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UNCOVERING DYNAMICS IN THE ACCUMULATIONOF

TECHNOLOGICAL CAPABILITIES AND SKILLS IN THE MOZAMBICAN

MANUFACTURING SECTOR

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Uncovering dynamics in the accumulation of technological capabilities and skills in the Mozambican manufacturing sector

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Abstract

This paper examines the formation and accumulation of skills and technological capabilities in the Mozambican manufacturing sector. To this effect, it deploys Sanjaya Lall's technology capabilities conceptual and methodological framework to examine these issues for the Mozambican metalworking and light chemical sectors in the context of historical dynamics taking place in Mozambique in the economic and industrial policy spheres. This analysis shows that these two industries are experiencing a process of gradual technological obsolescence, combined with a progressive simplification of production processes that is leading to a weakening of their technology capability and skill base. In this context, neither foreign direct investment, nor other mechanisms of technology transfer identified in the literature as contributing to the process of technological and skills accumulation, appear to have been able to reverse these trends. In light of available evidence on recent industrial (policy) developments, this paper argues that this process can be seen as a response to a deteriorating policy and economic environment that in the past two decades has undermined investments in industrial technological development in Mozambique.

Keywords: Manufacturing; Technology Capabilities; Skills; Industrial Policy; Sub-Saharan Africa; Mozambique.

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1. Introduction

Since its independence from Portugal in 1975 Mozambique has undergone three decades of economic, political and social transformation. Following the departure after independence of most of the Portuguese settler population, which, at the peak of the colonial period numbered around 250,000 people, the Mozambican economy went into a virtual standstill, experiencing a very sharp drop in economic activity. As a response to this situation, the post-independence Frelimo government adopted in the late 1970s a strategy of central planning of the economy, aimed at achieving rapid economic growth and ending underdevelopment by the 1990s. The failure of this strategy to achieve these goals, partly due to its unrealistic nature, but also to the multiple economic and political constraints the country faced after independence, led the government to adopt in the mid 1980s a comprehensive agenda of economic liberalisation and reform. During its initial stages this agenda centred on macroeconomic stabilisation and structural adjustment of the economy, with efforts shifting towards more general (economic) governance considerations during the late 1990s and the 2000s. Having been the sixth most industrialised economy in Sub-Saharan Africa during the late colonial period (World Bank, 1990), industrial development concerns have traditionally occupied a prominent place in development policy formulation and debates in Mozambique. This is true both for the period of central planning of the economy, during which the government's development strategy was largely centred around triggering a process of accelerated heavy industrialisation (Pitcher, 2002), as well as to the (post) adjustment period, in which privatisation, enterprise reform and, later, investment climate concerns have been an important element of policy debates on economic and governance reform in Mozambique (See Cramer 2001; Pitcher 2002; World Bank, 1995, 2005; Lledó, 2008).

It is against this background that this paper examines manufacturing dynamics in Mozambique from an industrial technology perspective. It focuses on two main themes that are deemed critical to understand current patterns of technology and skill formation in the Mozambican manufacturing sector: First, the analysis of underlying historical trends of skills and technology capability accumulation; Second, the exploration of different forms of acquisition of technological capabilities and skills by manufacturing firms in Mozambique and of their impact on these their skills and capability base. The paper examines these issues against the broader institutional, policy and economic setting in which developments of this nature have unfolded in Mozambique. This approach provides a novel insight to industrial development considerations in Mozambique, inasmuch no specific analysis has been

undertaken of these issues. Still, it is in line with other research examining the links between technology change, industrial growth and economic development, including work in the technology capability field (e.g. Lall, 1992, Bell & Pavitt, 1995, Biggs *et al*, 1995).

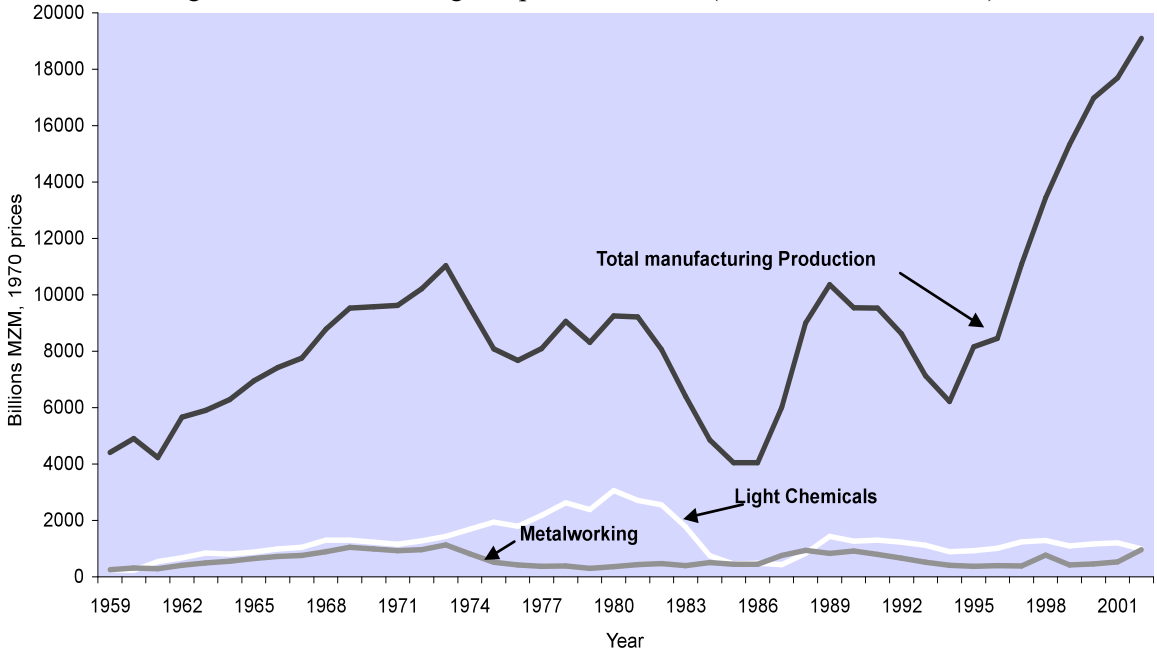
To this end, this paper makes use of Sanjaya Lall's technology capability conceptual and methodological framework (Lall 1992, 1993) to examine these issues for firms operating in two manufacturing sectors: metalworking and light chemical industries. In this sense, it follows similar applied work in this line of research undertaken for other developing countries, such as Ghana (Lall *et al*, 1994) Sri Lanka (Deraniyagala, 2001a,b), Tanzania (Deraniyagala & Semboja, 1999), Kenya (Wignaraja & Ikiara, 1999), Mauritius (Wignaraja 2002) and, more recently, Uganda, Philippines, Malaysia, Indonesia and Thailand (Rasiah, 2004). Lall's framework identifies capabilities in the various areas of manufacturing that refer to firms' ability to engage in technology-related activities and efficient production. It focuses in those spheres of manufacturing that are considered relevant for these purposes, such as product development, process development and industrial engineering, identifying specific firm characteristics that relate to the different facets that technological capabilities take within the firm in each of these areas. The analysis presented here is largely centred on the examination of firm-level survey data collected during 2004 for firms employing ten or more workers operating in these two sectors in the capital province of Maputo, which accounts for 60 to 70 percent of industrial production in Mozambique (RPED, 2003). This survey covered a total sample of 90 firms, 56 in metalworking and 34 in the light chemicals sector, representing 98.3 and 75.6 percent of the true population of firms operating within the sampling frame predefined for this survey, respectively. The analysis of this data is complemented throughout this paper with the discussion of events taking place in Mozambique in the macro-, meso-economic and policy spheres, based on information obtained from interviews with key informants and other (secondary) sources.

2. Industrial development in Mozambique in perspective

Manufacturing activities in Mozambique have their origin in the late Portuguese colonial period. During the 19th and early 20th centuries the colonial authorities discouraged industrial activities in Mozambique, in order to eliminate all competition to Portuguese manufacturing firms and, thus, safeguard Portugal's ambitions for industrialization. However, by the mid 1950s the colonial authorities change this policy, allowing a growing number of manufacturing and processing activities to take place in Mozambique, so as to accommodate

for a growing Portuguese settler population, reduce export costs in agro-processing activities and absorb surplus second-hand industrial equipment increasingly available in Portugal (Hedges, 1999). In this context the Mozambican manufacturing sector experiences a process of rapid expansion, throughout the 1960s and early 1970s, with manufacturing value added increasing by 160 percent between 1959 and 1973 and investment in manufacturing almost quintupling during this same period. As a result, by 1973 the manufacturing sector in Mozambique is responsible for employing 99,500 workers in around 1500-2000 industrial

Figure 1: Manufacturing Output 1959-2001 (1970 Billion Meticais)



units and for generating over 11 percent of the country's GDP (Nunes, 1975; UNIDO, 2003).

Independence from Portugal in 1975 and the political turmoil that followed led to a sharp decline of industrial activity in Mozambique, with manufacturing output falling by over 30 percent between 1974 and 1976. A key factor behind this debacle was the departure of around 200,000 Portuguese settlers in the aftermath of independence, who had supported the growth of these manufacturing sectors by providing skilled labour and a growing demand for locally produced manufactured goods. As a response to this situation the post-independence Frelimo government adopted a model of central planning of the economy, intervening numerous industrial firms abandoned by its Portuguese owners, and formulating a strategy aimed at ending underdevelopment by the 1990s, based on a process of accelerated industrialisation (World Bank, 1985). Despite these intentions, by 1985 manufacturing activity had reached a historical low, with production down to levels of the early 1960s and

capacity utilisation estimated to be below 30 percent in most industries (World Bank, 1990). Several factors have been identified as being responsible for this poor industrial performance. These include the adoption of an unrealistic strategy of heavy industrialization and, as acknowledged by the Frelimo government, an excessive role of the state in industrial management, which generated poor incentives for private investment and undermined firms' ability to adapt to adverse conditions (Egero, 1987). Also, the civil war with Renamo and the continuous covert attacks from the South African apartheid regime, which were partly targeted to industrial infrastructures around Maputo, whilst causing general economic disruption elsewhere in the country. In addition, the recession that hit the world economy in the early 1980s and the drought affecting the country between 1982 and 1985, which reduced purchasing power in rural areas and the supply of raw materials to local industries, further damaged any prospects for industrial recovery (Castel-Branco, 1994; World Bank, 1985). Finally, the government appears to have been unable to address many of the structural constraints inherited from the colonial and post-colonial periods, such the industrial sectors' strong dependency on imports of intermediary goods and capital equipment – exacerbated by the balance of payments constraints that Mozambique faced in the 1980s, the general lack of technical and management skills or the use of increasingly obsolete manufacturing equipment.

In 1986 the Mozambican government initiated a process of structural reform and economic liberalisation that has continued until the present date. In the two decades that have elapsed since then, manufacturing activity has, overall, experienced a substantial recovery, with the share of manufacturing value added over GDP reaching a historical peak of 14.8 percent in 2004 (World Bank, 2007). However, this figure hides a less impressive reality, characterised by a growing concentration of manufacturing production in a small number of industries and firms, and a general thinning and weakening of Mozambique's manufacturing base, with manufacturing employment falling from over 111,000 workers in 1987 to 31,500 in 2005. Thus, by 1999 only nine firms accounted for 56 percent of industrial production, with the two largest, South African Breweries and Coca-Cola, responsible for 25.7 percent of industrial output (WTO, 2001). This process of growing concentration has continued into the 2000s as several industrial mega-projects have been established in Mozambique. Only Mozal, an aluminium smelter operating outside Maputo since 2000 and perhaps the most renowned of these projects, accounted for 6.7 percent of the country's GDP, 38 percent of its growth and 55 percent of its exports in 2004, whilst only employing around 1,100 workers (GOM, 2005). Meanwhile, other traditionally important sectors have fared less well. Some have

almost disappeared, as is the case of garments and textiles, barely accounting for 0.1 percent of manufacturing production in 2005, down from 23 percent in 1988, or the cashew-nut industry, which in the 1970s was one of the most important in the world.

Several factors have been identified as currently constraining manufacturing development in Mozambique. The most frequently cited refers to investment climate constraints imposed by a burdensome regulatory and administrative environment, and the general inadequacy of business infrastructures (RPED, 2003; CTA, 2004). In addition to these business environment considerations, the manufacturing sector suffers from other important structural problems that equally hamper industrial development in Mozambique. These include a tight monetary framework and a strategy of financial restraint that has raised the cost of investment, with lending rates in local currency above 25 percent in nominal terms throughout most of the late 1990s and 2000s. Also, a steep decline of business opportunities for local firms resulting from the strong competition exerted by the import and informal sectors, the collapse of upstream industries and the decline in demand caused by the general fall of formal employment in the economy. Additionally, this sectors' general technological backwardness and weak skill base has further undermined local manufacturing firms' competitiveness and market position in local and international markets (RPED, 2003). Finally, the privatisation of over 1,200 SOEs undertaken throughout the 1980 and 1990s does not appear to have lead to any significant modernisation of the manufacturing sector's technological base (Cramer, 2001; Pitcher, 2002).

These manufacturing dynamics have coincided with a weakening of the Mozambican policy and institutional framework for industrial development, further hampering the possibility of addressing these multiple constraints. At present there are various institutions and NGOs providing technical capacity building support, business development services and financial facilities to manufacturing firms in Mozambique. Yet, the overall impact and reach of these initiatives has been limited (Warren Rodriguez, 2007a). This has partly been the result of the difficult business environment faced by manufacturing firms operating in Mozambique, which has ultimately reduced the demand for this type of services; But it is also the consequence of the fragmentation and weak coordination of these interventions, the lack of a clear strategy for manufacturing development in Mozambique and the few resources devoted to these purposes. The government does have a National Strategy for the Industrial Sector, which sets out the guiding principles for government intervention in this sphere. However, this document, which dates back to 1997, presents these issues in very general and

formulaic terms and is generally considered not to have been implemented, with the main government institutions involved in private sector development promotion lacking the technical, financial and human resources to do so (Castel-Branco, 2002; Warren-Rodriguez, 2007b). Overall, these facts and events reflect the little attention that industrial development currently receives, both from the government and the international aid community, in a context where, beyond general investment climate considerations, manufacturing development does not constitute a priority area of policy intervention in Mozambique.

3. Obsolescence and simplification of technologies and skills in light chemical and metalworking industries

In general, events in the metalworking and light chemical sectors have mirrored those unfolding in the Mozambican manufacturing industry as a whole. The origin of these industries can be traced back to the mid 1950s. During this time the first industrial units in these two sectors are established in Mozambique as a response to the growing demand for industrial equipment, spare parts, repair & maintenance services and consumer goods from other manufacturing industries, the agricultural sector and, more generally, a growing Portuguese population settling in Mozambique. During the 1960s and early 1970s both sectors expand rapidly, coinciding with the colonial authorities' pursuit of a strategy of fast economic development in Mozambique. Hence, manufacturing output between grew at an average annual rate of 18.4 percent in light chemical industries and of 13.3 percent in metalworking 1959 and 1973, in a context in which industrial output and GDP were already growing at annual rates of 7.1 and 4.3 percent, respectively. As a result, by 1973 metalworking and light chemicals industries were employing 4,232 and 10,442 workers (UNIDO, 2003). The expansion and consolidation of activities in these two industries resulted in the establishment of several considerably large, integrated and, at the time, relatively modern firms, especially in the metalworking sector (Nunes, 1975). Independence in 1975 had a somewhat in both sectors. As with other sectors, metalworking industries experienced a very sharp decline in production, with output falling by 67.4 percent between 1973 and 1977 whilst light chemical production continued to growth at a steady pace until 1980. However, by 1986 production in both sectors had reached historical lows, similar to those of the early 1960s. Since then manufacturing activity in both metalworking and light chemical industries has remained relatively stagnant, with production barely growing by 2.8 and 18.7 percent in

real terms over the 1988 and 2002, and these sectors' share of aggregate manufacturing production falling to only 1.7 and 3.7 percent by 2005, respectively.

At present both sectors include firms producing a wide range of products. The metalworking industry in the province of Maputo is conformed by firms that engage in the transformation of metallic material into fabricated products.[1] It includes manufacturers of machinery, metal parts, transport equipment, metal furniture and galvanized steel places, as well as firms providing specialised engineering services involving the maintenance, repair and reconstruction of metal equipment and parts. Whilst producing a wide range of goods, firms in this sector generally make use of similar production technologies and manufacturing processes. On the other hand, light chemical industries in Maputo specialise in the production of plastic goods (household items, furniture, bags), rubber products, paints, glues, varnishes, detergents, foams, cosmetics, medicines or industrial and medicinal gases.[2] Due to the nature of the inputs used in these activities firms in this sector engage in substantial process engineering to ensure that inputs meet required production standards and are combined in the right proportions, since this will greatly affect the quality of the final product. Production processes in this sector also share certain technological traits. Hence, they generally involve mixing inputs, this constituting a crucial phase of their production processes, and in many cases (e.g. plastics, rubbers or foams), involve a process of extrusion.

3.1. Historical downward trend in technology capability accumulation

In their current configuration, both metalworking and light chemicals industries have an important presence of companies that were established during the colonial period, with almost 50 percent of firms surveyed for this research having been created prior to Mozambique's independence from Portugal in 1975.[3] Many of these firms still operate with the same core production technologies as they did during colonialism, with over a third of the equipment installed in these firms estimated to be at least 20 years old, i.e. dating back at least to the early 1980s and, probably, to the pre-independence period. In fact, for 36 of the firms surveyed, representing 40 percent of the sample, at least half of their equipment was 20 years old or more. Of these, 25 firms had at least three quarters of their machinery above this age and 11 operated entirely with equipment more than 20 years old. The survey conducted by ANEMM in 1995 of the Mozambican metalworking sector (ANEMM, 1996) serves to

[1] This sector corresponds to divisions 28, 29, 34 35 and 36 of the ISIC Rev.3.1 version.
[2] Light chemical industries correspond to divisions 24, 25 and 36 of the ISIC Rev.3.1 version.
[3] 48 percent of metalworking and 50 percent of light chemical firms.

confirm this, with 50 of the 60 firms surveyed for this study reporting equipment, on average, 20 years old or more; i.e. dating back at least to the 1970s. In fact, for 27 of these 54 firms, most of the equipment had been purchased as far back as the mid 1960s.

Interestingly, despite the age of these firms and of their core production technologies, these companies generally present a relatively strong technology capability base, especially when compared to firms established since independence. Thus, overall, firms established before 1975 appear to be, on average, still more capable than firms created after independence in all capability spheres. These firms tend to have better systems than younger enterprises to engage in product development, use efficiently their manufacturing machinery and ancillary equipment and control the quality of their products and manufacturing and processes, as the indices capturing Product development, production technology and process capabilities in Table 1 suggest.[4] By sector, firms pertaining to this period appear especially more capable than average in metalworking, whilst less in light chemicals, where these differences are weaker. This is partly due to the fact that capability requirements in chemical industries in the spheres of production captured in these indices are more stringent. For instance, in terms of process capabilities, manufacturers of paints and glues, foams, personal hygiene or cleaning products tend to require some form of quality control systems, regardless of their age, size or origin, due to the nature of their production processes.

Table 1. Test of means: Pre- vs. post-independence firms

	Metalworking			Light Chemicals			Both Sectors		
	< 1975	> 1975	t-test	< 1975	> 1975	t- test	< 1975	> 1975	t- test
Number	27	29	n.a.	17	17	n.a.	44	46	n.a.
Technology Capability	6.06	4.05	.002**	6.43	6.04	.500	6.20	4.78	.008**
Product dev. Cap.	.84	.42	.023**	.145	.00	.154	.57	.27	.022**
Production Tech. Cap	2.87	2.11	.022**	3.82	3.39	.454	3.24	2.58	.038**
Process Capabilities	2.33	1.52	.036**	2.47	2.65	.719	2.39	1.93	.146
Quality Control Cap	.81	.48	.131	1.29	1.24	.870	1.00	.76	.233
Inventory Cap.	1.52	1.03	.044	1.18	1.41	.440	1.39	1.17	.258

**** Indices for which the t-test indicates that group means are statistically different at a 5 percent significance level**

Clearly, the capability indices constructed for this purpose can only capture whether the various types of technology capabilities under consideration existed or not at the time the

[4] See Annex 1 for an explanation of how these indices were constructed and of their constituent elements.

survey was conducted in 2004. Therefore, they do not necessarily reflect the capabilities that these firms established during the colonial period had at the time of independence. In this sense, it is possible, that they partly or wholly capture efforts to upgrade technological capabilities that have taken place since that date. This in part was the case during the first decade after independence, when many of these companies were nationalised or intervened. As a result, several of these firms were integrated into production units and placed under governmental control (Pitcher, 2002). In the two sectors examined here at least two such units were created: ENCOME E.E., resulting from the merger of several metalworking enterprises, and EMPLOME E.E., a similar industrial conglomerate of plastic manufacturing firms. The creation of these industrial units involved a significant reorganisation of production in these sectors and some technology upgrading efforts.[5] For instance, in metalworking the government created a specialised division in charge of promoting technological development, through reverse engineering, or the adaptation and modification of foreign technologies. These units also benefited from important technology transfers through technology cooperation agreements with foreign governments, as was the case of at least eight enterprises surveyed. In this sense, it is clear that these firms' current capability levels also reflect, to some extent, investments undertaken in the aftermath of independence, in addition to investments from the colonial period.

Another possibility is that current technological capabilities of firms established during the colonial and post-independence periods reflect investments undertaken since the mid 1980s, after the Mozambican government adopted its current agenda of economic reform and liberalisation. This possibility might seem as plausible in light of the fact that many of these firms were part of the process of enterprise privatisation that took place in the 1980s and 1990s and, therefore, would in principle appear as likely recipients of technology-upgrading investments. However, the available evidence suggests that these investments, if any, did not entail any substantial change in these firms' capability base. Hence, the few studies that exist on this topic (Cramer, 2001; Pitcher, 2002) suggest that, in general, privatisation did not appear to have been followed by a reorganisation of the industrial sector, nor by a process of large-scale plant rehabilitation and technology-upgrading investment. This also seems to have been the case of privatised firms in the metalworking and light chemicals sectors. Thus, over half of the former SOEs included in the sample (18 out of 34) continued operating with the

[5] Interviews with Jacinto Loureiro and Eugenio Simão, owners of two of the firms surveyed, Metalec and Compromet, whom at the time were senior government officials involved in industrial sector management

same equipment and production systems after their privatisation, without any rehabilitation or replacement investments taking place. Moreover, of the remaining 16 firms, many reported having only undertaken minor investments after their privatisation to repair and service existing equipment. In this respect, privatisation in these two sectors would appear to have been mainly a process of ownership transfer from the State to private investors, rather than part of a strategy for industrial modernisation and transformation. These findings are in line with the fact that a very large proportion of these firms' production equipment, which partly embody these firms' current capabilities and past technological efforts, is over 20 years old, thus dating back to at least to the 1980s, before the privatisation processes started.

Altogether, the above results suggest the existence of a structural break in technological capabilities between older and younger firms, especially intense in the case of metalworking firms. In other words, although older firms frequently operate with very old equipment and production systems, largely dating back to the colonial period and the first decade after independence, they also present a stronger and deeper capability base than firms established after that date. Still, these results need certain qualification.

First, these largely dichotomous indices can only capture the tangible facet of firms' technological capabilities, as they were present at the time they were surveyed in 2004, and only in a limited way. Consequently, they cannot capture the quality, complexity or extent to which these capabilities are effectively used by firms in these two sectors. For instance, it is possible that some of the quality control, product development or production technology systems that exist in older firms are obsolete, or in disuse, as was evident in some cases. Yet, even in this case, the above results would still indicate that these firms, at some point in the past, presented a stronger capability base than firms established more recently.

Second, it is possible that these capabilities indices reflect technology-upgrading investments undertaken since that date. Yet, as argued above, this is only possible to a certain extent and, in any case, would still not explain the large differences in patterns of technology capability accumulation between older and younger firms; i.e. why older firms are technologically more capable than companies established more recently.

Finally, the above figures could be reflecting a technological selection bias problem, by which, over time, technologically more capable firms tend to survive longer than less capable ones. This would actually provide support to the contention found in the technology

capability literature that technology capabilities positively shape the performance of manufacturing firms (Lall & Latsch, 1999, Wignaraja, 2002, Rasiah, 2004). If this were the case, the figures for firms established prior to independence would not represent an unbiased sample of the population of firms that existed at that time but, instead, a selection of those firms which were technologically more capable and, therefore, were in better conditions to survive. However, the available evidence suggests that this has not been the case. Hence, several of the technologically more capable firms established during the colonial period and in the years immediately after independence have closed over the past decade. This is the case, for instance, of MABOR, a manufacturer of rubber tyres included in the survey, which has the highest technological capabilities score, yet had paralysed its operations as of 2005. It has also been the case of several firms in the metalworking sector, as figures from the survey conducted by ANEMM in 1995 indicate (Table 2). Thus, Maputo firms established prior to 1987 that were included in this survey and which have since ceased to operate appear to be, on several accounts, technologically more capable and with higher skills than those that have survived until today.

Table 2. 1995 Technology traits of Maputo metalworking firms; survivors vs. exitors

	Survivor Firms	Firms Exited
Total number of firms	21	11
Average age of firms	29.0	26.4
% with quality control systems	9.5	27.3
% w/ maintenance & repair systems	42.9	72.7
% workers w/ secondary education	6.3	10.4

Source: Own calculations based on ANEMM (1996)

Overall, these results are suggestive of a process of gradual weakening of these two sectors' technological capability base over the past two decades, with greater incidence in the metalworking sector. This process would appear to be the result of new entrants in these two sectors presenting weaker technological capabilities than older firms, rather than of intra-firm weakening of technological capabilities.

3.2. Technology capabilities and manufacturing complexity in historical perspective

This gradual weakening of the metalworking and light chemical sectors' technological base is also captured when examining the evolution of aggregate manufacturing complexity in these industries, which can be taken as a proxy of their technological capabilities in

production. In this sense, it is reasonable to assume that as manufacturing complexity increases firms will require higher levels of technological capabilities and skills to continue to engage in efficient production. For instance, simple manufacturing processes, such as packaging, labelling or bottling do not require of the level of skills (e.g. engineers) or complex capabilities (e.g. quality control systems, product design capabilities or extensive in-house maintenance and repair services) necessary in more advance and complex production lines. From this perspective, patterns of technology capability development would simply reflect the degree of industrial complexity, deepening and development of an economy, a given sector or, even, an individual firm. This idea is in line with Pack and Westphal's (1986) contention that economic development can be seen as a process of technology capability development, by which countries move from simpler to more complex production processes.

In the context of the survey of Mozambican metalworking and light chemical firms, manufacturing complexity was captured in terms of their level of production integration. Production integration was defined as the number of separable stages of production firms' engaged in before their final output was produced, and was obtained by calculating the average level of production integration of each firms' three main product lines, weighted by the share of these products in their total sales. In the sample, production integration ranges from a value of one, awarded to firms that only engage in packaging activities, to a maximum of nine production processes, with an average level of product integration of 3.6 processes. As shown in Table 3, this measure of manufacturing complexity presents a reasonably strong correlation with firms' age in both sectors, with all the three correlation coefficients statistically significant at the 5 percent significance level and presenting the expected positive sign. These results suggest that older firms engage in more complex manufacturing processes that are likely to require of greater levels of capabilities and skills, corroborating the contention made above that over time there has been a process of production simplification in these two industries, by which newly established firms are adopting simpler production processes that require fewer technological capabilities and skills to produce similar products than those manufactured by older firms.

Table 3. Spearman's Correlation: Age and production integration

	Spearman's Correlation	Significance (2-tailed)
Metal- Engineering	.400(**)	.000
Light Chemicals	.431(**)	.002
All Firms	.400(**)	.000

** Significant at the 0.01 level (2-tailed).

This process of production simplification was evident in factory visits to several firms recently established in these two sectors, which engaged in very simple transformation activities, often involving only product packaging or assembly, having imported an almost finalised product from abroad. This group of firms includes many foreign companies that have set up plants in Mozambique operating very simple production lines that require little technological expertise. In fact, recent foreign investment projects have especially contributed to this process, with the average level of production integration of greenfield FDI projects set up in these two sectors since independence estimated at 3.02 production processes,[6] down from a sample average of 3.6 stages. These include 6 firms that only engaged in one-stage manufacturing activities, basically packaging or assembling final products. This tendency towards the simplification of production processes is also taking place within older firms established in Mozambique for several generations. Some of these firms are currently orienting part of their production towards the manufacture of goods that require a degree of transformation below that they are capable of undertaking, reinforcing this process of production simplification. In the sample, at least 21 firms fell under this category, 14 in metalworking and another seven in light chemicals, and were on average engaging in 2.7 production stages, down from a potential maximum 4.4 stages of production.[7]

Again, these results need certain qualification. Hence, in some cases intra-firm and intra-sector reductions in production integration reflect changes in the type of manufacturing these firms are currently engaging, rather than a process of production simplification. These might require fewer stages of transformation but may not necessarily imply that they require lower skills and capabilities, simply different ones. This was case of some older metalworking firms which have moved from manufacturing metal products, such as containers, agricultural tools or metal furniture, to providing specialised engineering services that require highly

[6] These values correspond to the 26 firms created since 1975 with a foreign equity share equal or above 50 percent. The average age of this group of firms was 5.2 years.
[7] Potential values correspond to the level of product integration of each firms' most complex product line.

qualified workers and the use of hi-tech equipment, yet involve fewer manufacturing stages. However, only five firms in this sector fell under this category: three metalworking companies that were providing specialised engineering services to MOZAL, and two other firms that had changed entirely their product portfolio. In any case, these changes would reflect a process of capability specialisation and not necessarily capability deepening. With regard to the remaining 16 firms that had seen their level of production integration fall below their maximum level, factory visits clearly suggested that they were producing simpler products that required less skills and capabilities than those needed for the production of goods they had manufactured in the past. Another possibility is that the reduction in intra-firm or intra-sector levels of production integration simply reflects a process of producer specialisation accompanied by a process of sector or economy-wide diversification. In this context, individual firms would specialise in engaging in a smaller number of production processes, whilst at a sector or economy-wide level manufacturing complexity along the production chain would remain the same or increase. Still, there is little evidence that this has been the case in Mozambique, especially considering that the survey included almost all firms in these sectors in the province of Maputo and, thus, would have captured this production specialisation-cum-diversification dynamics. In fact, what emerges from firms' survey responses is that there is very little subcontracting within these sectors, or between these industries and other sectors, with firms selling mostly to final consumers and purchasing, an average, 90 percent of their production inputs from abroad.[8]

3.3. Technology capability loss in the context of economic reform and liberalisation

As discussed in Section 2 this evolution has taken place against an economic and policy background that has not facilitated investments to upgrade and accumulate technology capabilities in manufacturing firms. In this respect, historical events taking place in the economic, policy and institutional spheres have also contributed to this process of technological obsolescence and production simplification. Hence, the departure of most Portuguese settlers after independence entailed an important loss to the Mozambican manufacturing sector's skill base, undermining the ability of industrial firms to efficiently operate relatively complex production lines. This large and sudden loss in technical and managerial skills, together with the generally low skills of the Mozambican population – a

[8] This percentage should be viewed with caution since it is not based on book figures recorded in sample firms' accounts. Still, the narrowness of the Mozambican industrial sector, and the fact that there are no manufacturers in Mozambique of the primary materials used in these sectors suggests that share is reasonable.

result of decades of discriminatory employment and educational policies (Johnston, 1990; Newitt, 1995; Hedges, 1999) – and the inability of successive post-independence governments to reverse this situation (Warren-Rodriguez, 2007b), has deterred technology-upgrading investments in existing plants or new industrial projects that could have bolstered the Mozambican technological capability base. At the same time, it has prompted the emergence of new firms that engage in manufacturing processes that involve a lower degree of transformation and, consequently, require lower and fewer skills and technology capabilities. Additionally, economic disruption caused by the departure of the Portuguese settler population, which provided an important market for firms in these sectors, various decades of war, together with a deteriorating economic environment, with increasing levels of competition from imports and the informal sector, the collapse of key upstream sectors and a sharp rise in the cost of finance, has further deterred technology-upgrading investments, by reducing the markets these firms served and raising the costs of investment. In this respect, sample managers' over these issues are consistent with those reported by the various investment climate surveys undertaken in Mozambique (e.g. RPED 1999, 2003), which systematically find the high cost and inaccessibility of finance, and a difficult business environment as critical constraints to private sector development.

It is important to note that these events have coincided with a gradual deterioration of the Mozambican policy and institutional framework for private sector development (see section 2). This deteriorating policy and institutional setting has made it harder to address this weakening technology capability base and declining levels of manufacturing complexity. Hence, it has hindered the formulation and implementation of policies that could have addressed these problems and eased the constraints to technology capability acquisition in these sectors. For instance, a weak national quality and standards agency, which in 2004 only employed 13 people, five with a university degree, has effectively impeded local firms from obtaining any form of product or process certification. On the other hand, a weak regulatory and inspection framework has resulted in very little control being exercised over the quality of products and production processes, undermining these firms' quality control efforts.

Altogether, these developments have led to a profound change in the nature of manufacturing production in Mozambique, which partly contributes to explain this fall in the overall levels of technological capabilities. For instance, the decline of other industrial sectors – such as the textile, garments or cashew nut industries – makes it unprofitable for newly established metalworking firms to acquire the technological capabilities and know-how to

produce equipment and spare parts for these industries. Firms established in earlier periods, on the other hand, find it difficult to make use of capabilities of this nature they had acquired in the past, which helps explain the low levels of capacity utilisation and large numbers of idle equipment that exists in many of these firms, with capacity utilisation rates estimated for 2003 at 50.5 and 48.3 percent in metalworking and light chemical industries. At the same time, new markets have appeared for firms in these industries, such as construction and civil engineering projects, which no longer require these capabilities. The demand for consumer goods produced by these two sectors has also experienced a significant shift, with firms increasingly producing simpler and lower-quality products aimed at supplying a low-income population, such as small metal structures, rudimentary kitchenware, or manpowered cement-brick makers and flower mills, which has reduced product development and quality control requirements. Finally, the nature and small size of these markets often impedes continuous production of standardised products, reducing the scope for using formal quality control systems and the incentives to maintain permanent in-house repair and maintenance services.

In this sense, the decline in aggregate levels of technological capabilities and manufacturing complexity observed in these two sectors can be seen as a response to the various constraints, of an economic, policy or institutional nature, that firms in these two sectors face, and which have undermined the acquisition of technological capabilities and the gradual increase in manufacturing complexity and industrial deepening in Mozambique.

4. The impact of foreign direct investment (FDI) on the accumulation of skills and technology capabilities

In this context of ongoing production simplification and capability weakening, foreign direct investment would emerge as a prime source of technology and know-how transfer to the Mozambican metalworking and light chemical sectors and, therefore, as a means building up their overall skill and technology capability base. The role of FDI as a source and channel of technology transfers from advanced economies to developing countries is well documented in the technology and development literature (see Blomstrom & Kokko, 1996; or Keller, 2004). From this perspective, foreign investors contribute to the process of technological change in developing countries by introducing advanced production and managerial techniques, new products and skills, as well as technologies embodied in manufacturing equipment. The importance of foreign ownership as a source of technological capabilities has also been fully incorporated into the technology capability analytical framework. This strand

of literature typically argues that foreign-owned firms can have a positive impact on developing countries' capability levels, since: (i) these firms have greater access to proprietary technological knowledge through their parent companies; (ii) they generally have greater awareness of the importance of developing firm-level technology capabilities for manufacturing performance; (iii) they have a better knowledge of new technological developments unfolding in more advanced economies; and (iv) have greater access to finance and, therefore, can better invest in the acquisition of technological capabilities. From this perspective, a (strong) positive correlation would be expected between the degree of foreign ownership and levels of technological capabilities. This is the case of several empirical studies examining technological capability dynamics in developing countries (e.g. Lall *et al*, 1994; Deraniyagala, 2001a, b; Wignaraja, 2002; Rasiah, 2004;).

4.1. On the irrelevance of FDI as a source of skills and technology capability accumulation

With low levels of industrial development and few, if any, resources devoted to R&D, industrial technological development in Mozambique largely relies on international transfers of foreign technologies (RPED, 2003). This is also the case of metalworking and light chemical industreies where, despite the existence of small processes of local innovation and adaptation of foreign technologies, core production technologies and associated production skills and capabilities originate from abroad. In this context, FDI would appear to be a prime source of technology, know-how and skill transfer for firms operating in these sectors, where as many as 33 firms were fully foreign-owned, another 16 had a a majority of equity owned by foreign investors and four other firms had minority shares owned by foreign investors.

Yet, despite the weight given to these arguments, foreign direct investment does not appear to have played a significantly distinctive role in the formation and accumulation of technology capabilities and skills in the Mozambican metalworking and light chemicals sectors. A first indication of the weak role played by FDI in this sphere is the weak association that exists between the degree of foreign ownership in firms of these two sectors and the various dimensions of technological capabilities considered here (see Table 5). Thus, only one out of the various capabilities indices under consideration, product development capabilities in metalworking, appears to be statistically correlated with foreign ownership at a 5 percent significance level. Moreover, this coefficient presents a negative sign, suggesting that, if anything, levels of product development capabilities in this sector fall as the degree of

foreign ownership in sample firms increases. Beyond this coefficient, the remaining correlation coefficients are all highly statistically insignificant.

Table 5: Spearman's correlation: Foreign ownership and Technology Capabilities

	Metalworking		Light Chemicals	
	Spearman's Correlation	*Sig. 2-tailed*	Spearman's Correlation	*Sig. 2-tailed*
Technology Capabilities	-.198	*.143*	.086	*.627*
Product development capabilities	-.268(*)	*.046*	-.224	*.204*
Production technology capabilities	-.187	*.167*	.022	*.903*
Process capabilities	.001	*.997*	.129	*.468*
Quality control capabilities	-.082	*.549*	.041	*.818*
Inventory capabilities	.080	*.560*	.170	*.335*

* Correlation is significant at the 0.05 level (2-tailed).

One potential source of error with these correlations is that these coefficients only measure the level of association between technology capabilities and unweighted shares of foreign ownership, treating all firms as being equally as large. In this respect, it is possible that the impact of foreign investment on firms' technology capabilities is greater in larger enterprises, given the potential economies of scale often associated with technological development,[9] and so too its general impact on these two sectors' technology capability base. Yet, when taking size into account, the negative association between foreign ownership and firm-level product development capabilities is magnified, with large and very large firms, where the bulk of foreign equity is concentrated, accounting for much of the negative correlation between product development capabilities and foreign ownership (See Table 6). Another reason why these correlation coefficients may not capture the full effect of foreign ownership on levels of technology capability is that several firms in these two sectors are of mixed ownership. In these cases the differential impact of foreign ownership on firms' capabilities might not proportional to its equity share, assumption underlying the correlation analysis presented in Table 5. Put in other words, foreign investors might be contributing to the technological base of these firms in a magnitude higher than their equity share. Yet, the number of these firms is relatively small (20) and most are largely foreign-owned,[10] reducing the potential impact of this effect on the above correlations.

[9] See Wignaraja (2002) or Freeman and Soete (1997) for an examination of the economies of scale associated with technology development.
[10] Foreign investors held more than 50 percent of shares in 17 firms and more than 75 percent in 8 companies.

Table 6: Spearman's correlation: foreign ownership and technology capabilities by size

	MICRO <10 Workrs	SMALL 20>Wks>10	MEDIUM 50>Wks>20	LARGE 100>Wks >50	VERY LARGE >100 Workers
Number	2	15	37	24	12
Technology Capability	-1.000	.015	.004	-.074	-.302
Sig. (2-tailed)	*1.000*	.958	.982	.731	.340
Product dev. cap.	.	.140	-.069	-.511(*)	-.693(*)
Sig. (2-tailed)	*.*	*.618*	*.685*	*.011*	*.013*
Production tech. cap	-1.000	-.170	.010	.207	-.413
Sig. (2-tailed)	*1.000*	*.544*	*.954*	*.331*	*.182*
Process capabilities	.	.291	.085	-.054	-.058
Sig. (2-tailed)	*.*	*.292*	*.618*	*.803*	*.858*
Quality control cap	.	.302	-.062	.024	.022
Sig. (2-tailed)	*.*	*.274*	*.716*	*.910*	*.945*
Inventory cap.	.	.257	.189	-.100	-.051
Sig. (2-tailed)	*.*	*.355*	*.263*	*.644*	*.874*

** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).

A way of gaining insight into the differential impact of foreign ownership on sample technological capability levels is focusing on the two sub-samples of firms that are either fully Mozambican or totally foreign-owned, and examining whether there are any systematic differences in their capabilities scores. In this respect, the results of the test for equality of means reported in Table 7 suggest that the only significant difference between these two groups are in the sphere of product development, where fully foreign-owned firms appear as more capable than wholly Mozambican-owned companies.

Table 7. Tests of equality of means: Foreign vs. Mozambican fully owned firms

	Mean		Wilks' Lambda	F	Sig.
	Foreign (n=37)	Moz. (n= 33)			
Total Technology Capabilities	5.36	5.12	.998	.164	.687
Product development cap.	0.15	0.58	.886	8.737	.004**
Production technology cap.	2.84	2.90	1.00	.033	.856
Process capabilities	2.12	1.86	.992	.542	.464
Quality control cap.	0.78	0.72	.999	.071	.791
Inventory capabilities	1.33	1.13	.987	.868	.355

** Correlation is significant at the 0.01 level (2-tailed)

These results do not necessarily entail that FDI has not played over the years an important role in the formation of technological capabilities in these two industries. Hence, only a very small number of firms in both sectors were originally established with Mozambican capital. In fact, many of the firms that appear as Mozambican were established

during the colonial period by (foreign) Portuguese investors. In this respect, it should be noted that Mozambique's current industrial base continues to be largely shaped along the industrial structures established during the late colonial period by Portuguese and other foreign investors. In the sample, this group comprises a total of 44 firms, 27 in metalworking (48.2 percent of this sub-sample) and another seventeen in light chemicals industries (50 percent). Many of these firms (31) were taken over by the state after independence and, later, privatised during the 1980s and 1990s. During this privatisation process Mozambican nationals purchased stakes in several of these firms,[11] so that they currently appear as being partly or fully Mozambican-owned. However, their technology capabilities, as measured in the indices used here, reflect, to a significant extent, investments that date back to the colonial period and, hence, with similar characteristics to those of FDI. In this sense, only 20 firms can be considered to have been entirely established with Mozambican capital since 1975, 14 in metalworking and another six in light chemicals. Yet, even for these firms, capability levels are at *a par* with those of the 26 foreign enterprises (i.e. at least 50 percent foreign-owned) established since 1975 and that, consequently, are not the result of foreign investments undertaken during the colonial period (See Table 8). Altogether, these results suggest that FDI to these sectors has not had a significant differential impact, in terms of contributing to the enhancement and accumulation of technological capabilities in sample firms, when compared to Mozambican fully or partly-owned firms.

[11] Of the 31 sample firms established during the colonial period and later nationalised, only three were fully sold to foreign capital. Of the remaining 28 firms, 19 were fully or mostly sold to Mozambican nationals.

Table 8. Purely Mozambican vs. foreign-owned, test of group means

METALWORKING	Foreign (n=15)		Mozambican (n=14)		t-test
	Mean	Std. Dev.	Mean	Std. Dev.	(Sig.)
Technology Capabilities	4.24	1.69	3.85	3.25	0.687
Product development Cap.	0.45	0.69	0.39	0.65	0.811
Production technology. cap	2.05	1.00	2.17	1.59	0.809
Age of equipment	7.51	4.70	14.33	7.96	0.009
Process capabilities	1.73	1.33	1.29	1.49	0.401
Quality control cap.	0.47	0.74	0.50	0.85	0.911
Inventory capabilities	1.27	0.88	0.79	0.89	0.157

LIGHT CHEMICALS	Foreign (n=11)		Mozambican (n=6)		t-test
	Mean	Std. Dev.	Mean	Std. Dev.	(Sig.)
Technology Capabilities	6.16	2.13	5.81	2.08	0.749
Product development. cap.	0.00	0.00	0.00	0.00	n.a.
Production technology. Cap	3.16	1.67	3.81	1.31	0.423
Age of equipment	8.72	4.64	8.25	3.14	0.830
Process capabilities	3.00	0.89	2.00	1.90	0.155
Quality control cap.	1.55	0.93	0.67	1.21	0.115
Inventory capabilities	1.45	0.82	1.33	1.03	0.794

A similar situation arises with regard to the provision of skills, in the sense that foreign companies operating in the metalworking and light chemical sectors do not appear as being better skilled than Mozambican-owned firms. With regard to these issues, the technology literature generally argues that FDI can be an important source of foreign know-how for host developing economies through, amongst others, the direct transfer of skills to local subsidiaries of multinational firms (Asiedu, 2004). These transfers can take the form of secondment of skilled expatriate workers to local subsidiaries or of greater efforts to train local staff. In addition, their ability to pay higher salaries often allows foreign companies to attract local workers with higher qualifications, which reflects in a higher stock of skills of foreign-owned firms (te Velde, 2003). However, as with the impact of foreign ownership on technological capabilities, all these skill transfer elements, which, to one degree or other, are incorporated in the skill indices considered here, do not appear to be present in the Mozambican metalworking and light chemical sectors. This is best captured by the absence of any strong correlation between foreign ownership and these various skill indices, with only one index significantly and positively correlated to foreign ownership, firm-wide skills in light chemicals industries (See Table 9).

Table 9. Spearman's correlation: Skills and foreign ownership

	Metalworking	Light Chemicals	Total
ALL SKILLS	.222	.274	.252
Sig. (2-tailed)	*.100*	*.117*	*.017*
Managerial skills	.107	.022	.070
Sig. (2-tailed)	*.432*	*.900*	*.514*
Firm-wide skills	.251	.349(*)	.302
Sig. (2-tailed)	*.062*	*.043*	*.004*

* Correlation is significant at the 0.05 level (2-tailed).

4.2. Factors explaining FDI's weak technological and skill impact

Several factors can help explain these somewhat unexpected results with regard to the impact of FDI on patterns of technological capability and skill accumulation in these two sectors, suggesting that the relationship between foreign ownership, skills and the international transmission of know-how runs along more complex lines. With regard to the impact of FDI on skill accumulation it is important to underline that Mozambican managers in the sample fare quite well when compared to the skill levels of their foreign Counterparts. Hence, there is a similar proportion of Mozambican and expatriate managers with university studies, secondary and technical education, who have a command of foreign languages and regularly travel abroad for business purposes (Table 10). Moreover, it should be noted that several Mozambican-owned firms have foreign managers and, likewise, foreign enterprises also employ Mozambican managers. As a result, managerial skill levels in Mozambican and foreign-owned enterprises in each of the categories under consideration are reasonably close (see last two columns in Table 10).

Table 10. Managerial skills in metalworking and light chemical firms

	Mozambican Managers	Foreign Managers	Moz. Firms (>50%)	Foreign Firms (≤50%)
%. of Managers:				
with university studies	52.1	61.9	56.1	57.1
With Sec + tech. studies	10.4	9.5	26.8	38.8
Studied Abroad	33.3	78.6	36.6	71.4
Mozambican	100	0.0	15.6	22.2
Average Work Experience				
In Total	24.4	30.2	26.8	27.3
In sector	13.5	19.3	15.8	16.4
In company	9.4	11.8	10.1	10.9
As manager in sector	12.7	14.8	14.4	13.0
As manager - total	17.6	20.1	20.8	17.8
Abroad	3.9	17.5	3.5	13.2
Speak foreign languages (%)	70.8	76.2	68.3	77.6
Regular travel for business (%)	79.2	85.7	80.5	83.7

In terms of firm-wide skills, i.e. the skill-levels of firms' total workforce, foreign-owned firms generally do present higher scores. However, Mozambican companies have workforces with relatively similar skill levels, whilst also engaging in activities to improve their skill base, in some cases more than foreign-owned companies. Hence, whilst only 12.2 percent of Mozambican firms have formal in-house training programmes and facilities, as opposed to 24.5 percent of foreign enterprises, local companies in these two sectors make twice as much use of external training programmes in Mozambique, and almost as much use of training courses abroad as foreign companies.

Table 11. Managerial skills in sample firms

	Mozambican Firms (>50%)	Foreign Firms (≤50%)
Average % of workers with:		
Engineering degree	0.19	0.16
With university studies	2.32	3.12
Secondary / technical edu.	15.56	21.66
Training (% of firms):		
Internal training program	12.20	24.49
Local external training	4.02	2.11
Foreign external training	2.10	2.85

Furthermore, as argued in Section 3, recent foreign investors have over-contributing to the process of production simplification and capability weakening that has characterised the evolution of technology capability accumulation in these two sectors. Local firms, on the other hand, have available other equally important sources of technology and skill transfer and acquisition, which have offset the presumable technological prowess of foreign firms operating in these two sectors.

Yet, beyond these specific factors it is important to underline that, in the Mozambican context, foreign enterprises do not constitute a homogenous category of firms, with this heterogeneity also applying to their technology and investment strategies in Mozambique. In this respect, these results do not deny the importance in specific instances of FDI as a source of skills and capabilities accumulation in the metalworking and light chemical sectors. In several cases foreign investors do appear to have purposely invested in upgrading existing capabilities and skills as part of their investment strategies in Mozambique, either by establishing new firms, expanding existing factory plants or acquiring existing companies. In fact, in a number of cases, these investments have generated important technological and knowledge externalities to the rest of the economy, as has been the case of the technological spill-overs from the MOZAL aluminium smelter to several local metalworking firms (See Warren-Rodriguez, 2007b; Castel-Branco & Goldin, 2003). However, in many other instances this has not been the case, diluting the overall technological and skill impact of FDI in these sectors. For example, many foreign firms established in Mozambique for several decades continue to operate the same core technologies they had when they were created, without having undertaken any major technology or skill-upgrading investment, except for small maintenance and repair investments. Whilst the original investments that led to the creation of these firms in the 1950s, 1960s and 1970s might have resulted in the incorporation of what at the time were reasonably advanced technologies, in most instances these are now obsolete. Moreover, many of these firms' managers and owners have lived in Mozambique for many decades, so that it cannot be assumed that they have a better knowledge of current international technological trends than Mozambican businesses. It is significant in this respect that the 20 foreign entrepreneurs that exist in the sample had spent, on average, 65.4 percent of their professional careers working in Mozambique. When taking into consideration all 42 foreign managers that were interviewed, regardless of whether they owned or not these firms, this proportion drops significantly, but still remains at 44.8 percent of their work life. On the other hand, more recent foreign investments have frequently consisted of acquisitions of

existing firms, often as part of the privatisation process, without efforts being made to rehabilitate, replace or upgrade production facilities, despite the fact that these firms were operating with very obsolete technologies. In this sense, it is noteworthy that nine out of 17 mostly foreign-owned firms which have their origin in the acquisition of existing industrial assets admitted not having undertaken any major investments to rehabilitate or upgrade existing manufacturing facilities when they were purchased, even though the average imputed age of their equipment was 17.2 years at the time.[12] This situation has not been exclusive of foreign investors and similar situations have arisen with Mozambican operators. In fact, it has also been the case of several firms in both sectors that have remained under the same ownership since their creation. However, together with the factors outlined above, this lack of technology-upgrading investments by foreign investors purchasing existing industrial assets in Mozambique has contributed towards the negligible differential impact that FDI has had on the Mozambican metalworking and light chemical sectors' technological and skills base.

Interviews with managers of these firms, Mozambican and foreign, suggested they were aware of the importance of investing in upgrading their technical capabilities. However, market constraints deterred them from undertaking such investments. In all, 45 firms considered that market related constraints, such as the small size of the Mozambican market, poor business prospects, strong competition and low profitability heavily constrained their ability to invest in technology acquisitions. Another 12 also considered these to be important constraints on such decisions. These findings are consistent with other studies of the industrial sector, such as the World Bank' assessment of its Industrial Enterprise Restructuring Project (World Bank, 2002), which recognises that privatisation was undertaken in a context in which many Mozambican investors were inexperienced, with no management and technical skills, and at a time where unstable macroeconomic conditions, high interest rates, import and informal sector competition, poor infrastructures, a weak business climate and, in some cases, declining international prices, undermined industrial (rehabilitation) investment, especially by Mozambican-owned firms. In other cases, the lack of investments in this technology sphere appeared to be more related to poor business strategies, or, simply, because other reasons had motivated these investments. For example, three owners of metalworking firms openly acknowledged they had acquired these firms only to have a registered business in

[12] Plant visits to these firms suggested that the actual number was probably larger. In this respect, it should be noted that these figures are based on responses by interviewees. Thus, it is reasonable to expect a bias towards managers/owners responding positively to whether they had invested in plant rehabilitation and upgrade when they purchased these firms to avoid appearing as having done nothing.

Mozambique from which they could invest in more lucrative operations. On the other hand, two other metalworking firms, have recently been at the centre of a corruption scandal involving the misuse of funds and grants made available by banks and donor agencies for their rehabilitation, following their privatisation (see Hanlon, 2001).

In any case, these findings underscore the Mozambican government's inability to establish a productive investment environment and to articulate an institutional and policy framework that promotes the effective transfer of technology and know-how through foreign direct investment, especially in the case of investments in the purchase of existing industrial plants. In this respect, it draws attention to the government's inability to ensure a better technological outcome from the process of privatisation that took place during the late 1980s and throughout the 1990s, in terms of ensuring that foreign and local buyers of privatised firms, effectively invested in plant rehabilitation and technological upgrade.

5. Technical cooperation arrangements and the accumulation of skills and technology capabilities

In this context of a generally weak technological impact of FDI, several enterprises operating in the metalworking and light chemical sectors, both Mozambican and foreign-owned, have actively engaged in efforts to acquire know-how, skills and technological capabilities through mechanisms other than foreign direct investment.[13] In these cases interaction with other firms, technology institutions or specialised consultants, has frequently played a decisive role in the acquisition of technological capabilities, equally as important as that played by FDI. The importance of these other channels of technology transfer has been recognised in the technology capabilities literature (e.g. Lall, 1992; Kagami *et al*, 1998), although its applied analysis has been scant.

In the two industries under consideration these firms constitute quite a large group, with at least 39 companies owing their technological base to a significant extent to this type of cooperative arrangements. These firms do not conform a homogeneous group and includes former SOEs, Mozambican firms and fully or partly foreign-owned enterprises. Furthermore, some firms engage in technology cooperation arrangements continuously, whilst others do so only on an ad hoc basis, usually at the time they were created. There are also important

[13] Although in the case of foreign-owned firms this may sound contradictory, it is important to note that several of these firms were created by foreigners established in Mozambique for many years.

differences as to the specific source of technology cooperation used. For instance, several companies had benefited from foreign technical assistance from international developmental agencies. These include several former SOEs that benefited from this type of arrangement whilst under state ownership in the 1980s and 1990s, receiving training and equipment from countries such as China or Sweden, as well as firms established with private Mozambican capital. Other firms have also benefited from the support provided by the various business development agencies or programmes that exist in Mozambique, in the form of specialised technical assistance, management training, certification, or consultancy and engineering services. These include PoDE and INNOQ amongst the most prominent business support agencies of this type. The former is a programme set up by the World Bank and other donor agencies in 2000 to support private sector development in Mozambique. This initiative, managed by a private consultancy firm under the general umbrella of the Mozambican Ministry of Industry and Trade, ran between 2000 and 2006, providing credit, training and technical assistance to local small and medium enterprises. INNOQ, on the other hand, is the government's quality and standards agencies and, in the past, has provided support to local firms in sphere of certification. In other cases, these technological relationships have taken the form of cooperation arrangements with other private firms. One very significant case in the metalworking sector has been that of the MOZAL aluminium smelter, which has played a critical role in upgrading the skills and technological capabilities of several firms in this industry, which were chosen to participate in MOZAL's linkages programme, MOZLINK. Under this programme, these companies have been able to establish reasonably stable sub-contractual relations with MOZAL providing repair, maintenance and reconstruction services to this aluminium smelter, whilst at the same time, receiving substantial transfers of technology and know-how (Castel-Branco and Goldin, 2003; Warren-Rodriguez, 2007b). Other firms have benefited from similar technological links with other private firms, though not to the extent of MOZAL. Finally, other companies in these two sectors make regular use of the services provided specialised external consultants. This has been especially important for firms in the light chemical sector where, manufacturers of paints or detergents make use of these specialised services for their product development and quality control needs.

In the context of the Mozambican metalworking and light chemicals manufacturing industries, technology cooperation with other firms, consultants, public agencies and non-profit organisations appear to have played a significant role in the transmission of technological capabilities and skills to firms operating in these two sectors, both Mozambican

and foreign-owned. An indication of the relevance of these cooperation mechanisms is the fact that the average levels of capability and skills of firms that regularly engage in these type of arrangements are generally significantly higher than for companies that do so only on an ad hoc basis or do not make use of this type of technology sourcing at all (Table 12).

Table 12.Test of means: firms that engage in continuous cooperation arrangements vs. firms that do not

	Continuous Coop. (n =18)		Others (n = 72)		*Sig. 2-tailed*
	Mean	St.Dev.	Mean	St.Dev	
Technological Capabilities	6.87	2.85	5.13	2.36	.009*
Product Development Cap.	.666	.662	.354	.620	.063***
Production technology cap	3.48	1.51	2.76	1.49	.071***
Process capabilities	2.72	1.45	2.01	1.45	.067***
Quality control capability	1.22	.943	.79	.934	.084***
Inventory capabilities	1.50	.857	1.22	.892	.237
All Skills	1.01	.268	.793	.292	.005*
Managerial skills	1.24	.259	1.04	.372	.035**
Firm-wide skills	.807	.429	.554	.446	.033**

* Significant at 10% level; ** significant at 5% level; *** significant at 1% level.

However, despite their positive incidence in the process of accumulation of skills and technological capabilities, the overall impact that these cooperative arrangements have had on these two sectors' technological and skill base remains limited. Hence, many of these firms have benefited of such arrangements on an ad hoc basis, in many instances as turnkey projects when they were first established, with only 18 firms, out of a total of 90, regularly making use of such arrangements. Furthermore, the potential for further upstream and downstream firm-to-firm technological linkages is limited in Mozambique due to the small number of large (foreign) companies capable of having a significant impact on local firms' technological and skill base, as well as by the reduced amount of subcontracting that exists in these two sectors. In addition, the impact of technology cooperation arrangements such as those established with business development programmes or service providers, are limited by the reduced extent and limited reach that these projects have in Mozambique, with only 24 firms in both sectors reporting to have ever made use of these technology extension facilities, in many instances not on a regular basis and, frequently, for training purposes not directly related to manufacturing production (e.g. secretarial or accountancy training). Finally, sectors or industrial projects that potentially present substantial scope for technology and know-how

transfers through subcontracting agreements to firms in these two sectors often do not do so, reducing a potentially important source of technology transfer. This is the case, for instance of the two sugar agro-industrial projects operating in southern Mozambique or the national railway company: CFM.[14]

With regard to this last point, several reasons explain why these potential linkages do not materialise. In part, there is an unfounded perception that local firms do not have the capacity to provide goods and services in the quality and time required, despite the fact that several firms in the sample had done so in the past and others were working for large multinational projects such as MOZAL at the time they were survey. As a result, these goods and services are frequently produced in-house, or purchased abroad in neighbouring South Africa, which presents a reasonably diversified industrial sector, competitive by international standards, and which can easily be reached from Maputo. Yet, in addition to this factor, there are also important informational failures that undermine local subcontracting by foreign firms. For instance, large foreign projects operating in Mozambique are frequently unaware of local manufacturing capabilities, factor made worse by the closeness of the South African market and the availability of similar services in that country. The case of the two sugar agro-industrial projects of Maragra and Xinavane, which operate within a 60 to 100 Km distance north of Maputo, provide a good example of this situation. In both instances, these sugar mills and adjacent sugar plantations undertake most of their repair and maintenance requirements in-house or, if necessary, have it done in neighbouring South Africa, where most of these companies originate from and where, often, they have previously run similar sugar operations. Similarly, they purchase much of their inputs (e.g. seeds, fertilisers), tools and other necessary equipment (e.g. hoses, irrigation systems, machinery, agricultural tools) directly from South Africa, despite the fact that many of these goods and services are easily available for purchase in from local firms Maputo and, in some cases, are locally manufactured. Partly, this situation arises because managers in these sugar operations (sugar mills and plantations) consider that prices for locally goods are not competitive and that local firms do not have the capacity to provide these goods and services with quality and time they require. However, they also recognise that it is their lack of knowledge of the local economy and, thus, of local businesses' ability to supply these goods and services which stops them from outsourcing locally. Moreover, despite the size of these operations, their relatively large procurement

[14] Based on interviews with at the Maragra and Xinavane sugar operations and CFM.

needs,[15] at least by Mozambican standards, and the fact that they have been operating in Mozambique since the mid 1990s, these firms had only recently been approached by one of the linkages projects that exist in Maputo, PoDE, underscoring the inability of existing linkages programmes and investment promotion agencies to maximise linkages and other (technological) dynamic benefits from FDI projects established in Mozambique.

6. Concluding comments

Overall, what emerges from this examination of existing patterns and underlying trends of technological capability and skill accumulation in the metalworking and light chemical sectors is a scenario in which these two industries are experiencing a process of growing technological obsolescence, combined with a progressive simplification of production processes that is leading to a weakening of their technological capability and skill base. This process can be seen as a response to a deteriorating policy, skills and economic environment that, in the past two decades, has undermined investments in industrial technological development. In this context, foreign direct investment, which is typically identified in the literature as a prime source of technology transfer to developing countries, overall does not appear to have had any positive differential impact on patterns of accumulation of technological capabilities and skills in these two sectors which could have helped reverse this process. In fact, FDI projects have actually contributed to this downward technological trend. Hence, many of these projects date back to the colonial period, and do not seem to have embarked in any major technology upgrading efforts in recent years. In other cases, foreign direct investment has been limited to the acquisition of existing assets, as part of the Mozambique privatisation process, with little plant rehabilitation and upgrade subsequently taking place. Finally, more recent FDI projects have often consisted of the establishment of very simple manufacturing operations, in line with this process of production simplification mentioned above. These outcomes are not only reflective of the nature of FDI in Mozambique, but also highlight the weaknesses of the current institutional framework for investment and linkages promotion in Mozambique. Other mechanisms of technology transfer do appear to have played a more positive role than FDI in the process of capability and skill accumulation in these two sectors, probably mitigating the effects of this weakening technological trend. This is for instance the case of technology cooperation arrangements with other firms or organizations. Yet, opportunities of this type are limited, since many upstream

[15] Estimated at USD 18 million in 2004 (GPSCA, 2005)

sectors have, in effect, ceased to exist in the past decades, or generate few downstream linkages. Furthermore, when they exist, informational gaps impede the realisation of such arrangements, again underscoring the weaknesses of the current institutional framework for investment and linkages promotion in Mozambique.

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Annex 1: Sanajaya Lall's technology capabilities framework and survey traits.

Lall's technology capabilities conceptual and methodological framework (Lall, 1992 and 1993) identifies capabilities in the various areas of manufacturing that refer to firms' ability to engage in technology-related activities and efficient production. It focuses in those spheres of production that are considered relevant for these purposes, such as product development, process development or industrial engineering. These broadly defined spheres of technology capability can then be broken down into a set of firm characteristics, relating to the different facets that technological capabilities take within the firm, and coded into a set of questions in a survey questionnaire.

In this context, firm-level data collected during the survey that forms the basis for this research was used to construct indices capturing firms' technological capabilities in four dimensions. These include three sub-indices capturing firm-level capabilities in product development, production technology, and process/industrial engineering (Table 1). Product development capabilities are those that allow firms to engage in product development activities such as introducing entirely new products, modifying existing ones, or producing and supplying purposely built products and services. Production technology capabilities, on the other hand, capture enterprises' ability to make an efficient use of their production technology; i.e. core machinery and ancillary equipment. Finally, process/industrial engineering capabilities refer to firms' ability to organise and control the production process in an efficient manner to optimise time, resources and ensure that production meets certain standards of production. In addition to these three dimensions, the analysis undertaken here includes a fourth general technology capabilities index, which obtained from the un-weighted summation of these three capability sub-indices. It also incorporates indicators capturing firm-wide and managerial skills, as well as a total skill index obtained in the same way.

Table 1. Components of firm-level technology capability and skill indices

Product development capabilities

- Firm has product development department
- Proportion of employees working in product development

Production technology capabilities

- Firm has contracted maintenance assistance
- Firm routinely does preventive maintenance
- Firm has a repair workshop
- Proportion of workforce doing maintenance
- Firm trained workers after purchasing new equipment
- Role played by the firm in specifying new purchases of equipment
- Firm modified purchases of new equipment to adapt it to local circumstances
- Imputed age of equipment
- Firm has CNC controlled equipment
- Firm has mechanically operated equipment

Process/industrial engineering capabilities

- Firm has quality control certificate
- Firm with quality control system
- Firm with quality control department
- Firm has inventory control system
- Firm has computerised inventory system

Managerial skills

- Managers' level of educational attainment
- Index of managers' professional experience
- Whether managers own other businesses
- Manager speaks foreign languages
- Manager travels abroad for work

Firm-wide skills

- Firm-wide composite education index
- Whether firm has in-house training program
- Firm sends workers to local external training
- Firm sends workers for training abroad