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# What is the state of the manufacturing sector in Mozambique?

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**Abstract:** The latest firm survey of Mozambique, the *Inquerito ás Indústrias Manufactureiras* (IIM) 2017, draws a concerning picture of the manufacturing sector. However, it is not obvious whether this is true for the population of manufacturing firms in Mozambique, as the representativeness of the IIM 2017 sample is not clear. This paper triangulates the findings of IIM 2017 by considering other indicators of the health of the manufacturing sector in Mozambique, including manufacturing gross domestic product, the latest enterprise census, and satellite imagery. Results indicate that the manufacturing sector grows at roughly the same pace as the population.

**Keywords:** census, manufacturing, Mozambique, satellite images, survey

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# 1 Introduction

The Survey of Mozambican Manufacturing Firms 2017—*Inquérito as Indústrias Manufactureiras* (IIM 2017) (DERG, UNU-WIDER, and CEEG 2018) draws a concerning picture of the manufacturing sector in Mozambique. The sampled firms decreased in size, reported large losses and faced a challenging business environment. However, it is not obvious whether this is true for the population of manufacturing firms in Mozambique.

Compared to the population of manufacturing companies, the representativeness of the 739 firms that were either in operation in both 2012 and 2017 or had closed down between the two rounds of enterprise surveys (DNEAP 2013; DERG, UNU-WIDER, and CEEG 2018) is largely unknown. Firstly, because the original 2012 sample was not fully nationally representative; secondly because the distribution of existing manufacturing firms might have shifted since 2012; and finally, because all firms in the sample are at least eight years of age (i.e. started operating in 2009 or before). It thus remains a possibility that economic activity in the sector has largely shifted towards new firms.

It is the purpose of this paper to draw a more complete picture of the state of the manufacturing sector in Mozambique. To do so, two approaches are pursued: Firstly, we reweigh the main results of IIM 2017 (DERG, UNU-WIDER, and CEEG 2018) using two available population estimates; and secondly, we investigate alternative sources of data on the development of the manufacturing sector. In particular, we examine three sources: i) aggregate figures of manufacturing GDP, ii) the 2014/15 Census on firms (CEMPRE), and iii) high-resolution satellite images in areas surrounding known small, medium, and large firms.[1]

Manufacturing GDP expanded by 23 per cent from 2011 to 2017, corresponding to an annual growth rate of 3.5 per cent. Even if this is substantially lower than total GDP growth (of 7.2 per cent during the period), it is still slightly above population growth (2.9 per cent per year during the period). This suggests that while the Mozambican economy has been deindustrializing in relative terms (manufacturing GDP slipped from 10.7 per cent to 8.6 per cent of total GDP), the manufacturing sector has still been expanding in absolute terms at a rate slightly higher than population growth.

It is possible to reconcile the decrease in firm size for the IIM 2017 sample with an overall expansion in the manufacturing sector if Mozambique has experienced a flux of new companies after 2009 (the IIM 2017 sample only includes companies founded 2009 or earlier). According to the latest enterprise census (the CEMPRE 2014/15), this is exactly what happened, as nearly half (49 per cent) of the 3,385 manufacturing companies in the dataset are founded after 2009.

The analysis of satellite imagery corroborates the finding that the manufacturing sector has been expanding during the period. Comparing the areas around the 132 small and medium-sized companies interviewed for the IIM 2017 in 2009 and 2017, the analysis finds an increase from 591 possible production units (areas that look similar to the sites of the manufacturing companies surveyed for the IIM 2017) to 730, or an increase of 25 per cent for the period as a whole.

[1] Throughout the paper we will be referring to micro (1–9 employees), small (10–49 employees), medium (50–299 employees) and large (300 or more employees) firms, using standard World Bank definitions.

## 2 Data on Mozambican manufacturing firms

In the following, we will be making use of a number of datasets on the Mozambican manufacturing sector. Before we go into details about the latest firm survey (the IIM 2017) and the last rounds of enterprise censuses in the next sections, an overview of the datasets used is provided in Table 1.

Table 1

| Source | Type | Number of manufacturing firms | Advantage | Drawback |
|---|---|---|---|---|
| IIM 2017 (DERG, UNU-WIDER, and CEEG 2018) | Tracer survey | 523 | Full panel data<br>Detailed survey with economic accounts | Not nationally representative<br>Only firms initiated before 2009 |
| IIM 2012 (DNEAP 2013) | Quasi-representative sample | 739 | Detailed survey | Not nationally representative |
| CEMPRE 2015 (INE 2015) | Population census | 3,548 | Covers all provinces | May exclude some micro firms |
| CEMPRE 2011 (revision) (INE 2011) | Population estimate | 3,245 | | Many firms found not to be existing in 2012 |
| CEMPRE 2002 (INE 2011) | Population census | 2,757 | Covers all provinces | May exclude some micro firms |
| Schou and Cardoso (2014) | Population estimate | 9,203 | Manufacturing firm estimate based on multiple sources | Imputed estimates (not firm-level data)<br>Not official census, but built on provincial lists |

Source: Authors.

### 2.1 IIM 2017

Being a tracer survey, the IIM 2017 was implemented during July–October of 2017 with the overarching goal of finding and re-interviewing all firms contained in DNEAP (2013). A few changes were made to the process and questionnaire of which two are worth highlighting: firstly, the enumerators hired were all recent graduates of university degrees such as economics and accountancy. This helped ensure a high data quality of the economic indicators. Secondly, the interviews were conducted using tablets, meaning that data quality control could be performed throughout data collection.

Out of 831 firms originally interviewed in 2012, 523 firms were still in operation, 216 were found to have closed in the period between the two survey rounds, and 92 were either not traceable or refused to partake in the survey.

The sampling of IIM 2017 was in effect done in 2012. The procedure followed by the team back then is described in the IIM 2017 (DERG, UNU-WIDER, and CEEG 2018) report as follows:

> Out of the population of manufacturing firms, six provinces, which had the highest concentration of manufacturing enterprises, were selected into the sample. It was subsequently decided to include the province of Tete because of developments during the

time of sampling in 2011. Within these provinces, the sample was limited to the districts with the highest concentration of companies. Therefore, mostly companies in large urban areas are included in the sample. Overall, the seven selected provinces contained 85 per cent of the total number of manufacturing companies. The selected locations represented more than 60 per cent of Mozambican manufacturing firms at the time. Of all the Mozambican manufacturing companies in 2004, 77 per cent were micro, 17 per cent small, and only 5 per cent of medium size, which is reflected in the sampling of the survey. (p. 9).

## 2.2 Manufacturing firm population estimates

The latest available census of companies in Mozambique is the 2014–15 firm census (*Empresas em Moçambique: Resultados do segundo censo nacional* 2014–15) (INE 2015). The 2014–15 census encompasses 51,237 companies employing some 583,000 people—of which 3,548 (employing some 99,000 people) were in manufacturing.

This constitutes a slight increase from the 3,245 manufacturing companies documented in the 2011-revision of the 2002 census (INE 2011).

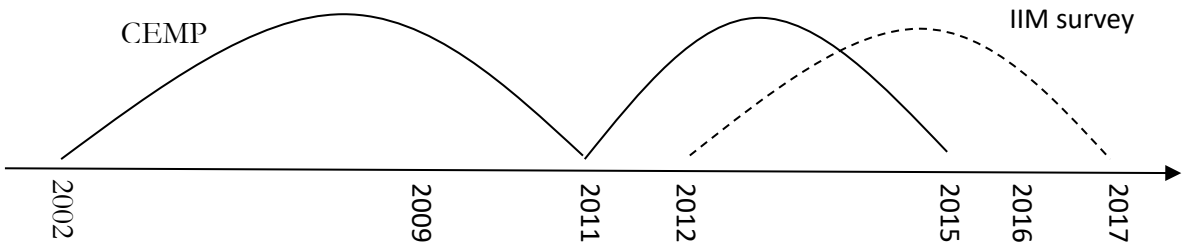
However, the IIM 2012 (DNEAP 2013) found that the 2011 census did not provide a reliable list of Mozambican manufacturing companies as it both contained many entries not actually in operation and failed to include many companies that did operate.

Therefore, Schou and Cardoso (2014) compared the 2011 census with a list of companies registered by the national and provincial authorities responsible for firm registration and tried to provide a revised estimate of the manufacturing firm population. It was found that the 2011 census grossly underrepresented micro firms and underrepresented small firms but provided a fairly accurate picture of medium and large manufacturing firms. Combining information from the 2011 census (INE 2011), the administrative lists, the IIM 2012 (DNEAP 2013) and the 2007 population census (INE 2007), Schou and Cardoso (2014) arrived at an estimate of 9,203 manufacturing companies (in 2011).

## 2.3 Comparing over time

To assess the state of manufacturing in Mozambique, it is important to look at developments over time. An issue here is that the key data series are not produced every year, which can make comparisons tricky. While manufacturing GDP and satellite imagery data is available every year, this is not the case for firm surveys and firm censuses. Overall, we consider three main time periods for which we have data, namely around the years 2002, 2011, and 2016. Figure 1 illustrates the years in which we have various data sources. The solid line shows the years of the enterprise census, namely 2002 and 2015 with a revision in 2011 (INE 2002, 2011, 2015). The dashed lines indicate different aspects of comparisons over time within the two IIM surveys. While the surveys that are compared were implemented in 2012 and 2017 (dashed line), the main economic indicators in those surveys are lagged with a year, namely to 2011 and 2016. Finally, when considering sampling issues, the years of comparison are 2009 and 2017, since the main concern with the results of IIM 2017 is that it only contains firms launched in 2009 or earlier.

Figure 1: Comparisons over time




Source: Authors.

## 3 Re-weighing the main results of survey

In this section, we calculate survey weights based on the subpopulations of first CEMPRE15 and since the estimates from Schou and Cardoso (2014). In both cases, the weights are estimated by province and size category. Table 2 shows the distribution of firms in each category for the three datasets.

Table 2: Distribution of manufacturing firms across population subgroups

| | IIM 2017 | | | CEMPRE 2015 | | | Schou and Cardoso 2014 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Micro | Small | Medium | Micro | Small | Medium | Micro | Small | Medium |
| Maputo City | 88 | 38 | 15 | 504 | 238 | 65 | 3,205 | 306 | 13 |
| Maputo Prov | 45 | 19 | 6 | 194 | 151 | 74 | 1,837 | 170 | 9 |
| Gaza | 41 | 5 | 2 | 151 | 16 | 7 | 134 | 11 | 3 |
| Sofala | 86 | 12 | 3 | 253 | 87 | 26 | 1,035 | 100 | 1 |
| Manica | 56 | 11 | 3 | 105 | 23 | 14 | 314 | 25 | 3 |
| Nampula | 33 | 13 | 4 | 106 | 71 | 23 | 881 | 68 | 10 |
| Tete | 31 | 5 | 2 | 108 | 30 | 7 | 128 | 12 | 1 |
| Total | 380 | 103 | 35 | 1,421 | 616 | 216 | 7,534 | 692 | 40 |

Source: Authors.

By applying the weights of either source of firm population, the results of IIM 2017 become indicative of the situation at the population level within each population subgroup.

The analysis bases itself on two important assumptions: first, that either CEMPRE15 or Schou and Cardoso (2014) constitutes a precise estimate of the population of manufacturing firms in Mozambique, and second that the firms present in IIM 2017 can be seen as a random sample of these. While it might be reasonable to believe the first assumption given the work and processes of the Instituto Naçional de Estatistica (INE) as well as Schou and Cardoso, the second assumption fails almost by definition since IIM 2017 has not been randomly sampled from either of the two population level datasets, and all firms included were established in 2009 or earlier.

Keeping the data constraints in mind, we proceed with caution to calculate weights relating to each of the two population estimates and revisit some of the main results of IIM 2017 in this light. The weights obtained for each province/size subgroup are simply the inverse of the probability of being in the sample. For instance, if 30 firms are present in a subgroup in IIM 2017, 60 in

CEMPRE15, and 90 in Schou and Cardoso (2014), the probabilities of a firm being in the sample are one half and one third respectively, so the CEMPRE15 weight for that group will be 2 and the SC-weight will be 3. Mathematically, the weights are calculated as follows:

$$W(CEMPRE)_{ps} = N_{ps}/n_{ps}$$

$$W(SC)_{ps} = N_{ps}/n_{ps}$$

We do not allow the weights of individual subgroups to be below one since we know for a fact that the firms in IIM 2017 existed at the time of the survey, hence the population cannot be smaller than one.

The various weights are presented in Table 3. Using CEMPRE15 as population, we re-weigh the observations in IIM 2017 by factors of between 1.88 (micro firms in Manica) and 12.33 (medium firms in Maputo Province). If we use the population estimates of Schou and Cardoso (2014), we re-weigh our sample subgroups by factors ranging from 1 (medium firms in Maputo city, Sofala, Manica and Tete) to 40.82 (micro firms in Maputo Province).

Table 3: Population weights for province/size subgroups

| | CEMPRE15 | | | Schou and Cardoso (2014) | | |
|---|---|---|---|---|---|---|
| | Micro | Small | Medium | Micro | Small | Medium |
| Maputo City | 5.73 | 6.26 | 4.33 | 36.42 | 8.05 | 1.00 |
| Maputo Prov. | 4.31 | 7.95 | 12.33 | 40.82 | 8.95 | 1.50 |
| Gaza | 3.68 | 3.20 | 3.50 | 3.27 | 2.20 | 1.50 |
| Sofala | 2.94 | 7.25 | 8.67 | 12.03 | 8.33 | 1.00 |
| Manica | 1.88 | 2.09 | 4.67 | 5.61 | 2.27 | 1.00 |
| Nampula | 3.21 | 5.46 | 5.75 | 26.70 | 5.23 | 2.50 |
| Tete | 3.48 | 6.00 | 3.50 | 4.13 | 2.40 | 0.50 |

Source: Authors.

The main differences between weighting using the CEMPRE15 database and the estimates from Schou and Cardoso (2014) arise from the fact that the former includes relatively fewer micro firms and relatively more small and medium firms.

### 3.1 Re-visiting results of IIM 2017

For a full overview of non-weighted results of the IIM 2017 survey, we refer to the descriptive report (DERG, UNU-WIDER, and CEEG 2018). As outlined in the introduction, the survey showed that the firms in the sample did not perform as well as hoped. For instance, the annual change in workforce for the companies was minus 6.5 per cent p.a., which led to the fact that the total workforce of the sampled firms was reduced from 13,900 to 8,100 between 2009 and 2017. Likewise, the share of firms reporting losses increased, fear of being shut down was extremely high, credit constraints were perceived as high, and informality and bribes persisted.

The main results of the re-weighting exercise are presented in Table 4. For most of the chosen indicators, the results become a bit more positive when using weights from CEMPRE15, while if we use the population estimates from Schou and Cardoso (2014), the main challenges faced by the sector are exacerbated. This relates to the note above about micro firms being relatively less represented in CEMPRE15 and more in Schou and Cardoso (2014) as well as the fact that micro firms generally seemed to be worse off in IIM 2017.

Table 4: Re-weighing of main results of IIM 2017

| | IIM 2017sample | CEMPRE15 weights | SC weights |
|---|---|---|---|
| Annual change in workforce | -6.52 | -5.86 | -7.76 |
| Total Value added | 3705316 | 5634833 | 1319976 |
| Average labour productivity | 163745 | 208314 | 145878 |
| Share of firms reporting losses | 0.32 | 0.33 | 0.35 |
| Share keeping formal accounts | 0.36 | 0.44 | 0.28 |
| Share fearing of being shut down | 0.42 | 0.41 | 0.48 |
| Credit constrained | 0.42 | 0.40 | 0.45 |
| Share of fully informal firms | 0.29 | 0.24 | 0.32 |
| Share reporting others bribe | 0.48 | 0.48 | 0.48 |

Source:Authors,

The same overall pattern is confirmed by the fact that average total value added is 52 per cent higher when applying CEMPRE15 weights and 65 per cent lower with SC weights. Labour productivity follows the same pattern, although not as pronounced. Looking at shares of firms that keep formal accounts, have fear of being closed down, are credit constrained, and are fully informal we reach the same conclusion, namely that by applying CEMPRE15 weights we arrive at slightly more positive results while the weights from Schou and Cardoso leads to more negative outcomes.

## 4 Alternative sources of information on the manufacturing sector in Mozambique

Having considered how the results of the IIM 2017 correspond to different weights, we now change focus and investigate two other indicators of manufacturing sector performance: CEMPRE and satellite imagery.

### 4.1 CEMPRE

The CEMPRE 2014/15, (INE 2015), documents over 70,000 companies in Mozambique, including some 3,500 in the manufacturing sector. Previously, the CEMPRE came out in 2002/03 and in a revised version in 2011 (INE 2011).

For our purposes, three questions are of interest:

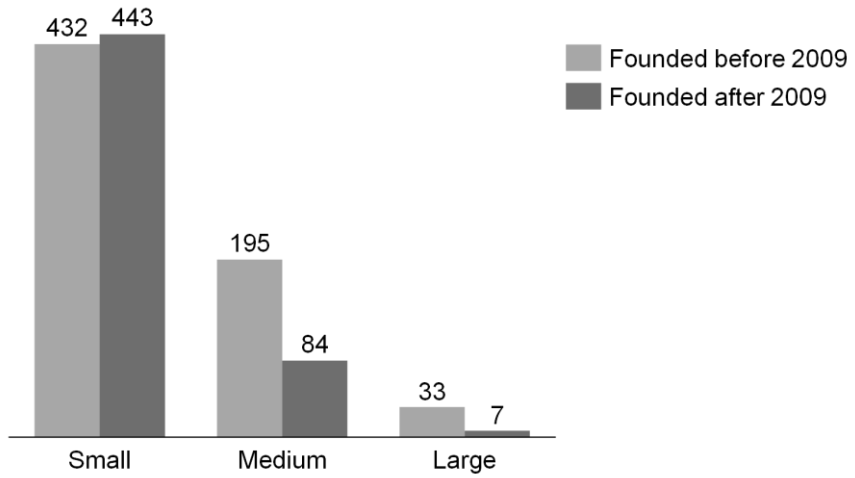
1. Are there any systematic differences in the number, type, and performance of manufacturing companies launched before and after 2009?
2. Did the number (and size) of manufacturing companies increase in the 2014 census compared to earlier censuses?
3. Which sectors and provinces perform relatively better or worse compared to earlier censuses?

As pointed out by Schou and Cardoso (2014), the Mozambican enterprise censuses cannot necessarily be considered reliable indicators of micro companies (many micro companies are registered incorrectly or not at all), but the larger the firm size, the more likely it is that the firm is correctly represented in the census. For this reason, we will focus in the following on small, medium and large companies.

Figure 2 shows that approximately half (45 per cent) of the non-micro firm entries are from firms established after 2009, including more than half of small companies and almost a third of medium sized companies. If newly established companies account for a large proportion of the total

expansion of the Mozambican manufacturing sector, this could be consistent with a decrease in size for established companies as found in the IIM 2017.

Figure 2: Number of companies established before and after 2009




Source: Authors' calculations using CEMPRE15 data.

The total number of people employed by firms established after 2009 is 81,000 while the companies established after 2009 employ some 26,000 people. This is understandable since most of the large manufacturing companies were established before 2009 and that the 33 large companies established before 2009 by themselves employ some 48,000 people.

Considering the geographical distribution of firms, it appears that while the companies founded before 2009 are concentrated in the traditional industrial centers of Maputo, Beira and Nampula, the companies established after 2009 are more spread out across the country, with Nampula, Zambézia and Tete provinces registering the largest proportion of companies established after 2009 as documented in Table 5. Maputo City, Gaza and Niassa registered the lowest proportion of companies established after 2009, while the remaining six provinces registered around the national average of 45 per cent.

Table 5: Number of companies by size, starting year and province

| | Small | | Medium | | Large | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before 2009 | After 2009 | Before 2009 | After 2009 | Before 2009 | After 2009 | Before 2009 | After 2009 | % after 2009 |
| **Niassa** | 9 | 5 | | | | | 9 | 5 | 36 |
| **Cabo Delgado** | 10 | 13 | 3 | 0 | 2 | 0 | 15 | 13 | 46 |
| **Nampula** | 25 | 74 | 22 | 12 | 7 | 3 | 54 | 89 | 62 |
| **Zambézia** | 20 | 38 | 4 | 3 | 1 | 0 | 25 | 41 | 62 |
| **Tete** | 8 | 34 | 6 | 5 | 1 | 0 | 15 | 39 | 72 |
| **Manica** | 14 | 11 | 10 | 8 | 2 | 0 | 26 | 19 | 42 |
| **Sofala** | 53 | 48 | 20 | 13 | 4 | 1 | 77 | 62 | 45 |
| **Inhambane** | 30 | 31 | 3 | 2 | | | 33 | 33 | 50 |
| **Gaza** | 15 | 6 | 8 | 4 | 1 | 0 | 24 | 10 | 29 |
| **Maputo province** | 68 | 98 | 59 | 24 | 8 | 1 | 135 | 123 | 48 |
| **Maputo Cidade** | 180 | 85 | 60 | 13 | 7 | 2 | 247 | 100 | 29 |
| **Total** | 432 | 443 | 195 | 84 | 33 | 7 | 660 | 534 | 45 |

Source: Authors' calculations using CEMPRE15 data.

The many new companies in Nampula province can perhaps partly be attributed to the developments around Nacala, where a special economic zone was established in 2009 and from where much of the Tete coal is shipped. The surge of new companies in Tete can likely be attributed to the coal boom following discovery of large reserves of coal in Moatize around 2008. Finally, the large proportion of new companies in Zambézia is perhaps the province slowly beginning to catch up—66 small, medium and large companies is still not much for a province with over five million inhabitants.

In terms of industrial sectors, the industrial landscape in Mozambique continues to have a very large proportion of companies in the food sector—accounting for more than a third of companies founded before 2009 and almost half of the companies founded after 2009, as documented in Table 6. The food sector also exhibits an even higher proportion (53 per cent) of new companies than the manufacturing sector as a whole. The tobacco, apparel, rubber and plastic, and other manufacturing sectors added relatively few new companies after 2009 while the wood and non-metallic mineral sectors experienced added a larger proportion of new companies than the manufacturing sector as a whole.

Table 6: Number of companies by size, starting year and sector

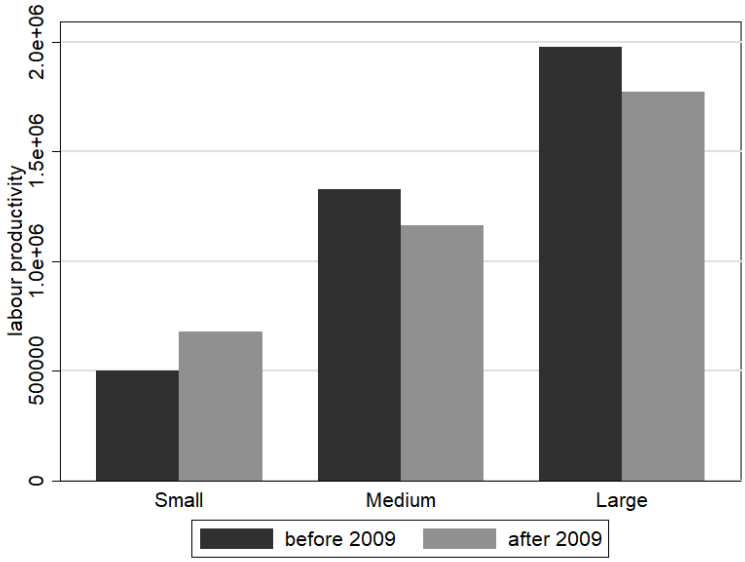
| | Small | | Medium | | Large | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before 2009 | After 2009 | Before 2009 | After 2009 | Before 2009 | After 2009 | Before 2009 | After 2009 | % after 2009 |
| **Food** | 160 | 220 | 51 | 38 | 19 | 4 | 230 | 262 | 53 |
| **Beverages** | 10 | 15 | 10 | 3 | 5 | 0 | 25 | 18 | 42 |
| **Tobacco** | 4 | 1 | 5 | 0 | 1 | 0 | 10 | 1 | 9 |
| **Textiles** | 9 | 3 | 5 | 4 | | | 14 | 7 | 33 |
| **Apparel and leather etc.** | 18 | 5 | 7 | 0 | 3 | 0 | 28 | 5 | 15 |
| **Wood** | 46 | 56 | 10 | 10 | | | 56 | 66 | 54 |
| **Paper** | 6 | 1 | 10 | 2 | | | 16 | 3 | 16 |
| **Publishing and printing** | 39 | 23 | 8 | 0 | 0 | 1 | 47 | 24 | 34 |
| **Chemicals** | 9 | 7 | 13 | 6 | | | 22 | 13 | 37 |
| **Rubber and Plastic** | 15 | 4 | 11 | 2 | | | 26 | 6 | 19 |
| **Non-metallic mineral products** | 16 | 40 | 14 | 6 | 1 | 0 | 31 | 46 | 60 |
| **Basic metals** | 6 | 4 | 8 | 1 | 1 | 0 | 15 | 5 | 25 |
| **Fabricated metal products** | 28 | 31 | 16 | 5 | 0 | 2 | 44 | 38 | 46 |
| **Machinery and equipment** | 8 | 8 | 4 | 1 | | | 12 | 9 | 43 |
| **Furniture etc.** | 28 | 20 | 10 | 2 | 1 | 0 | 39 | 22 | 36 |
| **Other manufacturing** | 30 | 5 | 13 | 4 | 2 | 0 | 45 | 9 | 17 |
| **Total** | 432 | 443 | 195 | 84 | 33 | 7 | 660 | 534 | 45 |

Source: Authors' calculations using CEMPRE15 data.

With a population growth of almost 3 per cent per year, the manufacturing sector GDP per capita has barely grown from 2011 to 2017. As the population grows, demand for basic goods (food, clothing, housing, etc.) increases. The sector breakdown above shows that many of the newly established companies are in sectors producing basic goods for the local population—companies in the food, apparel, wood, non-metallic minerals, fabricated metal products, and furniture account for 82 per cent of the companies established after 2009.

As for labour productivity, Figure 3 illustrates that medium and large companies established after are likely to be less productive than their older peers, but small companies are likely to be more productive when younger.

Figure 3: Labour productivity by starting date for small, medium and large firms, 2017

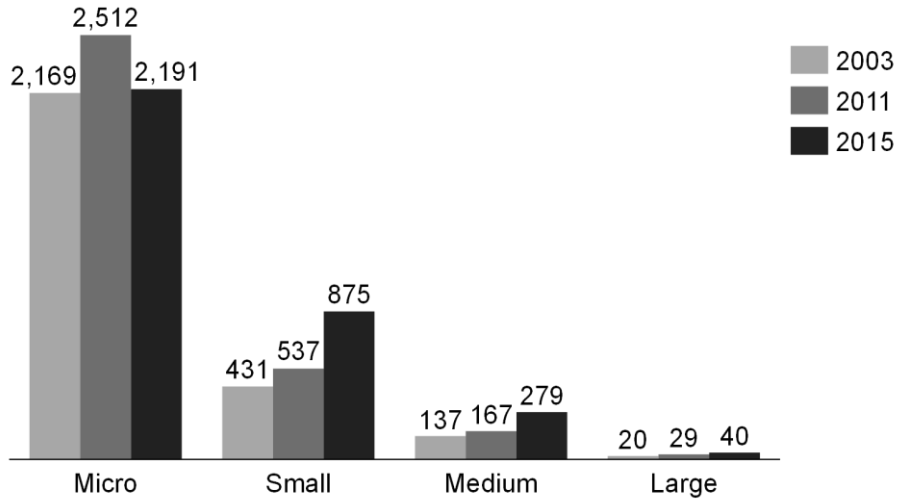



Source: Authors.

Having studied in detail the differences between old and new firms in the most recent census, we now turn to comparing censuses over time.

Figure 4 displays the number of firm entries in each census by firm size. While the number of micro firms hovers around the same level, there is a large increase of around 100 per cent in the number of small, medium and large companies registered from 2003 to 2015, with most of the increase taking place after 2011. The companies interviewed for the CEMPRE in 2003, 2011, and 2015 (INE 2011, 2015) employed a total of 53,000, 72,000 and 107,000 employees.

Figure 4: Number of companies by firm size in the three latest enterprise censuses



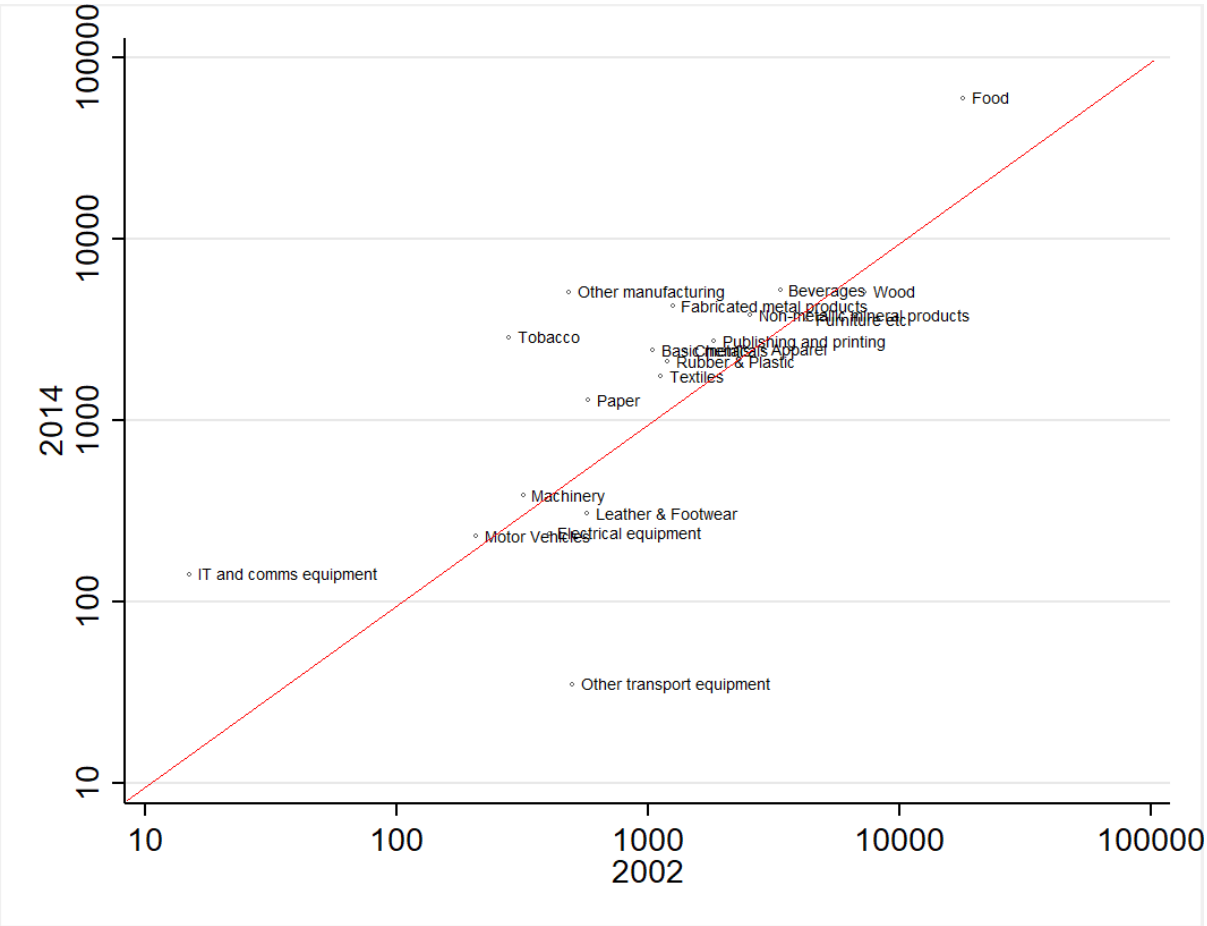

Source: Authors' calculations using data from CEMPRE 03, CEMPRE11 and CEMPRE15.

To study the performance of manufacturing firms over time across provinces and sectors, we construct two pseudo-panels based on totals and averages within province or sector subgroups. This allows us to evaluate which sectors and provinces have performed better or worse over time.

Figures 5 and 6 show the logarithm of the total number of employees in each sector and province respectively for the years 2002 and 2014. All markers placed above the 45-degree line indicate an overall increase while a placement below the line indicates a decrease for the specific group.

The results show that the subsectors with the largest increase in workforce are IT and communications equipment, Tobacco, and Other manufacturing, while the worst performing sectors include Other transport equipment, Leather and footwear, and Electrical equipment. There is thus no consistent evidence that the types of manufacturing firms that grow the most in Mozambique are more complex or technology-intensive than other.

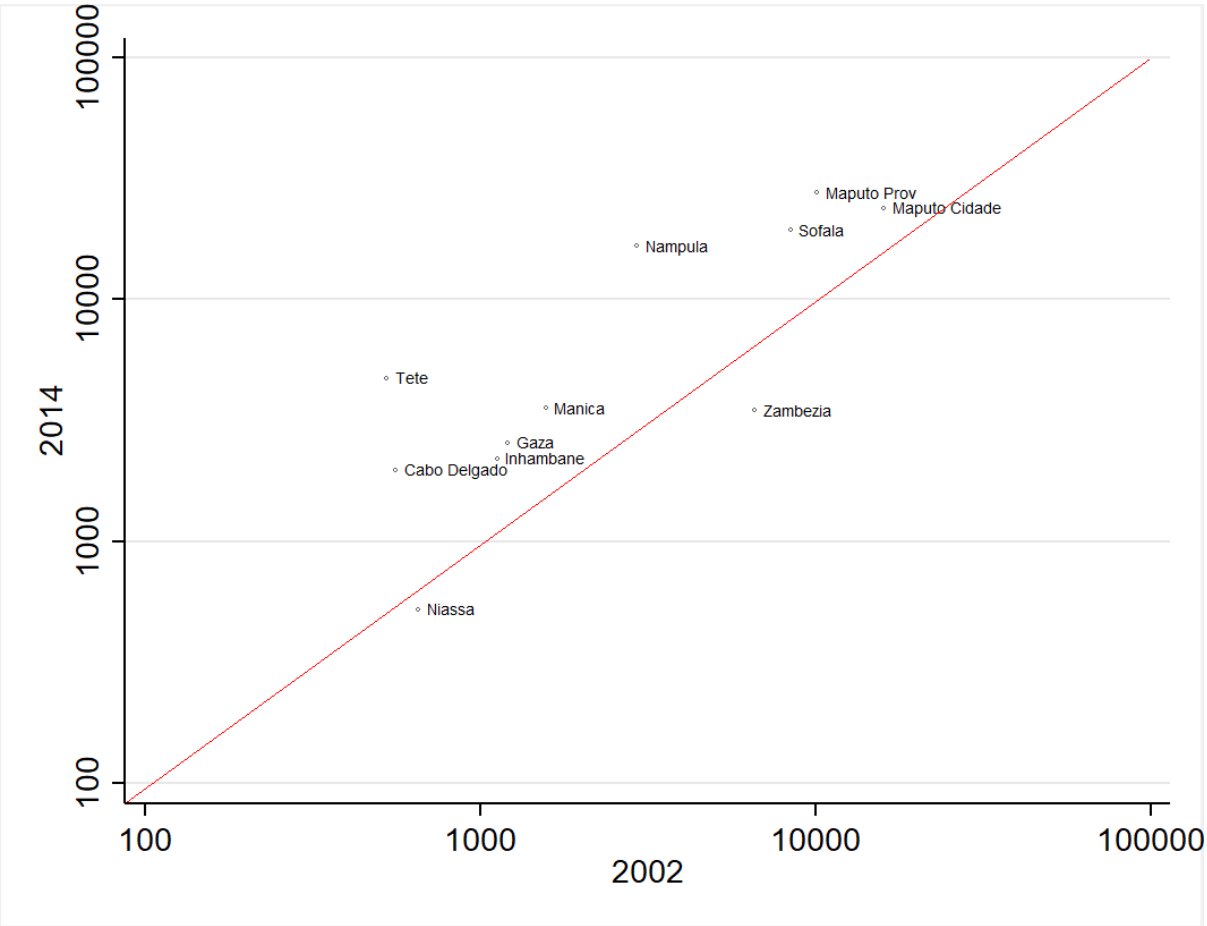
Figure 5: Total number employees in 2002 and 2014, by sector




Source: Authors.

Looking at differences across provinces, the provinces that have seen the largest increases are Tete, Nampula and Maputo Province, while Zambézia and Niassa have seen a decrease in the number of employees in manufacturing. So while Zambézia ranks high in the number of firms launched since 2009, the sector generated more jobs in 2002 than in the year of the latest round of the census.

Figure 6: Total number employees in 2002 and 2014, by province




Source: Authors.

## 4.2 Satellite imagery

Many firms have emerged since 2009, and especially the smaller newcomers seem to be more productive in terms of business volume per worker than their older peers. However, the methodology behind the registration of firms in CEMPRE15 is not described in much detail by the INE, and as noted previously, the team behind the sampling of IIM 2012 (DNEAP 2013) questioned the completeness of the database. This section therefore explores alternative evidence, by looking at the number of potential manufacturing units from a different perspective, namely, the sky.

First, the GPS coordinates collected by enumerators while implementing the IIM 2017 survey were used to obtain satellite images of all firms and their surroundings through Google Maps API. A quick assessment revealed that there was a stark difference in the way firms of different size look from above. While firms categorized as large or medium in most cases were easily identifiable from satellite images, and small firms often so as well, micro firms were very hard to distinguish from residential buildings, and are generally located in residential areas or in small buildings along major roads.

The aerial appearance of a small, medium, or large manufacturing firm depends mostly on its location in relation to the nearest urban center. Firms located in city centers are most often located at the ground level of apartment buildings, and thus not observable from a bird's-eye perspective. However, most of the geo-coded firms are located around the outskirts of cities along larger access

roads or in industrial agglomerations. In these places, buildings belonging to firms with at least ten employees have a distinct appearance: a relatively large production building with a metal roof (often painted) surrounded by a small open space and a fence. Buildings, whose appearances fit the description above are defined in the following as 'potential production units'.

The purpose of this analysis is to count the number of potential production units within a radius of around 500 meters from any small, medium or large firm in the IIM 2017 sample, in the years 2009 and 2017. This will provide an indication of the expansion of the sector, since new manufacturing firms need buildings to operate.

Many potential production units observed from satellite images will not be part of any manufacturing company, but are in fact simply storage facilities, shops, or firms within other sectors. However, assuming the errors in categorization of firms are not systematically different in the two years, by subtracting the number of potential production units in 2009 from those in 2017, we cancel out errors made in both years. Further, by assuming that manufacturing firms constitute a constant fraction of the observed potential production units, the percentage change of the measure within an area corresponds to the percentage change in manufacturing firms.

In principle, it is possible to scan through satellite imagery of the entirety of Mozambique, taking note of all potential production units in the two years, but in practice, this would be extremely time-consuming, and most areas would contain very few firms. We therefore define radii of approximately 500 meters around the 132 firms in IIM 2017 with at least ten employees, and focus our attention on these zones. The benefit of limiting our sample in this way is that we know for a fact that manufacturing firms exist in these areas, and that at least some amount of clustering is present in the sector. The caveat is that new industrial zones that may have appeared since 2009 are not included. However, it is not unlikely that the rates of expansion within the sampled areas are representative for the country as a whole.

Once overlaying the circles that define our area of analysis onto satellite images from 2017 in Google Earth, we proceed by 'tagging' all potential production units within the zones using a tool in Google Earth called 'path' and note the number of units within each circle (not overlapping). We then use a second tool to scroll back in time and take note of the number of units in 2009. Figure 7 shows a graphical example of the methods in a place where a few new potential production units have emerged between the two years.

An alternative approach to the problem would have been to use machine-learning techniques such as object identification through convolutional neural networks to identify changes in the number of potential production units over time. However, two factors contribute to making this a less viable solution: firstly, historical satellite data is not yet publicly available through Maps API, so obtaining the imagery for 2009 in the right size and resolution is not straight-forward. Secondly, an initial sample size of 132 firms is orders of magnitude smaller than recommended sample sizes for image recognition of objects that are not always easily distinguishable from their surroundings.

Figure 7: Analyzing satellite imagery

Section of Beira 2009 Section of Beira 2017

Notes: In the images, the yellow and red dots represent locations of a small and medium sized firm in the IIM sample. The green circles define a 0.05 degree (500 meters) radius around sampled firms, and the thin, white, jagged line is a path drawn on top of buildings tagged as potential production units. The two images are of the same area in Beira in 2009 and 2017. As can be seen, several potential production units have emerged in the area between the two years.

Source: Google Earth.

Table 7 shows the main results. 730 potential production units were identified within radii of 500 meters from the GPS coordinates of 132 small and medium sized companies in the IIM 2017 sample. Out of these, 591 also existed in 2009, judged from the historical satellite images analyzed. This corresponds to an increase of 139 potential production units, or 24 per cent. This relates well with the overall increase in manufacturing GDP of 23 per cent observed from Figure 2, suggesting that counting the number of potential production units from satellite images might be a useful proxy for assessing changes in manufacturing activity.

Table 7: Changes in potential production units 2009–17, by province

| | Production units 2009 | Production units 2017 | Change | Change in % |
|---|---|---|---|---|
| Maputo City | 320 | 375 | 55 | 17 |
| Maputo_Prov. | 71 | 94 | 23 | 32 |
| Gaza | 5 | 9 | 4 | 80 |
| Sofala | 88 | 112 | 24 | 27 |
| Manica | 48 | 68 | 20 | 42 |
| Nampula | 39 | 42 | 3 | 8 |
| Tete | 20 | 30 | 10 | 50 |
| Total | 591 | 730 | 139 | 24 |

Source: Authors.

When comparing Table 7 to Table 5, it appears that the provinces that have seen the largest share of manufacturing firms launched after 2009 (using CEMPRE15 data) also seem to have the largest increases in the number of potential production units (using satellite imagery). This suggests that

census and satellite imagery data broadly tend to corroborate each other, when it comes to the development of the Mozambican manufacturing sector.

## 5 Conclusions

The analysis began by re-estimating some of the results of a recent manufacturing company survey, the IIM 2017 (DERG, UNU-WIDER, and CEEG 2018) using two different sets of weights corresponding to two different manufacturing firm population estimates (the CEMPRE15 and Schou and Cardoso 2014). As the IIM 2017 documents decreasing firm sizes across provinces and firm size, adding different weights did not result dramatically different estimates for firm growth.

Applying CEMPRE15 weights (more emphasis on larger firms) reduces the average drop in employees from 6.5 people to 5.9 people, while applying Schou and Cardoso (2014; more emphasis on micro firms) weights increases it to 7.8 people.

To triangulate the result of negative growth in the sample of Mozambican manufacturing companies, the analysis progressed to consider manufacturing GDP, where a 3.5 per cent average growth rate (from 2011 to 2017) was documented, only slightly higher than population growth of 2.9 per cent per year for the period, but still high in absolute terms.

It was suggested that negative growth in the IIM 2017 sample (that only considers companies established before 2009) could be reconciled with positive overall growth in the manufacturing sector if a lot of manufacturing companies were established after 2009. Considering the latest manufacturing firm census (the CEMPRE15) this is exactly the case, as companies established after 2009 accounted for almost half of the total number of entries in the census data.

It was also suggested that many of the newly established companies are focused on providing the same basic goods for a growing population, thus expanding the volume of manufactured goods, but not producing more advanced goods. As many as 82 per cent of the companies established after 2009 are in sectors where this could be the case.

This result was corroborated by findings from the analysis of satellite imagery, where visual analysis of the areas in which the companies in the IIM 2017 sample are located suggested that the number of 'potential production units' across 132 areas increased by 24 per cent from 2009 to 2017.

The results indicate that to be consistent with the general development within the sector, a future survey of manufacturing firms in Mozambique should not only trace the firms already interviewed in 2012 and 2017, but also attempt to draw a more representative sample of the population of firms. To this end, a combination of CEMPRE15 and more frequently updated satellite images of the main cities is likely to provide a better sampling frame.

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