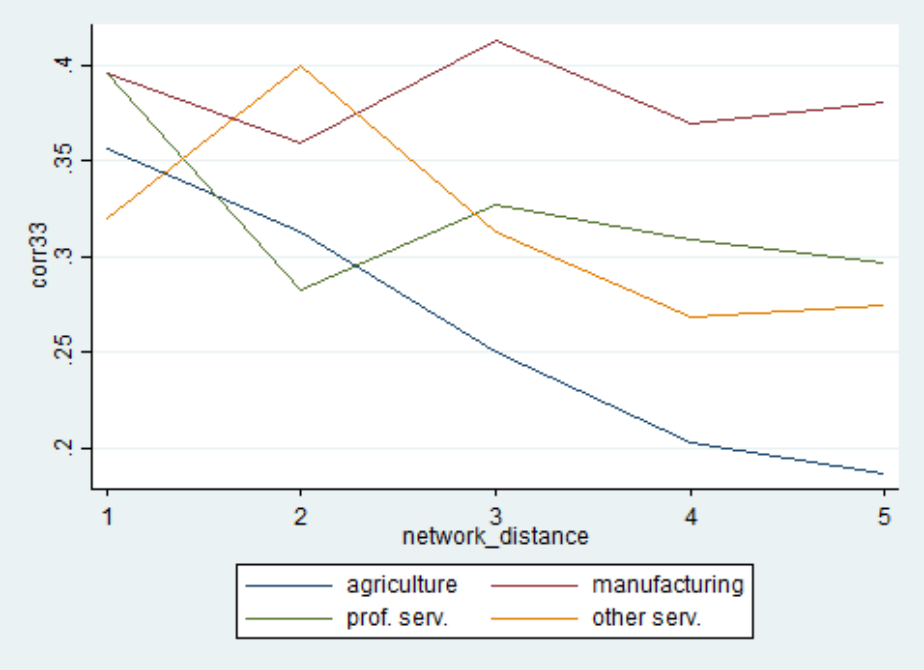

Figure 9: Correlation of output and network distance, disaggregated by sector

Finally, we look at the contribution of hub industries to output growth in the rest of the economy. As shown in Figure 5, some industries are more connected to the rest of the economy than others and serve as hubs. If we believe that these hubs have a disproportionate impact on aggregate output we would expect changes in their output and productivity to explain a large proportion of aggregate output.

In Figure 10, we present the quarterly change in output growth in the top 10 most interconnected industries alongside the quarterly change in output growth in the whole economy. The graph indicates the strong relationship between the two series indicating that hub industries are disproportionately influential in shaping economic growth. The correlation coefficient between the two series is 0.83. By contrast, the equivalent correlation coefficients for the 10 industries in the middle of the interconnectedness distribution is just 0.51.

In Figure 11, we present the trajectory of labour productivity growth[18] in the top ten most interconnected industries next to the output growth of the whole economy. Clearly, there is a positive correlation between the two series although less strong than the correlation

[18]Here productivity is simply output per worker

in output shown in Figure 10. The correlation coefficient in top ten sectors (0.49) again exceeds the correlation score in the average ten sectors (0.29).

One concern one might have with these graphs is that we are double counting: the top ten most interconnected industries are also the largest. To address this, we do two things. First, we select the larger sectors in the middle of the interconnectedness distribution such that the overall volume of transactions in the top ten sectors and average ten sectors is equal. Second, we reestimate the correllation coefficients with the influence of the top ten sectors removed. When we net these sectors out, we find similar correlation coefficients[19].

Figure 10: Output Growth top ten most interconnected sectors and all sectors

[19]For output correlation we find 0.76 and for productivity correlations we find 0.49

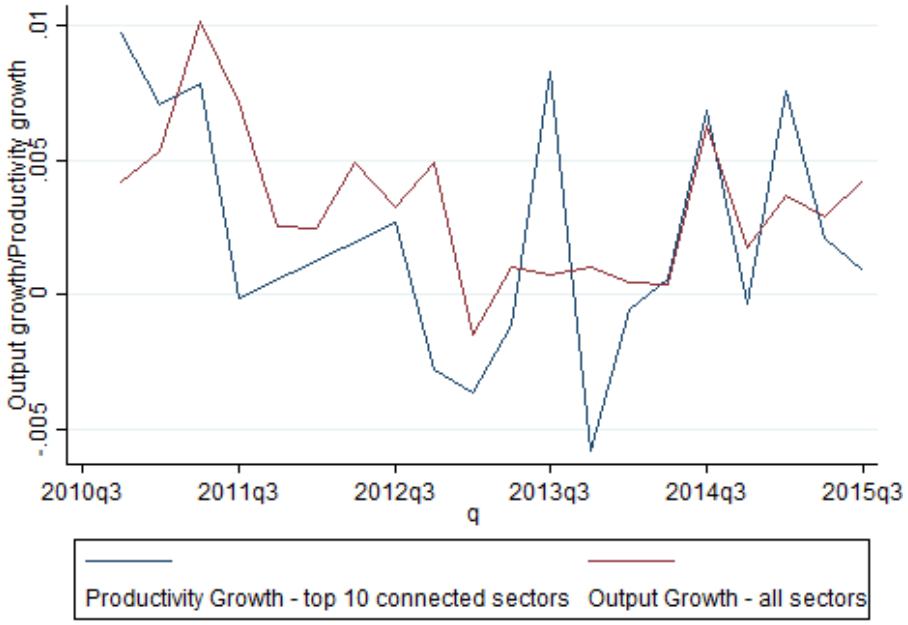

Figure 11: Output Growth and productivity growth in top ten connected sectors

Interpreting these results causally would be a mistake, given the simultaneity bias between the series being discussed. However, they do provide suggestive evidence that some of the sectors identified as high growth industries without smokestacks are also crucial to driving growth in the rest of the economy and provide government with a list of the most important interconnecting sectors of the economy.

4.2 Sales and employment spillovers from FDI

Large amounts of time and resources are spent on encouraging FDI. A key justification for this exertion is the assumed positive impact on domestic firms and employees through information spillovers, higher wages, greater competition and new suppliers. However, the presence of FDI is far from a sufficient condition for productivity spillovers. Instead, it depends on the macroeconomic conditions in the host country and the existence of linkages between foreign and domestic firms (Sutton et al., 2016).

Theory suggests the mechanisms for these spillovers are more likely to operate vertically along the value-chain as opposed to horizontally as firms have an incentive to improve performance of their suppliers but not of their competitors (Markusen and Venables, 1998,

Rodriguez-Clare, 1996, Varian, 1995). A large empirical literature has confirmed a lack of horizontal intra-sector spillovers (Djankov and Hoekman, 2000 and Aitken and Harrison, 1999, Javorcik, 2004), but some evidence of spillovers over backward linkages through the supply network (Javorcik, 2004). Evidence on knowledge transfer is thus mixed. It seems likely that FDI could crowd in or crowd out domestic firms, and that it depends on the sector the FDI comes from. As shown in Figure 12, Rwanda and Uganda have seen rapid growth in FDI as a proportion of GDP since 1970. However, very little evidence exists on the consequences of this rapid growth.

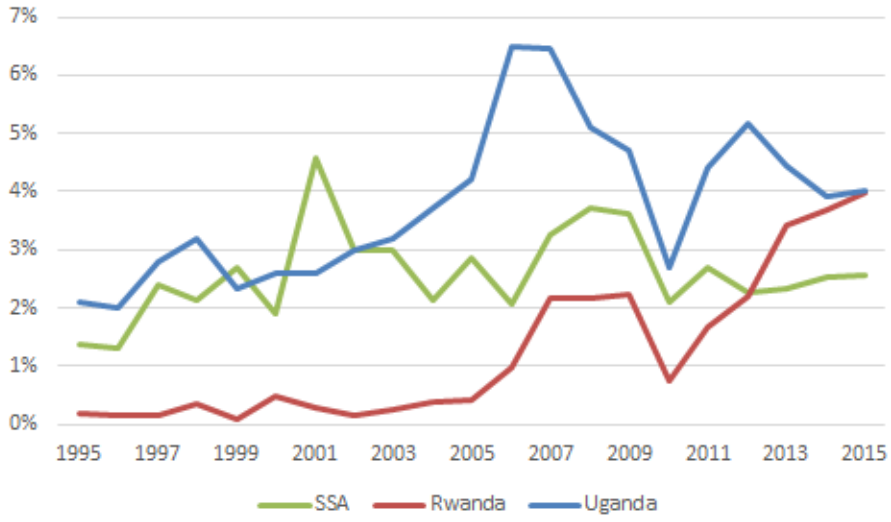

Figure 12: Net inflows FDI as a percentage of GDP, Uganda and Rwanda
Source: World Bank World Development Indicators, 2016

In this final section, we use firm-level data from Rwanda between 2009 and 2016 to consider how foreign investment in industries without smokestacks compares to FDI in more extractive industries in its capacity to create output, employment and productivity spillovers to the rest of the economy.

4.2.1 Estimation strategy

Following Javorcik (2004), we estimate the following equation on the Rwandan firm VAT data to test the correlation between the intensity of linkages to foreign owned firms and a vector of outcome variables.

$$Y_{ijt} = \alpha + \beta_1 Backward_{ijt} + \beta_1 Forward_{ijt} + \delta X_{ijt} + a_i + a_j + a_t + u_{ijt} \quad (1)$$

where $Y_{ijt} = \{Employees, Sales, Productivity\}$[20] for firm i, in sector j at time t. We exploit the panel nature of the dataset to include firm and time fixed effects so that estimates can be interpreted as the within-firm change in FDI supply-chain intensity.

Whereas Javorcik (2004) proxies for linkages through the presence of FDI in different sectors, we can directly observe which firms are trading with which other firms. Therefore, the forward and backward linkage variables are generated at the firm level through the Rwandan firm input-output matrix. $Forward$ linkage is defined as the ratio of foreign supplier to total suppliers for firm i in sector j at time t. $Backward$ linkages is defined analogously on buyers.

$$Forward_{ijt} = \sum FDIsuppliers_{ijt} / \sum suppliers_{ijt} \quad (2)$$

$$Backward_{ijt} = \sum FDIbuyers_{ijt} / \sum buyers_{ijt} \quad (3)$$

We run separate regressions for each sector of FDI to try to identify if FDI in different sectors has more spillovers to the rest of the economy than in others.

4.2.2 Results

Results from the regressions for sales, employment, and labour productivity are given in Tables 6, 7, and 8, respectively.

From Table 6, we can see that an increase in the intensity of foreign buyers in a firm's supply-chain (backward linkage) has a positive and significant impact on sales of the supplying firm only if the foreign firm is in the manufacturing sector. In other sectors, the effect is also positive, but it is not significant. By contrast, if there is an increase in foreign suppliers, this appears to have no impact on firm's sales. The sign and size of these effects are consistent with the analysis in Javorcik (2004), which was only conducted on a sample of

[20] In each case we take the natural log.

manufacturing firms and found positive and significant effect on backward, but not forward linkages.

Turning to Table 7, we can see that an increase in foreign buyer intensity also causes an increase in employment across all sectors. Again, this effect is strongest in the manufacturing sector. These results are consistent with sales spillovers from FDI to domestic industries downstream but not upstream. They are also consistent with a heterogeneity of effects across sectors, with manufacturing FDI having a much larger impact on their supply-chain.

In Table 8, we look to see if there are productivity spillovers from FDI to domestic firms. Unlike for employment and output, their is no clear evidence of productivity spillovers either forwards or backwards along the supply-chain. The reason for this null result could be that there really is no technology transfer. Alternatively, it may be that the time series we observe is too short to see effects. It may also be that FDI spillovers do not show in labour productivity improvements, but rather capital or total factor productivity, for which we have no measure.

5 Conclusion

In this paper we utilized transaction level tax-administration data to study firm networks with a specific focus on industries without smokestacks in Uganda and Rwanda. We first turned to the characteristics of the most productive firms in each sector in order to conclude what type of firm can become an engine for within-sector growth. Using data on labour productivity we ranked the 275 ISIC industries and compared the top 30 across sectors. Firstly, we found that scale matters not only in the manufacturing sector, but also in industries without smokestacks such as the selected service sector and agri-business industries. Of course this is true for utility services providers or air transport providers that rely on large capital investments, but it also holds for retailers and wholesalers, who need to build up logistics chains and systems to exploit savings that come with scale. Secondly, the data shows that firms need not be first hand actors in the external sector in order to benefit from the competitive pressures and learning that this can provide[21], but that nonetheless it

[21] Figure 13 in the Annex shows that exporters have higher output/worker

is common among highly productive firms to have at least second degree connections to the external sector. Service sector firms that act as intermediaries between the domestic and external economy are a strong case in point to exploit this property. Thirdly, the industries we study highlight that cheap imports are crucial for productivity, as imports make up large fractions of high-productivity firms' input use. This points to the importance of a liberal import regime, but also opens the window of opportunities for domestic companies that can aspire to substitute these inputs.

After studying firms that have the potential to lead to sector-level growth, we turn to consider whether industries without smokestacks also have the potential for spillover effects across firms and industries. First we show that some services industries play an absolute crucial role as hubs of the economy, and that the average number of connections with other firms in the economy is highest in the services sector, followed by the manufacturing sector. We then show that growth in output and productivity in these industries is a strong indicator of overall economic growth, which indicates that these industries do have substantial spillover or pull-effect on the remaining economy. Lastly, we study sales and employment spillovers from FDI using data from Rwanda. We do find positive spillover effects appear to be present across sectors, but the estimates tell us that they are most likely to occur in the manufacturing sector. More generally, our results show that industries without smokestacks can play an important role in structural transformation, and that looking at finer levels of disaggregation illuminates a path toward growth and transformation that need not solely based on the manufacturing sector.

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6 Regression Results

Table 6: Sales spillovers

	(1) all	(2) manufacturing	(3) agriculture	(4) mining	(5) services
Backward Linkage	0.00144	0.0248***	0.00115	0.0112	-0.00237
	(0.58)	(2.99)	(0.17)	(0.39)	(-1.00)
Forward Linkage	0.000766	-0.00331	-0.00822	-0.0450	0.000547
	(0.31)	(-0.83)	(-0.23)	(-0.62)	(0.20)
Constant	15.89***	15.65***	15.73***	16.19***	16.16***
	(641.95)	(466.19)	(69.65)	(64.16)	(437.19)
Time and firm fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	9480	4775	227	132	4346

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Employment spillovers

	(1) all	(2) manufacturing	(3) agriculture	(4) mining	(5) services
Backward Linkage	0.00185**	0.00909***	0.00598**	0.00314	0.000437
	(2.18)	(3.94)	(2.65)	(0.35)	(0.66)
Forward Linkage	0.00116	0.000238	0.00465	0.0109	0.000449
	(0.93)	(0.04)	(0.80)	(0.50)	(0.35)
Constant	1.881***	1.840***	1.989***	1.845***	1.912***
	(120.68)	(86.19)	(22.05)	(18.92)	(78.56)
Time and firm fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	6244	3080	162	103	2899

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Productivity spillovers

	(1) all	(2) manufacturing	(3) agriculture	(4) mining	(5) services
Backward Linkage	-0.00146	0.00350	-0.0134***	0.00300	-0.00254
	(-0.62)	(0.40)	(-3.86)	(0.07)	(-0.99)
Forward Linkage	0.00346	0.00678	0.0206**	-0.176***	0.00143
	(0.95)	(0.39)	(2.61)	(-6.92)	(0.39)
Constant	14.33***	14.14***	14.16***	14.68***	14.52***
	(434.15)	(296.70)	(105.48)	(80.21)	(300.03)
Time and firm fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	4694	2212	139	88	2255

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

7 Tables and Graphs

Table 9: Mean Firm by sector and variable in 2015 USD[22].

Source:	PAYE		VAT		Customs	
	Employees # of	AvWage	Output	Input	Export	Import
Uganda						
Agriculture	46	171	85,661	20,161	56,018	22,730
Manufacturing	39	123	214,565	121,921	18,560	120,894
Mining	28	263	101,806	77,801	18,651	135,437
Other	15	292	10,485	2,113	391	16,141
Services	18	184	35,515	17,713	5,597	19,109
Rwanda						
Agriculture	19	183	49,427	9,729	27,010	8,450
Manufacturing	35	226	64,953	21,219	7,213	63,127
Mining	62	311	150,173	20,344	157,914	9,478
Other	53	526	11,092	2,529	186	3,646
Services	15	261	29,811	12,706	1,748	10,975

[22]The mean for exports and imports is scaled by the total number of observations across datasets.

Table 10: Ranking of top 30 Ugandan industries by labor productivity, at ISIC level

	ISIC	Industry	# of Comp.	Av. Wage	# of Workers	Av. Output	%is exp.	%EAC exp.	%OECD exp.	%supply exp.	Export/ Import
1	Marine aquaculture	Agriculture	3	64	103	1,570,713	0.67	0.33	0.67	0.00	10.93
2	Manufacture of cement, lime and plaster	Manufacturing	4	49	80	7,129,316	0.50	0.50	0.50	0.75	0.01
3	Manufacture of fertilizers and nitrogen	Manufacturing	1	334	12	487,294	1.00	0.00	0.00	1.00	0.01
4	Other telecommunications activities	Services	13	315	6	52,651	0.00	0.00	0.00	0.00	.
5	Wholesale of solid, liquid and gaseous fuels	Services	106	252	23	565,767	0.08	0.05	0.03	0.31	0.01
6	Post-harvest crop activities	Agriculture	15	133	22	130,088	0.60	0.60	0.53	0.40	6.01
7	Activities of holding companies	Services	2	284	2	79,134	0.00	0.00	0.00	0.00	.
8	Marine fishing	Agriculture	15	172	24	451,096	0.27	0.20	0.20	0.00	35.60
9	Manufacture of malt liquors and malt	Manufacturing	12	73	52	2,223,659	0.42	0.25	0.17	0.17	0.14
10	Wholesale on a fee or contract basis	Services	67	118	29	233,772	0.09	0.04	0.01	0.19	0.45
11	Wholesale of waste and scrap etc	Services	54	213	12	84,916	0.13	0.09	0.02	0.35	0.37
12	Retail sale of beverages	Services	44	158	21	154,863	0.05	0.00	0.02	0.25	1.18
13	Medical and dental practice activities	Services	81	83	19	218,558	0.04	0.04	0.00	0.05	0.39
14	Retail sale of automotive fuel	Services	158	108	22	277,667	0.05	0.03	0.02	0.21	0.02
15	Manufacture of tanks, reservoirs etc	Manufacturing	3	143	13	246,699	0.67	0.67	0.00	0.67	0.03
16	Retail sale of hardware, paints and glass	Services	531	172	5	30,909	0.07	0.02	0.01	0.17	0.63
17	Manufacture of pharmaceuticals	Manufacturing	10	100	65	558,610	0.60	0.50	0.00	0.50	0.09
18	Passenger air transport	Services	21	228	19	388,441	0.33	0.14	0.19	0.24	0.16
19	Manufacture of veg and animal oils and fats	Manufacturing	25	103	60	1150981	0.32	0.32	0.16	0.24	0.18
20	Manufacture of refined petrol. products	Manufacturing	8	193	29	281,205	0.38	0.38	0.00	0.50	0.04
21	Extraction of natural gas	Mining	7	265	50	155,324	0.29	0.14	0.29	0.43	0.03
22	Electric power generation, transm. and dist.	Services	147	219	23	253,193	0.09	0.03	0.04	0.24	0.09
23	Tanning and dressing of leather and fur	Manufacturing	9	119	39	473,625	0.67	0.44	0.56	0.56	3.73
24	Manufacture of pumps, compressors etc	Manufacturing	1	608	1	22,678	0.00	0.00	0.00	1.00	.
25	Wholesale of construction materials	Services	448	176	10	62,497	0.11	0.05	0.00	0.31	1.04
26	Wireless telecommunications activities	Services	8	183	48	559,512	0.13	0.13	0.00	0.38	0.76
27	Wholesale of food, beverages and tobacco	Services	493	137	15	67,611	0.09	0.03	0.03	0.14	5.06
28	Retail sale of second-hand goods	Services	137	159	5	59,815	0.06	0.01	0.00	0.02	0.34
29	Other specialized construction activities	Services	45	316	26	25,004	0.02	0.02	0.00	0.18	0.00
30	Sale of motor vehicles	Services	827	201	7	36,947	0.03	0.01	0.00	0.05	0.55
	Mean across all ISIC industries		88	182	17	34,813	0.04	0.02	0.01	0.05	3.89

Table 11: Ranking of top 30 Rwandan industries by labor productivity, at ISIC level

	ISIC	Industry	# of Comp.	Av. Wage	# of . Workers	Av. Output	%is exp.	%EAC exp.	%OECD exp.	%supply exp.	Export/ Import
1	Retail sale of second-hand goods	Services	17	128	3	34,627	0.12	0.06	0.00	0.24	0.12
2	Mining of metal ores	Mining	1	906	12	778,460	1.00	0.00	1.00	0.00	419.24
3	Inland water transport	Services	4	1,185	8	232,508	0.25	0.00	0.00	0.00	0.11
4	Other mining and quarrying	Mining	124	201	52	206,323	0.16	0.03	0.07	0.04	17.39
5	Manufacture of tobacco products	Manufacturing	2	1,047	78	371,149	0.50	0.50	0.50	0.00	0.24
6	Activities of households as employers	Services	2	831	1	16,582	0.00	0.00	0.00	0.00	.
7	Other specialized wholesale	Services	1,689	294	7	39,709	0.13	0.05	0.01	0.17	0.55
8	Leasing of personal and household goods	Services	7	717	1	21,495	0.00	0.00	0.00	0.14	.
9	Wholesale of metals and metal ores	Services	44	878	6	18,117	0.11	0.02	0.07	0.20	29.54
10	Other reservation service and related act.	Services	15	2,454	4	21,975	0.00	0.00	0.00	0.07	.
11	Retail sale of food, beverages and tobacco	Services	818	191	10	36,672	0.11	0.03	0.01	0.09	0.67
12	Retail sale of automotive fuel	Services	57	180	16	168,470	0.16	0.05	0.02	0.26	0.05
13	Telecommunications	Services	91	648	22	80,457	0.13	0.09	0.05	0.23	0.27
14	Manufacturing	Manufacturing	29	240	12	93,699	0.21	0.14	0.03	0.10	1.77
15	Animal production	Agriculture	70	168	16	24,983	0.13	0.06	0.06	0.04	5.44
16	Wholesale of household goods	Services	79	135	8	18,731	0.16	0.04	0.00	0.15	0.04
17	Public administration and defence	Other	4	2,595	12	17,102	0.00	0.00	0.00	0.00	.
18	Retail sale of textiles, clothes	Services	2,157	189	5	13,751	0.08	0.02	0.00	0.10	0.68
19	Retail sale in non-specialized stores	Services	9	842	6	31,992	0.00	0.00	0.00	0.11	.
20	News agency activities	Services	175	115	4	12,552	0.13	0.01	0.00	0.15	0.13
21	Other retail sale of new goods	Services	916	214	4	17,288	0.08	0.02	0.01	0.14	0.46
22	Wholesale of fuels	Services	110	184	8	30,518	0.21	0.05	0.01	0.17	0.15
23	Wholesale of textiles, cloth.etc	Services	28	225	43	252,275	0.18	0.11	0.04	0.18	0.01
24	Extraction of crude petrol. and nat. gas	Mining	5	6,040	2	27,605	0.20	0.00	0.00	0.00	9.41
25	Wholesale of food, beverages and tobacco	Services	53	165	22	104,851	0.25	0.13	0.19	0.02	12.88
26	Travel agency and tour operator activities	Services	71	354	11	26,651	0.06	0.03	0.00	0.10	0.10
27	Manufacture of comm. equipment	Manufacturing	144	234	6	14,407	0.03	0.01	0.00	0.08	0.04
28	Building completion and finishing	Services	52	539	27	44,622	0.15	0.08	0.08	0.13	0.06
29	Manufacture of refined petrol. products	Manufacturing	147	221	5	22,204	0.12	0.05	0.01	0.23	0.35
30	Wholesale of construction materials etc	Services	7	305	30	182,762	0.14	0.00	0.00	0.14	0.27
	Mean across all ISIC industries		235	366	12	22,396	0.05	0.02	0.01	0.05	2.58

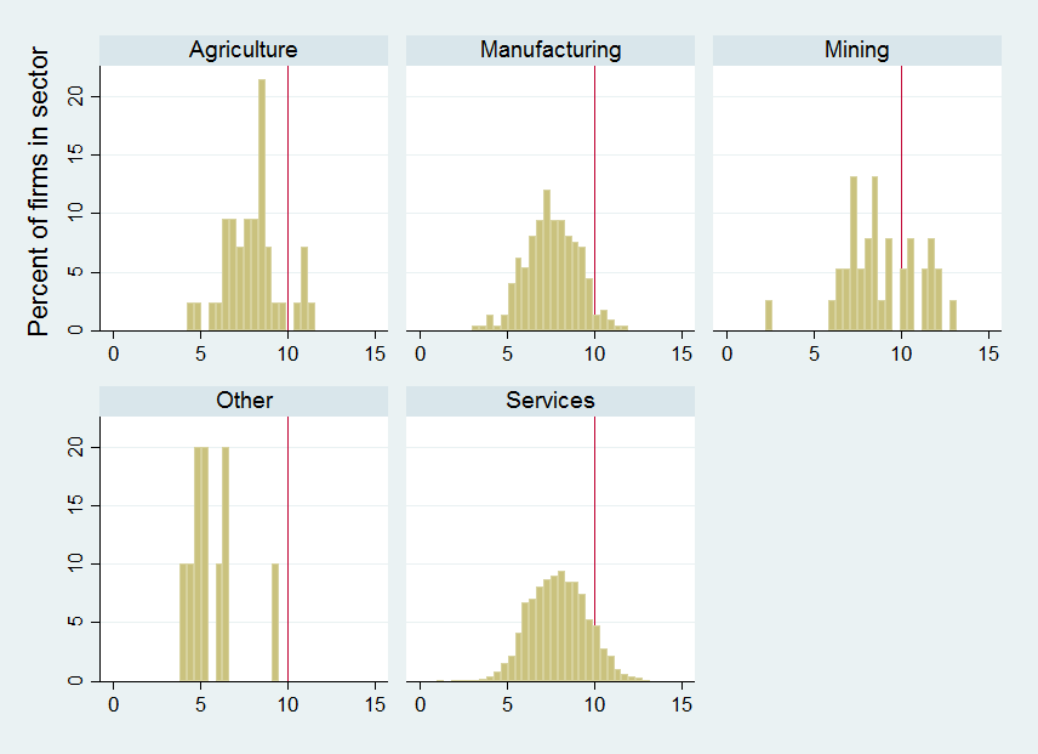

Figure 13: Histograms of output/worker across industries in Rwanda, logarithmic scale

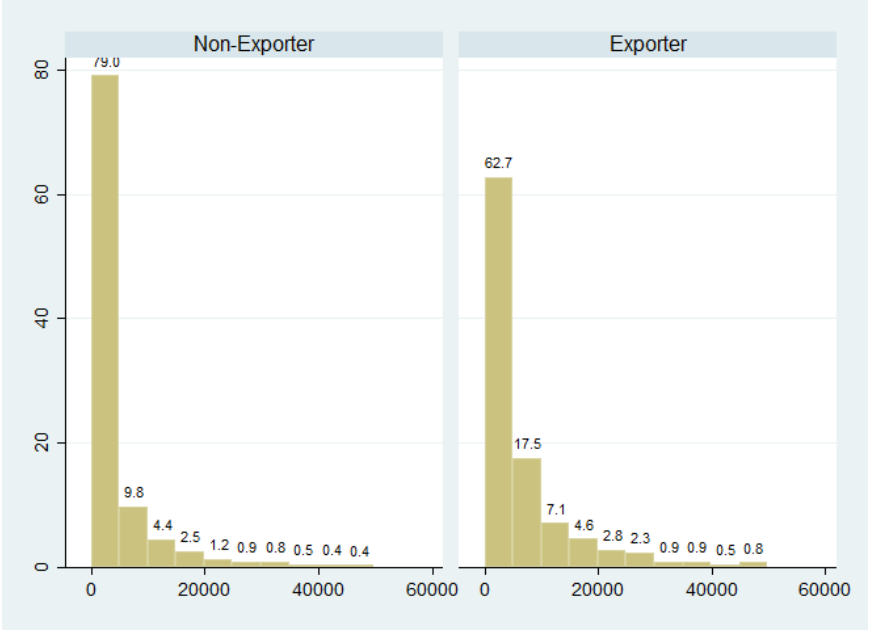

Figure 14: Exporters vs Non-exporter - Output/worker in Uganda in 2015 USD, trimmed at 50,000 for legibility

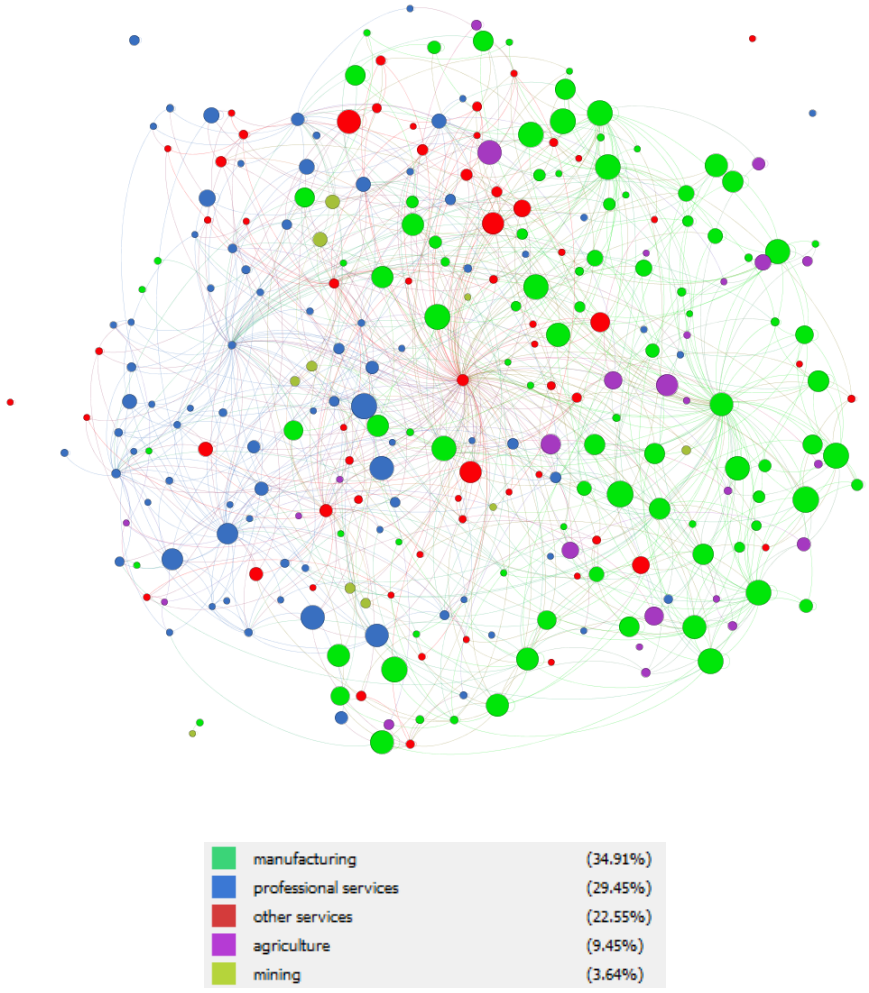

Figure 15: Graphical representation of Uganda sectoral input-output matrices for the years 2009-2015. Each node corresponds to an industry and each edge represents an input-supply relationship between two industries. Larger nodes show the industry has more imports as a percentage of total inputs, this helps to identify 'hub' industries. The layout of nodes is determined by ForceAtlas2 network layout algorithm. ForceAtlas2 is a force directed layout: it simulates a physical system in order to spatialize a network. Nodes repulse each other like charged particles, while edges attract their nodes, like springs. These forces create a movement that converges to a balanced state (Jacomy et al., 2014).

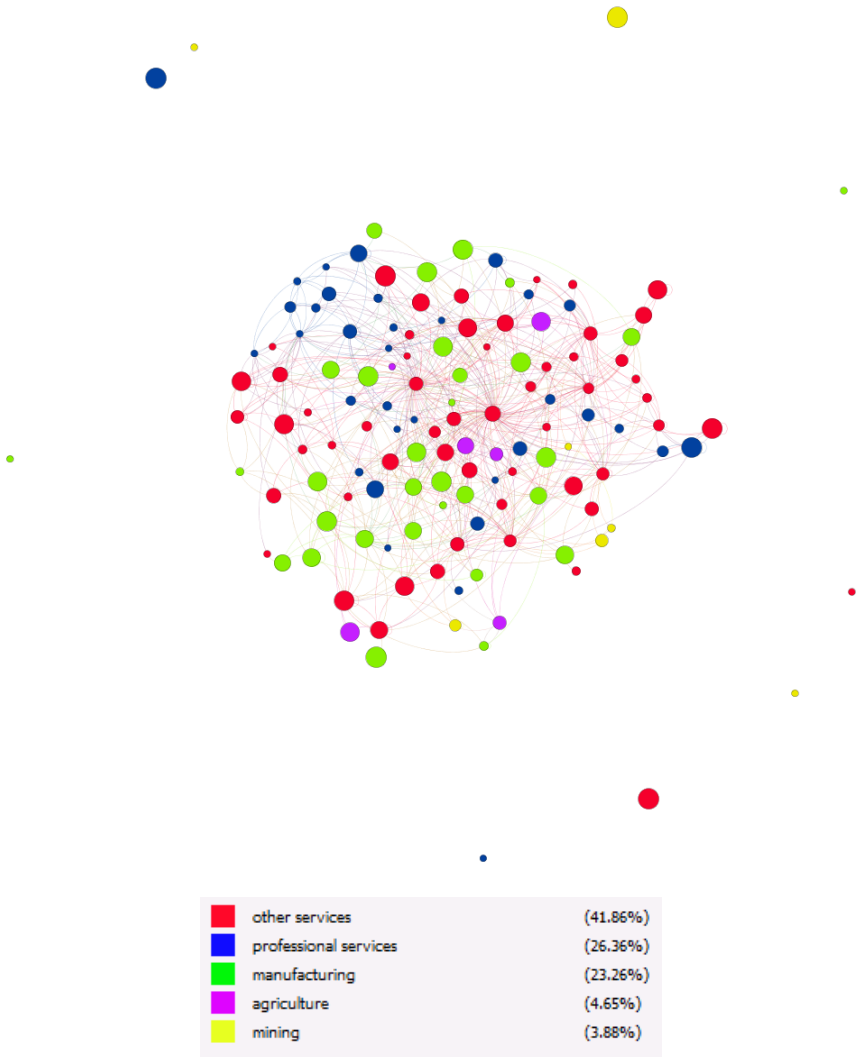

Figure 16: Graphical representation of Rwandan sectoral input-output matrices for the years 2013-2014. Each node corresponds to an industry and each edge represents an input-supply relationship between two industries. Larger nodes show the industry has more imports as a percentage of total inputs, this helps to identify 'hub' industries. The layout of nodes is determined by ForceAtlas2 network layout algorithm. ForceAtlas2 is a force directed layout: it simulates a physical system in order to spatialize a network. Nodes repulse each other like charged particles, while edges attract their nodes, like springs. These forces create a movement that converges to a balanced state (Jacomy et al., 2014).