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Uncovering Trends 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 metalworking and light chemical sectors. To this end, it deploys Sanjaya Lall's technology capabilities framework to examine these processes 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 technology transfer mechanisms appears to have been able to reverse these trends. In light of available evidence, 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.*

1. Introduction

Since its independence from Portugal in 1975 Mozambique has experienced three decades of continued economic, political and social transformation. This has included a process of accelerated decolonization, the adoption of a model of central planning of the economy and, since the mid-1980s, the implementation of a comprehensive programme of economic reform and liberalization. Having been the sixth most industrialized economy in sub-Saharan Africa during the late colonial period, industrial development concerns have traditionally occupied a prominent place in development policy 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 industrialization (Pitcher, 2002), as well as for the post-liberalization period, starting in the mid-1980s, during which privatization, enterprise reform and, later, investment climate concerns have been important elements of policy debates in Mozambique (see World Bank, 1995; Cramer, 2001; Pitcher, 2002; Lledó, 2008).

These developments have coincided in time and scope with the wider international debate over the role of industrialization in development. This debate has been particularly intense with regard to industrial growth prospects in sub-Saharan Africa, a region that has

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lagged behind other developing parts of the world in terms of its industrial performance (UNCTAD, 2008).

At one end of this debate authors such as Owens & Wood (1997) and Wood & Mayer (2001) have argued that sub-Saharan countries should avoid pursuing a strategy of industrial development altogether. Instead, sub-Saharan nations should focus on developing their primary commodities and natural resources export base, given their comparative advantage in these activities, their low skill base, the commoditization of low-end international manufacturing markets and the strong competition exerted in these sectors by exporters in South and Southeast Asia, which have significantly reduced the benefits of industrialization as a means of development.

Others authors (Lall & Latsch, 1999; Stein, 2003), however, maintain that industrialization is an intrinsic part of the process of structural transformation that characterizes economic development, by which economies move up the international technology ladder and value chain to produce increasingly sophisticated goods. From this perspective, what is required to promote industrial development in sub-Saharan Africa are policies that address the multiple constraints of a structural, technological, infrastructural or institutional nature that countries in the region face in the sphere of manufacturing.

This latter approach is rooted in the Kaldorian analysis of industrialization and economic development (Kaldor, 1967; Thirlwall, 2002) This approach views manufacturing production as an engine of economic growth, owing to its ability to generate economy-wide productivity gains and other dynamic benefits, and, therefore, its power to trigger processes of structural transformation and economic growth in developing countries. Technical progress plays a central role in this paradigm, as it is considered a key factor behind productivity growth and, consequently, a driver of long-run capital accumulation.

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 understanding 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 the analysis of their impact on these firms' skill and technology 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 paper applies 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 chemicals. It follows similar applied research in other 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, the Philippines, Malaysia, Indonesia and Thailand (Rasiah, 2004). Lall's framework identifies capabilities in the various areas of manufacturing that relate 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.[1]

The analysis presented in this paper is centred on the examination of enterprise survey data collected during 2004 for firms employing 10 or more workers operating in these two sectors in the capital province of Maputo, which accounts for 60–70% of Mozambique's industrial production (RPED, 2003). This survey covered a sample of 90 firms, 56 in metalworking and 34 in the light chemicals sector, representing 98.3 and 75.6%, respectively, of the true population of firms operating within the sampling frame defined for the survey. The analysis of these data is presented together with a discussion of events taking place in Mozambique in the macroeconomic, meso-economic and policy spheres.

2. Industrial Development in Mozambique in Historical Perspective

The first signs of manufacturing activity in Mozambique appeared in the early colonial period, with the establishment of some basic processing capabilities in and around plantations operated by chartered companies in the central and northern regions of the country. Despite these early developments, until the mid-20th century the colonial authorities largely discouraged industrial development in Mozambique with the aim of safeguarding Portugal's ambitions for industrialization, by limiting any competition to the Portuguese manufacturing sector.

By the mid-1950s, however, the colonial authorities had allowed a growing number of manufacturing activities to take place in Mozambique, in order to accommodate an expanding Portuguese settler population, reduce export costs in agro-processing activities and absorb surplus second-hand industrial equipment available from Portugal (Hedges, 1999). As a result of this policy shift, throughout the 1960s and early 1970s the Mozambican manufacturing sector experienced a process of rapid expansion, with manufacturing value added increasing by 160% between 1959 and 1973 and investment in manufacturing almost quintupling during this same period. By 1973, the Mozambican manufacturing sector was responsible for generating over 11% of the country's GDP, employing 99 500 workers in around 1500–2000 industrial units.

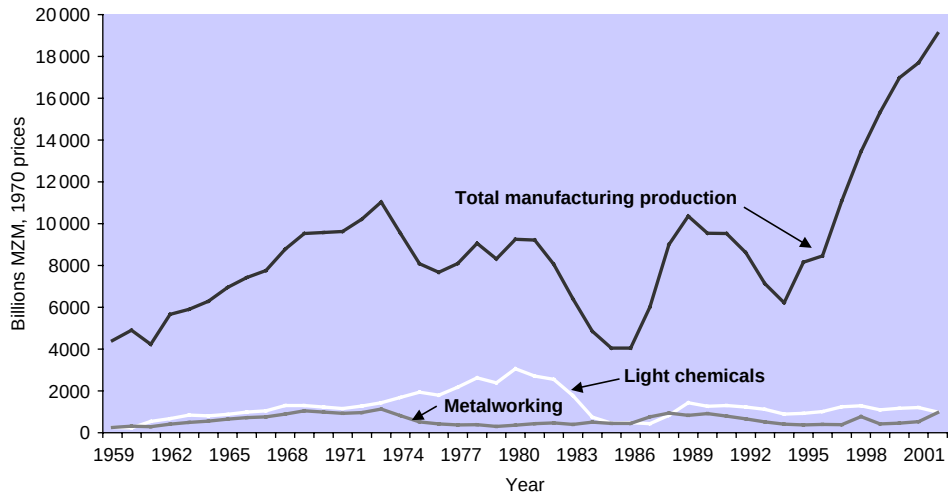

Figure 1. Manufacturing output 1959–2001 (1970 billion meticais).

Independence from Portugal in 1975 and the political turmoil that ensued led to a sharp decline in industrial activity, with manufacturing output falling by over 30% between 1974 and 1976. A key factor behind this drop was the departure in the aftermath of independence of around 200 000 of approximately quarter of a million Portuguese residents who had settled in Mozambique during the colonial period. This population had supported the growth of these manufacturing sectors by providing both skilled labour and a growing demand for locally produced manufactured goods, in a context in which decades of colonial employment and educational discrimination against the African population had prevented it from joining the industrial workforce, except in menial jobs (Johnston, 1990).

As a response to this deteriorating situation, the first post-independence Frelimo government adopted a model of central planning of the economy, taking over the management of numerous industrial firms abandoned by their Portuguese owners, and formulating a strategy of accelerated industrialization aimed at ending underdevelopment by the 1990s (World Bank, 1985). However, these ambitious goals were met by a weak manufacturing response, with manufacturing activity reaching a historical low in 1985, with production down to levels of the early 1960s and capacity utilization estimated to be below 30% in most industries (World Bank, 1990).

Several factors have been identified as being responsible for this poor industrial performance. To start with, the adoption of an unrealistic strategy of heavy industrialization and the excessive role of the state in industrial management appear to have created poor incentives for private investment and undermined firms' ability to adapt to adverse conditions (Egerö, 1987). The civil war with Renamo, spanning from the early 1980s until 1992, and the continuous covert attacks from the South African apartheid regime, also had a particularly damaging effect on manufacturing activity, as many of these attacks were targeted on industrial infrastructures around Maputo, in an attempt to disrupt economic activity. Adding to this, the recession that hit the world economy in the early 1980s and the drought affecting Mozambique between 1982 and 1985 further damaged any prospects for a quick industrial recovery, by reducing the purchasing power of the rural population, as well as the supply of raw materials to local industries (World Bank, 1985). Finally, the Frelimo government appears to have been unable to address the various structural constraints inherited from the colonial and post-colonial periods, such as the industrial sector's strong dependency on imports of intermediate goods and capital equipment, which exacerbated the balance of payments constraints that Mozambique faced in the 1980s, the general lack of technical and management skills and the use of increasingly obsolete manufacturing equipment.

This deteriorating situation led the Frelimo government of Joaquim Chissano to adopt a strategy of structural reform and economic liberalization in 1986 that has continued to the present. In the two decades that have elapsed since then, manufacturing activity has, overall, experienced a significant recovery, with the share of manufacturing value added in GDP reaching a historical peak of 14.8% in 2004.

This overall positive manufacturing response to structural adjustment and liberalization has, however, coincided with 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, and with a growing concentration of manufacturing production in a small number of industries and firms. Thus, by 1999 only nine firms accounted for 56% of industrial production in Mozambique, with the two largest companies, South African

Breweries and Coca-Cola, responsible for 25.7% of industrial output (World Trade Organization, 2001). This process of growing concentration continued into the 2000s as several industrial mega-projects started operating in Mozambique. MOZAL alone, an aluminium smelter operating outside Maputo since 2000 and employing around 1100 workers, the most renowned of these projects, accounted for 6.7% of the country's GDP in 2004, 38% of its growth and 55% of its exports. Meanwhile, other traditionally important sectors have fared less well. Some have almost disappeared, as in the case of garments and textiles, which accounted for barely 0.1% of manufacturing production in 2005, down from 23% in 1988; or the cashew nut industry, which in the 1970s was a leading producer and exporter in international markets.

Several factors have been identified as currently constraining manufacturing development in Mozambique. The most frequently cited refer to investment climate constraints imposed by a burdensome regulatory and administrative environment, and the general inadequacy of business infrastructures (RPED, 2003; CTA, 2004). Other important constraints include the implementation, since the early 1990s, of a tight monetary policy framework and a strategy of financial restraint that has raised significantly the cost of investment, with lending rates in local currency above 25% in nominal terms throughout most of the late 1990s and 2000s. In addition, the strong competition exerted by the import and informal sectors, the collapse of upstream industries and the decline in demand caused by the sharp drop in formal employment have led to a steep decline in business opportunities for local manufacturing firms. These firms' general technological backwardness and weak skill base have further undermined local manufacturing firms' competitiveness and market position in local and international markets (RPED, 2003).

These developments have taken place in a context in which the government has gradually shifted its industrial development policy focus towards attracting large foreign industrial mega-projects, largely linked to the South African mineral and energy complex (Virtanen & Ehrenpreis, 2007). This has been to the detriment of a broader approach to industrial development that addresses the various constraints of a structural and institutional nature that afflict the Mozambican manufacturing sector and promotes broad-based manufacturing development (Castel Branco, 2004).

The government does have a National Strategy for the Industrial Sector, which sets out the guiding principles for government intervention in this sphere, identifying most of the constraints outlined above and laying out a strategy for broad-based industrial development. However, this document, which dates back to 1997, 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-Rodríguez, 2007b).

This shifting policy paradigm has coincided with a steady weakening of the Mozambican policy and institutional framework for industrial development, which has further undermined any chance of addressing these multiple constraints. For example, a weak regulatory and enterprise inspection system, a recurrent finding of investment climate studies in Mozambique (RPED, 1999, 2003 CTA, 2004), has resulted in very little control being exercised over the quality of products and production processes, undermining firms' quality control efforts. The formulation and implementation of sectoral policies and master plans, on the other hand, is seriously constrained by the lack of human and technical resources to implement these programmes. For instance, the National Directorate of Industry of the Ministry of Industry and Trade, which is responsible for

formulating and implementing industrial policy, had in 2004 a total staff of 27 people, of whom only 13 had a university degree. Similarly, the National Quality and Standards Agency, responsible for providing quality assurance and metronomy services to local manufacturing firms, had a staff of only 13 people in 2004, only five of whom had a university degree (Warren-Rodríguez, 2007a).

Beyond these government agencies, at present there is a considerable number of private companies, donor-sponsored agencies and non-governmental organizations (NGOs) providing technical capacity-building support, business development services, financial facilities and micro-credit to local firms in Mozambique. Yet, the overall reach and impact of these initiatives have been limited. This has partly been the result of the difficult business environment faced by manufacturing firms operating in Mozambique, which has reduced the demand for these types of service. Additionally, the fragmentation and weak coordination of these initiatives, in the sense of not being aligned or responding to an overall strategy for industrial and technology development, have also contributed, from a supply side, to the low effectiveness of these business development initiatives (Warren-Rodríguez, 2007a).

3. Obsolescence and Simplification of Technology and Skills in Metalworking and Light Chemical Industries

The origin of the Mozambican metalworking and light chemical sectors can be traced back to the mid-1950s. During this period the first industrial units in these two sectors were established in Mozambique as a response to the growing demand for industrial equipment, spare parts, repair and maintenance services and consumer goods.

During the 1960s and early 1970s both sectors expanded rapidly, with manufacturing output growing at an average annual rate of 18.4% in light chemical industries and 13.3% in metalworking between 1959 and 1973. As a result of this rapid growth, by 1973 metalworking and light chemicals industries were employing 4232 and 10 442 workers, respectively (UNIDO, 2003). This expansion was accompanied by the creation of several considerably large, integrated and, at the time, relatively modern firms, especially in the metalworking sector (Nunes, 1975). Independence from Portugal in 1975 had a somewhat different impact on the two sectors. As with other areas in the economy, metalworking industries experienced a very sharp decline in production, with output falling by 67.4% between 1973 and 1977. Light chemical production, on the other hand, continued to grow at a steady pace until 1980. However, by 1986 production in both sectors had reached historical lows, down to levels of the early 1960s. Since then, manufacturing activity in both metalworking and light chemical industries has stagnated, with production growing at an annual compound growth rate of 0.2 and 1.2%, respectively, in real terms between 1988 and 2002.

At present both sectors include firms producing a wide range of products. The metalworking industry in the province of Maputo consists of firms that engage in the transformation of metallic material into fabricated products.[2] It includes manufacturers of machinery, metal parts, transport equipment, metal furniture and galvanized steel plates, as well as firms providing specialized engineering services involving the maintenance, repair and reconstruction of metal equipment. Although producing a wide range of goods, firms in this sector generally use similar production technologies.

Light chemical firms, on the other hand, specialize in the production of plastic goods (household items, furniture, bags), rubber products, paints, glues, varnishes, detergents, foams, cosmetics, medicines and industrial and medicinal gases.[3] Owing to the nature of the inputs used in these activities, firms in this sector engage in substantial process engineering activities to ensure that inputs meet required production standards and are combined in the right proportions, as this greatly affects the quality of the final product. Production processes in this sector also share certain technological traits. For instance, they typically involve mixing inputs, and in many cases, such as in the production of plastics, rubbers or foams, they involve a process of extrusion.

3.1 Historical Downward Trend in Technology Capability Accumulation

Currently, both metalworking and light chemicals industries include an important presence of companies that were established during the colonial period, with almost 50% of surveyed firms having been created then.[4] 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 companies estimated to be at least 20 years old at the time of the survey, i.e. dating back at least to the early 1980s and, probably, to the pre-independence period. The 1995 survey by ANEMM[5] of the Mozambican metalworking sector (ANEMM, 1996) confirms these patterns, with 50 of the 60 firms surveyed for this study reporting equipment, on average, 20 years old or more; that is, dating back at least to the 1970s.

Interestingly, despite the age of these firms and of their core production technologies, these companies generally show a relatively strong technology capability base, especially when compared with firms established since independence. Thus, overall, firms established before 1975 appear to be, on average, 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 their manufacturing machinery equipment efficiently, and control the quality of their products and manufacturing processes, as the indices capturing product development, production technology and process capabilities in Table 1 indicate. Differentiating by sector, firms created during this period are more capable than average in metalworking, whereas in light chemicals the differences are smaller. This is partly because capability requirements in chemical industries in the spheres of production captured in these indices are more stringent. For instance, all manufacturers of paints and glues, foams, personal hygiene or cleaning products tend to require some form of quality control system, regardless of their age, size or origin.

The capability indices presented in Table 1 only capture whether the various technology capabilities under consideration existed or not at the time the firms were surveyed. Consequently, they do not necessarily indicate the capabilities that firms established during the colonial period had at the time of independence. Thus, it is possible that they partly or wholly capture efforts to upgrade technological capabilities that have taken place since that period.

This is in part the case for several firms in the sample that were nationalized and integrated in production units under direct government control after independence (Pitcher, 2002).[6] The creation of these industrial units involved a significant reorganization of production and some technology upgrading efforts.[7] These units also benefited from important technology transfers through technology cooperation agreements with foreign governments, as was the case of at least eight enterprises in the survey. Hence, in addition

Table 1. Test of means: pre- versus post-independence firms[a]

	Metalworking			Light chemicals			Both sectors		
	Pre-1975	Post-1975	*t*-Test	<1975	>1975	*t*-Test	<1975	>1975	*t*-Test
Number	27	29	n.a.	17	17	n.a.	44	46	n.a.
Aggregate technology capabilities	6.06	4.05	0.002**	6.43	6.04	0.500	6.20	4.78	0.008**
Product development capabilities	0.84	0.42	0.023**	0.145	0.00	0.154	0.57	0.27	0.022**
Production technology capabilities	2.87	2.11	0.022**	3.82	3.39	0.454	3.24	2.58	0.038**
Process capabilities	2.33	1.52	0.036**	2.47	2.65	0.719	2.39	1.93	0.146
Quality control	0.81	0.48	0.131	1.29	1.24	0.870	1.00	0.76	0.233
Inventory systems	1.52	1.03	0.044	1.18	1.41	0.440	1.39	1.17	0.258

[a] See Appendix 1 for an explanation of how these indices were obtained.
** Indices for which the *t*-test indicates that group means are statistically different at a 5% significance level.

to investments made during the colonial period, these firms' current capability levels reflect, to some extent, investments undertaken in the first decade after independence.

In principle, technological capabilities currently installed in firms established during the colonial and post-independence periods could also reflect investments undertaken since the mid-1980s, after the Mozambican government adopted its current agenda of economic reform and liberalization. The fact that many of these firms were involved in the process of enterprise privatization that took place in the 1980s and 1990s and, consequently, would in principle appear as likely recipients of technology-upgrading investments, supports this possibility.

The available evidence suggests, however, that investments arising from the privatization process did not entail any substantial change in these firms' capability base: the few studies that exist on this topic (Cramer, 2001; Pitcher, 2002) indicate that, in general, privatization was not followed by a reorganization of the industrial sector, or by a process of large-scale plant rehabilitation and technology-upgrading investment. This also seems to have been the case for privatized firms in the metalworking and light chemicals sectors. Thus, over half of former state-owned enterprises (SOEs) included in the sample (18 out of 34) continued operating with the same equipment and production systems after their privatization, without any rehabilitation or replacement investments taking place. Moreover, of the remaining 16 firms, many reported having undertaken only minor investments after their privatization, aimed at repairing and servicing existing equipment. In this respect, privatization in these two sectors can be considered to have consisted mainly of a process of ownership transfer from the state to private investors, with little impact on plant rehabilitation and modernization. These findings are consistent 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, dating back to at least to the 1980s, before the privatization processes started.

Altogether, the results reported in Table 1 suggest the existence of a structural break in technological capability development between older and younger firms, especially intense in the metalworking sector. 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.

These results need some qualification. First, the indices reported in Table 1 are mostly dichotomous in nature and, consequently, can capture only the tangible dimension of firms' technological capabilities, and only in a limited way. Consequently, they cannot capture the quality or sophistication of these systems, or the 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 not in use, as was evident in some cases. Yet, even if this were the 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, these capability indices might also be capturing technology-upgrading investments undertaken since the early 1980s. Yet, as argued above, this is possible only to a limited extent and, in any case, would still not explain the large differences in patterns of technology capability accumulation between older and younger firms. In other words, they would not explain why older firms are technologically more capable than companies established more recently.

Table 2. 1995 Technology traits of Maputo metalworking firms; survivors versus 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
% with maintenance and repair systems	42.9	72.7
% workers with secondary education	6.3	10.4

Source: Own calculations based on ANEMM (1996).

Finally, the above figures could simply be capturing a technology 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 a better condition to survive. However, evidence from the sample suggests that this was not the case. Hence, several of the technologically more capable firms established during the colonial period have closed down since independence, including several firms in the metalworking sector, as figures from the survey conducted by ANEMM in 1995 indicate (Table 2). Thus, firms established prior to 1987 included in this survey that have since ceased to operate were, on several accounts, technologically more capable and better skilled than those that have survived until today.[8]

Altogether, these results point to the existence of a process of gradual weakening of these two sectors' technological capability base over the past two decades, with greater incidence of decline in the metalworking sector. This process would appear to be the result of new entrants in these two sectors having 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. However, it is reasonable to assume that as manufacturing complexity increases firms will require higher levels of technological capabilities and skills to continue engaging in efficient production. For instance, simple manufacturing processes, such as packaging, labelling or bottling, do not require the level of skills or complex capabilities necessary in more advanced and complex production lines.

For 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 in which firms engaged before the final output was produced. It was obtained by calculating the average level of production integration of each firm's three main product lines, weighted by the share of these products in their total sales.

Table 3. Spearman's correlation: age and production integration

	Spearman's correlation	Significance (2-tailed)
Metalworking	0.400**	0.000
Light chemicals	0.431**	0.002
All firms	0.400**	0.000

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

In the sample, production integration ranges from a value of one, awarded to firms that engage only in packaging activities, to a maximum of nine production processes, with an average level of product integration of 3.6 processes for the full sample of firms. As shown in Table 3, this measure of manufacturing complexity shows a reasonably strong correlation with firms' age in both sectors, with all the three correlation coefficients statistically significant at the 5% level and presenting the expected positive sign. These results suggest that older firms engage in more complex manufacturing processes that are likely to require greater levels of capabilities and skills, corroborating the contention that, over time, there has been a process of production simplification in these two industries, in which newly established firms are adopting simpler production processes that require fewer technological capabilities and skills to produce similar products as those manufactured by older firms.

This process of production simplification was evident in factory visits to firms recently established in these two sectors, which engaged in very simple transformation activities, often involving only product packaging or assembly operations, having imported an almost finished product from abroad. This group of firms includes many foreign companies that have set up plants in Mozambique operating very basic 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 foreign direct investment (FDI) projects established in these two sectors since independence estimated at 3.02 production processes,[9] down from a sample average of 3.6 stages. These include six firms that only engage in one-stage manufacturing activities, such as packaging or assembling final products. This tendency towards the simplification of production processes is also affecting older firms. Some of these firms are reorienting part of their production towards the manufacture of goods that require a degree of transformation below that which they are capable of undertaking, reinforcing this process of production simplification. In the sample, at least 21 firms fall into 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.[10]

Again, these results need some qualification. In some cases intra-firm and intra-sector reductions in production integration reflect changes in the type of manufacturing production these firms are currently engaging in, rather than a process of production simplification. These new forms of manufacturing might require fewer stages of transformation, but do not necessarily require less skilled workers or lower capabilities, simply different ones. This was the case in some older metalworking firms that have moved from manufacturing simple metal products, such as metal containers, agricultural tools or metal furniture, to providing specialized engineering services that require highly qualified workers and the use of sophisticated equipment, yet involve fewer manufacturing stages. Still, only five firms in this sector fell into this category: three metalworking companies that were providing specialized engineering services, and two other firms that

had changed their product portfolio entirely. In any case, these changes would reflect a process of capability specialization, not necessarily capability deepening.[11] For the remaining 16 firms that had seen their level of production integration fall below their maximum potential level, factory visits clearly suggested that they were producing simpler products that required lower skills and capabilities than those needed for the production of goods they had manufactured in the past.

The decline in intra-firm and intra-sector levels of production integration experienced by these two sectors could also reflect a process of producer specialization accompanied by a process of sector or economy-wide diversification. In this context, individual firms would specialize in a smaller number of production processes, while at a sector or economy-wide level manufacturing complexity along the production chain would remain the same or increase. However, there is little evidence that this has been the case, especially considering that the survey included almost all firms in these sectors in the province of Maputo and, therefore, would have captured these production specialization-cum-diversification dynamics. In fact, what emerges from firms' survey responses is that there are very few subcontractual linkages within these sectors, or between these industries and other sectors, with firms selling mostly to final consumers and purchasing on average 90% of their inputs from abroad. In this respect, firms in these sectors appear to operate in a very disconnected way, rather than as part of an integrated national or global production system.

3.3 Technology Capability Loss in the Context of Economic Reform

The results reported in the previous sections cannot be properly understood without making reference to the challenging socio-economic and policy environment in which firms in these two sectors have operated since Mozambique's independence from Portugal in 1975, as outlined in Section 2.

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 operate relatively complex production lines efficiently. This very large and sudden loss of technical and managerial expertise, together with the generally low skills of the Mozambican population and the inability of successive post-independence governments to reverse this situation, have deterred technology-upgrading investments in existing plants or new industrial projects. 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 levels of expertise and technology capabilities.

Additionally, the disruption caused by the sudden departure of the Portuguese settler population after independence, many years of war, together with a deteriorating economic and business environment, have further deterred technology-upgrading investments by firms in these two sectors, by reducing the markets these firms served, as well as by raising the costs of investment. This is consistent with managers' responses in the survey as to the main difficulties they face, as well as with the findings of the various investment climate surveys undertaken in Mozambique (e.g. RPED, 1999, 2003), which systematically found the high cost and inaccessibility of finance and a difficult business environment to be the main constraints to private sector development in Mozambique.

These events have coincided with a gradual deterioration of the Mozambican policy and institutional framework for private sector development, as discussed in 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.

Altogether, these developments have led to a profound change in the nature of manufacturing production in Mozambique, which partly explains 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 sectors—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 the kind of capabilities they had acquired in the past. This largely explains the large amount of idle equipment that exists in many of these firms, with capacity utilization rates estimated for 2003 at 50.5 and 48.3% in metalworking and light chemical industries. At the same time, new markets have appeared for firms in these industries that no longer require these capabilities. For instance, metalworking companies that have gone from manufacturing equipment to providing specialized engineering services have little need for product development and design capabilities and, instead, require highly qualified staff (e.g. specialized welders). 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 brick makers and flower mills, which has reduced product development and quality control requirements. Finally, the nature and small size of these markets often impede the continuous production of standardized products, reducing the scope for establishing in-factory quality control systems and the incentives to engage in continuous permanent quality control efforts.

From this perspective, 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 on the Accumulation of Skills and Technology Capabilities

With low levels of industrial development and few resources devoted to R&D, industrial technological development in Mozambique largely relies on international transfers of foreign technology (RPED, 2003). This is also the case for metalworking and light chemical industries 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 presumably constitute a prime source of technology capability and know-how acquisition in the Mozambican metalworking and light chemical sectors, especially considering that, at the time of the survey, as many as 30 firms in the sample were fully foreign-owned, another 16 had a majority of equity owned by foreign investors and four other firms had minority shares owned by foreign investors.

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; Keller, 2004). From this perspective, foreign investors contribute to the process of technological change in developing countries by introducing advanced production and managerial techniques and new products and skills, as well as technologies embodied in manufacturing equipment.

Foreign ownership as a source of technological capabilities has also been incorporated into the technology capability analytical framework (see Lall & Urata, 2003). This strand of literature typically argues that foreign-owned firms can have a positive impact on developing countries' capability levels because: (1) they have greater access to proprietary technological knowledge through their parent companies; (2) they generally have greater awareness of the importance of developing firm-level technology capabilities for manufacturing performance; (3) they have a better knowledge of new technological developments unfolding in more advanced economies; and (4) have greater access to finance and, therefore, greater capacity to invest in the acquisition of technological capabilities.

4.1 Weak Impact of FDI on Skills and Technology Capability Accumulation

From this perspective, a positive correlation would be expected to exist between the degree of foreign ownership and levels of technological capabilities in firms in the sample. This is the case according to several empirical studies examining technological capability dynamics in developing countries (e.g. Lall *et al.*, 1994; Deraniyagala, 2001a, b; Wignaraja, 2002; Rasiah, 2004). Yet, despite the weight given to these arguments in the development literature and the abundant evidence underscoring the positive technological impact that FDI has in developing countries, FDI 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 limited role played by FDI in this sphere is the weak association that exists in these two sectors between the degree of foreign ownership and the various dimensions of technological capabilities under examination (see Table 4). 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% 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 the sample increases.

One potential source of error with these correlations is that these coefficients measure only the level of association between technology capabilities and unweighted shares of foreign ownership, treating all firms as being equally large. In this respect, it is possible that the impact of foreign investment on firms' technology capabilities is greater in larger enterprises, given the economies of scale typically associated with technological development (Freeman & Soete, 1997; Wignaraja, 2002). Yet, when taking firm 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 5).

Another reason why these correlation coefficients may not capture the full effect of foreign ownership on levels of technology capability is the fact 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 be proportional to its equity share,

Table 4. 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	−0.198	0.143	0.086	0.627
Product development capabilities	−0.268*	0.046	−0.224	0.204
Production technology capabilities	−0.187	0.167	0.022	0.903
Process capabilities	0.001	0.997	0.129	0.468
Quality control capabilities	−0.082	0.549	0.041	0.818
Inventory capabilities	0.080	0.560	0.170	0.335

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

Table 5. Spearman's correlation: foreign ownership and technology capabilities by size

	Micro < 10 workers	Small 20 > workers > 10	Medium 50 > workers > 20	Large 100 > workers > 50	Very large > 100 workers
Number	2	15	37	24	12
Technology capability	− 1.000	0.015	0.004	− 0.074	− 0.302
Sig. (2-tailed)	*1.000*	0.958	0.982	0.731	0.340
Product development capabilities		0.140	− 0.069	− 0.511*	− 0.693*
Sig. (2-tailed)		*0.618*	*0.685*	*0.011*	*0.013*
Production technology capabilities	− 1.000	− 0.170	0.010	0.207	− 0.413
Sig. (2-tailed)	*1.000*	*0.544*	*0.954*	*0.331*	*0.182*
Process capabilities		0.291	0.085	− 0.054	− 0.058
Sig. (2-tailed)		*0.292*	*0.618*	*0.803*	*0.858*
Quality control capabilities		0.302	− 0.062	0.024	0.022
Sig. (2-tailed)		*0.274*	*0.716*	*0.910*	*0.945*
Inventory capabilities		0.257	0.189	− 0.100	− 0.051
Sig. (2-tailed)		*0.355*	*0.263*	*0.644*	*0.874*

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

an underlying assumption of the correlation analysis presented in Table 4. In other words, foreign investors might be contributing to the technological base of these firms in a magnitude higher than their equity share in these companies. Yet, the number of these firms is relatively small (20) and most are largely foreign-owned,[12] reducing the potential impact of this effect on the above correlations.

A way of gaining insight into the differential impact of foreign ownership on technological capability levels is by focusing on the two subsamples of firms that are either fully Mozambican or totally foreign-owned, and examining whether there are any systematic differences in their capabilities scores. However, the results of the test for equality of means reported in Table 6 suggest that the only significant difference between these two groups is in the sphere of product development, where fully foreign-owned firms appear to be less capable than wholly Mozambican-owned companies.

Table 6. Tests of equality of means: foreign versus fully Mozambican-owned firms

	Mean				
	Foreign ($n = 37$)	Mozambican ($n = 33$)	Wilks's lambda	F	Sig.
Total technology capabilities	5.36	5.12	0.998	0.164	0.687
Product development capabilities	0.15	0.58	0.886	8.737	0.004**
Production technology capabilities	2.84	2.90	1.00	0.033	0.856
Process capabilities	2.12	1.86	0.992	0.542	0.464
Quality control capabilities	0.78	0.72	0.999	0.071	0.791
Inventory capabilities	1.33	1.13	0.987	0.868	0.355

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

These results do not necessarily imply that FDI has not over the years played an important role in the formation of technological capabilities in these two industries. Only a very small number of firms in both sectors were originally established with Mozambican capital: many firms that appear in the survey as being Mozambican were initially established by (foreign) Portuguese investors during the colonial period. In the sample, this group comprises a total of 44 firms, 27 in metalworking (48% of this subsample) and another 17 in light chemicals industries (50%). Many of these firms (31) were taken over by the state after independence and, later, privatized during the 1980s and 1990s. During this privatization process Mozambican nationals purchased stakes in several of these firms,[13] 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, have similar characteristics to those that have benefited from FDI. Thus, only 20 firms can be considered to have been established entirely 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% foreign-owned) established since 1975 and that, consequently, are not the result of foreign investments undertaken during the colonial period (see Table 7). Altogether, these results suggest that FDI in these two sectors has not had a significant differential impact on patterns of technology capability accumulation in these manufacturing sectors.

A similar situation arises in relation to the provision of skills. The technology literature generally argues that FDI can be an important source of foreign know-how for host developing economies through, among other channels, the direct transfer of skills to local

Table 7. Purely Mozambican versus foreign-owned, test of group means

	Foreign ($n = 15$)		Mozambican ($n = 14$)		t-Test
Metalworking	Mean	SD	Mean	SD	(Sig.)
Technology capabilities	4.24	1.69	3.85	3.25	0.687
Product development	0.45	0.69	0.39	0.65	0.811
Production technology	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	0.47	0.74	0.50	0.85	0.911
Inventory capabilities	1.27	0.88	0.79	0.89	0.157
	Foreign ($n = 11$)		Mozambican ($n = 6$)		t-Test
Light chemicals	Mean	SD	Mean	SD	(Sig.)
Technology capabilities	6.16	2.13	5.81	2.08	0.749
Product development	0.00	0.00	0.00	0.00	n.a.
Production technology	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	1.55	0.93	0.67	1.21	0.115
Inventory capabilities	1.45	0.82	1.33	1.03	0.794

Table 8. Spearman's correlation: skills and foreign ownership

	Metalworking	Light chemicals	Total
All skills	0.222	0.274	0.252
Sig. (2-tailed)	*0.100*	*0.117*	*0.017*
Managerial skills	0.107	0.022	0.070
Sig. (2-tailed)	*0.432*	*0.900*	*0.514*
Firm-wide skills	0.251	0.349*	0.302
Sig. (2-tailed)	*0.062*	*0.043*	*0.004*

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

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 typically allows foreign companies to attract local workers with higher qualifications, which results in a higher stock of skills in 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 another are incorporated in the skill indices considered here, are not present in the Mozambican metalworking and light chemical sectors: foreign companies operating in the metalworking and light chemical sectors do not appear to be better skilled than Mozambican-owned firms. 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 8).

4.2 Factors Explaining FDI's Weak Technological and Skill Impact

Several factors explain these rather unexpected results relating to the weak impact of FDI on patterns of technological capability and skill accumulation in these two sectors. With regard to skill accumulation, it is important to underline that Mozambican managers in the sample fare quite well when compared with their foreign counterparts. Thus, there is a similar proportion of Mozambican and expatriate managers with university, secondary and technical education who have a command of foreign languages and regularly travel abroad for business purposes (Table 9). Moreover, 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 9).

In terms of firm-wide skills, i.e. the skill levels of firms' workforce, foreign-owned firms generally do present higher scores. However, Mozambican companies have workforces with relatively similar skill levels, while also engaging in activities to improve their skill base, in some cases more so than foreign-owned companies. Hence, while only 12.2% of Mozambican firms have formal in-house training programmes and facilities, as opposed to 24.5% 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.

In relation to the impact of FDI on technology capability accumulation, these results can be explained by the fact that recent foreign investors have contributed disproportionately to the process of production simplification and capability weakening that has taken place

Table 9. Managerial skills in metalworking and light chemical firms

	Mozambican managers	Foreign managers	Mozambican firms (>50%)	Foreign firms (≤50%)
% of managers:				
with university studies	52.1	61.9	56.1	57.1
with secondary + technical 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

Table 10. Managerial skills in sample firms

	Mozambican firms (>50%)	Foreign firms (≤50%)
Average % of workers with:		
engineering degree	0.19	0.16
university studies	2.32	3.12
secondary/technical education	15.56	21.66
Training (% of firms):		
internal training programme	12.20	24.49
local external training	4.02	2.11
foreign external training	2.10	2.85

in these two sectors, by operating simpler production processes that require fewer skilled workers, as argued in Section 3. Local firms, on the other hand, have available other sources of technology and skill acquisition, which offset the technological advantage that foreign firms operating in these two sectors in Mozambique might have over local firms.

Beyond these specific factors, it is important to draw attention to the fact that foreign enterprises do not constitute a homogenous group. In fact, in several cases foreign investors have invested in upgrading existing capabilities and skills as part of their investment strategies in Mozambique. In some instances, these investments have actually generated important technological and knowledge externalities to the rest of the economy, as was the case of the technological spillovers from the MOZAL aluminium smelter to several local metalworking firms (see Castel-Branco & Goldin, 2003; Warren-Rodríguez, 2007b). In this respect, these results do not deny the importance of FDI as a source of skills and capabilities accumulation in the metalworking and light chemical sectors in specific instances.

In many other instances, however, this has not been the case, diluting the overall technological and skill impact of FDI in these sectors. 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 investments,

except for small maintenance and repair investments. Although the original investments that led to the creation of these firms from the 1950s to the 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 and, consequently, do not necessarily have a better knowledge of current international technological trends than Mozambican businesses. It is significant that the 20 foreign business owners in the sample had spent, on average, 65.4% of their professional careers working in Mozambique. When taking into consideration all 42 foreign managers who were interviewed, regardless of whether they owned the firms or not, this proportion drops significantly, but still remains at a considerable 44.8% of their work life.

By contrast, more recent foreign investments have frequently consisted of acquisitions of existing firms, often as part of the privatization process that took place in the 1990s, without efforts being made to rehabilitate, replace or upgrade production facilities. It is noteworthy that nine out of 17 mostly foreign-owned firms that 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.[14] This situation has not been exclusive to foreign investors: similar situations have arisen with Mozambican operators. In fact, this has also been the case for several firms in both sectors that have remained under the same ownership since they were first created. Nonetheless, this lack of technology-upgrading investments by foreign investors purchasing existing industrial assets in Mozambique has contributed to 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, both Mozambican and foreign, suggested they were aware of the importance of investing in upgrading their technical capabilities. However, market constraints and costly and inaccessible investment finance 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, a weak investment climate, strong competition and low profitability, heavily constrained their ability to invest in technology acquisitions. Another 12 also considered these to be important constraints. These findings are consistent with other studies of the Mozambican industrial sector, such as the World Bank's assessment of its Industrial Enterprise Restructuring Project (World Bank, 2002). This found that privatization was undertaken in a context in which many Mozambican investors were inexperienced, with no management and technical skills, and at a time when 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 investment, especially by Mozambican-owned firms.

In other cases, the lack of investment in this technology sphere appears to be more the result of poor business strategies, or, simply, because other reasons had motivated the original investment. For example, three owners of metalworking firms openly acknowledged they had acquired these firms only to have a registered business in Mozambique from which they could invest in more lucrative businesses.

As discussed in Section 2, these findings highlight 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 in these two sectors, especially in the case of investments in the purchase of existing industrial plants, such as those associated with the process of privatization that took place during the late 1980s and throughout the 1990s. However, there have been some examples of relatively successful initiatives aimed at promoting linkages between FDI projects and the local enterprise sector, such as the MOZLINK, PODE or CPI linkages programmes; but these have been limited in number, scope and reach. For instance, the more successful MOZLINK programme only supports this type of initiative with the MOZAL aluminium smelter.[15] On the other hand, PODE, which had a broader mandate, centred its efforts on a small number of firms operating in the capital city of Maputo and, in any case, closed down in late 2004 (Warren-Rodríguez, 2007b).

5. Technical Cooperation Arrangements and the Accumulation of Skills and Technology Capabilities

The weak technological impact of FDI in these two sectors has not prevented enterprises operating in the metalworking and light chemical sectors from actively engaging in efforts to acquire know-how, skills and technological capabilities through other channels. These include several enterprises that have made use of technology cooperation arrangements with other firms, technology institutions or specialized consultants, which have frequently played a decisive role in the acquisition of technological capabilities.

These firms constitute quite a large group in the sample, with at least 39 companies engaging in this type of activity. However, they do not constitute a homogeneous group of enterprises. Thus, some firms engage in technology cooperation arrangements continuously, whereas others do so only on an *ad hoc* basis, usually when they were first created. There are also important differences as to the specific source of technology cooperation used. For instance, several companies have benefited from foreign technical assistance provided by international developmental agencies. These include several former SOEs that benefited from this type of technology cooperative arrangement while 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 benefited from the support provided by the various business development programmes that exist in Mozambique, in the form of management training, certification, or consultancy and engineering services. In other cases, these technological relationships have taken the form of cooperation arrangements with other private firms. Finally, some companies make regular use of the services provided by specialized external consultants. This has been especially important for firms in the light chemical sector where manufacturers of paints or detergents make use of these specialized services for their product development and quality control needs.

Technology cooperation with other firms, consultants, public agencies and non-profit organizations has played a significant role in the transmission of technological capabilities and skills to firms operating in the metalworking and light chemicals sectors. These technology cooperation arrangements have contributed to making these firms among the technologically more capable and skilled firms in the sample. An indication of this is the fact that the capability and skill levels of firms that regularly engage in these types of arrangement are significantly higher than those of companies that do so only on an *ad hoc*

Table 11. Test of means: firms that engage in continuous cooperation arrangements versus firms that do not

	Continuous cooperation ($n = 18$)		Others ($n = 72$)		
	Mean	SD	Mean	SD	Sig. 2-tailed
Technological capabilities	6.87	2.85	5.13	2.36	0.009*
Product development capabilities	0.666	0.662	0.354	0.620	0.063***
Production technology capabilities	3.48	1.51	2.76	1.49	0.071***
Process capabilities	2.72	1.45	2.01	1.45	0.067***
Quality control capability	1.22	0.943	0.79	0.934	0.084***
Inventory capabilities	1.50	0.857	1.22	0.892	0.237
All skills	1.01	0.268	0.793	0.292	0.005*
Managerial skills	1.24	0.259	1.04	0.372	0.035**
Firm-wide skills	0.807	0.429	0.554	0.446	0.033**

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

basis, or those of firms that do not make use of this type of technology sourcing at all (Table 11).

Despite the positive impact that these cooperative arrangements have had in the process of accumulation of skills and technological capabilities, their overall impact on these two sectors' technological and skill base remains limited. Thus, as already indicated, many of these firms have benefited from such arrangements on an *ad hoc* basis, in many instances as turnkey projects when they were first established, with only 18 firms regularly making use of such arrangements. Moreover, the potential for further upstream and downstream firm-to-firm technological linkages is limited by 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 limited amount of subcontracting that exists in these two sectors. This adds to the limited reach of business development programmes operating in Mozambique, with only 24 firms in both sectors reporting ever having 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, foreign industrial projects operating in Mozambique that could potentially contribute to raising skills and technology capability levels in these two sectors through the transfer of technology and know-how embedded in subcontractual work with local firms often fail to do so.

One reason why these potential linkages do not materialize is the perception that local firms do not have the capacity to provide goods and services of the quality or in the 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 surveyed. 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 accessed by firms based in 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, a 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 distance of 60–100 km north of Maputo, provides a good example of this situation.[16] These two agro-processing projects, together with the two sugar companies operating in the central province of Zambezia, were responsible for generating 8.8% of Mozambique's exports in 2006, excluding exports from the MOZAL aluminium smelter, directly employing several thousands of workers in rural areas north of Maputo. In both instances, these sugar mills and adjacent sugar plantations undertake most of their repair and maintenance requirements in-house or, if necessary, in neighbouring South Africa, where most of these companies originate and where, in several cases, they have run similar sugar operations in the past. Similarly, they purchase many of their inputs (e.g. seeds, fertilizers), tools and ancillary equipment (e.g. hoses, irrigation systems, machinery, agricultural tools) directly from South Africa, despite the fact that many of these goods and services can easily be purchased from local trading firms in Maputo and, in some cases, are manufactured by local firms, including by companies in the metalworking and light chemical sectors. This situation arises partly because managers in these sugar operations (sugar mills and plantations) consider that prices for local goods are not competitive and that local firms do not have the capacity to provide these goods and services of the quality and in the time they require. However, owners and managers also recognize that it is their lack of knowledge of the local economy and, thus, of local businesses' ability to supply these goods and services that stops them from outsourcing locally. Moreover, despite the size of these operations, their relatively large procurement needs[17] 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 exists in Maputo, underscoring the inability of existing linkage programmes and investment promotion agencies to maximize linkages and other (technologically) dynamic benefits from FDI projects operating in Mozambique.

6. Concluding Comments

Overall, what emerges from this examination of patterns and underlying trends of technological capability and skill accumulation in the Mozambican 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, which, in the past two decades, has undermined investments in industrial technological development.

In this context, FDI, which is 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. This is because many of these projects date back to the colonial period, and do not seem to have embarked on any major technology upgrading efforts in recent years. In other cases, FDI has been limited to the acquisition of existing assets, as part of the Mozambique

privatization 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 the process of production simplification mentioned above. These outcomes not only reflect the nature of FDI in Mozambique, but also highlight the weaknesses of the current institutional framework for FDI 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, as many upstream sectors have, in effect, ceased to exist in the past decades, or generate few downstream linkages. Furthermore, when they exist, informational gaps impede the realization of such arrangements, again underscoring the weaknesses of the current institutional framework for investment and linkages promotion in Mozambique.

Notes

[1] See Appendix 1 for a detailed explanation of Sanjaya Lall's technological capabilities framework.
[2] This sector corresponds to divisions 28, 29, 34 35 and 36 of the ISIC Rev.3.1 version.
[3] Light chemical industries correspond to divisions 24, 25 and 36 of the ISIC Rev.3.1 version.
[4] Forty-eight per cent of metalworking and 50% of light chemical firms.
[5] The Portuguese national association of metal-machinery companies.
[6] 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.
[7] For instance, in the early 1980s the Mozambican government created a specialized division in charge of promoting technological development in the metalworking sector through reverse engineering activities and the adaptation and modification of foreign technologies.
[8] This is the case of MABOR, a manufacturer of rubber tyres included in the survey, which has the highest technological capabilities score, yet had frozen its operations as of 2005.
[9] These values correspond to the 26 firms created since 1975 with a foreign equity share equal to or above 50%. The average age of this group of firms was 5.2 years.
[10] Potential values correspond to the level of product integration of firms' most complex product line.
[11] An example of this type of dynamics is Agro-Alfa, the fifth largest company in the sample. This firm was established in 1955 and for many decades specialized in the production of agricultural machinery and tools. However, since the early 2000s it has gradually moved towards the provision of industrial engineering services for large industrial projects operating in Mozambique. Another case is that of METECH, a company established in 1964, and the seventh largest firm in the sample. After decades specializing in the production of metal structures, it had entered into a strategic partnership with KEMPE International, an Australian-based global engineering corporation, to provide specialized engineering services to MOZAL, an activity that at the time of the survey occupied most of this company's time.
[12] Foreign investors held over 50% of shares in 17 firms and more than 75% in eight firms.
[13] Of the 31 firms established during the colonial period and later nationalized, only three were fully sold to foreign capital. Of the remaining 28, 19 were fully or mostly sold to Mozambican nationals.
[14] Plant visits to these firms suggested that the true 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.
[15] See Castel-Branco & Goldin (2003) or Warren-Rodríguez (2007b) for an analysis of this programme.
[16] Based on interviews at the Maragra and Xinavane sugar operations.
[17] Estimated at US$18 million in 2004 (GPSCA, 2005).

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Appendix 1. Lall's Technology Capabilities Framework

Lall's technology capabilities methodological framework (Lall, 1992, 1993) identifies capabilities in various areas of manufacturing capturing firms' ability to engage in technology-related activities and efficient production. It focuses on those spheres of production that are considered relevant for these purposes, such as product development, process development, or industrial engineering. These broadly defined areas of technology

Table A1. Components of firm-level technology capability and skill indices

Product development capabilities
1. Firm has product development department
2. Proportion of employees working in product development

Production technology capabilities
1. Firm has contracted maintenance assistance
2. Firm routinely does preventive maintenance
3. Firm has a repair workshop
4. Proportion of workforce doing maintenance
5. Firm trained workers after purchasing new equipment
6. Role played by the firm in specifying new purchases of equipment
7. Firm modified purchases of new equipment to adapt it to local circumstances
8. Imputed age of equipment
9. Firm has CNC-controlled equipment
10. Firm has mechanically operated equipment

Process/industrial engineering capabilities
1. Firm has quality control certificate
2. Firm with quality control system
3. Firm with quality control department
4. Firm has inventory control system
5. Firm has computerized inventory system

Managerial skills
1. Managers' level of educational attainment
2. Index of managers' professional experience
3. Whether managers own other businesses
4. Manager speaks foreign languages
5. Manager travels abroad for work

Firm-wide skills
1. Firm-wide composite education index
2. Whether firm has in-house training programme
3. Firm sends workers to local external training
4. Firm sends workers for training abroad

capability can then be broken down into a set of firm characteristics, relating to the different facets that technology capabilities take within the firm, and coded in a survey questionnaire.

Firm-level data collected during the survey that form the basis for this research were 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 A1). 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 capture enterprises' ability to make efficient use of their production technology, i.e. core machinery and ancillary equipment. Process/industrial engineering capabilities refer to firms' ability to organize and control the production process in an efficient manner to optimize time and resources and to ensure that production meets certain standards of production. In addition to these three dimensions, the analysis undertaken here includes a fourth overall composite technology capabilities index. It also incorporates indicators capturing firm-wide and managerial skills, as well as a total skill index obtained in the same way.

These composite indices capturing firm-level skills and technology capabilities were obtained by directly aggregating each of the variables defined in Table A1, without applying any weights. Most of these variables are binary dichotomous variables, so that the larger the number of positive technological attributes reported by any firm, the higher the value of each of these technology-related subcomponents. Non-dichotomous variables were normalized by giving a value of "1" to the highest score reported for each of these

variables, and then transforming the remaining values accordingly. Similarly, the overall composite technology capabilities index was obtained by direct non-weighted summation of the three technology capability sub-indices. By awarding the same weight to each subcomponent, it is implicitly assumed that each technological capability and skill dimension is equally important.