USING PRODUCTION PIPELINES AS A RESEARCH METHODOLOGY FOR UNDERSTANDING COMPETITIVENESS: A CASE STUDY OF AN AUTOMOTIVE PLASTICS COMPONENT

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FOREWORD

The Industrial Restructuring Project (IRP) was initiated at the beginning of 1996 as the KwaZulu-Natal Industrial Restructuring Project (KZN IRP). The project initially focused exclusively on KwaZulu-Natal, but is now aimed at supporting industrial policy in South Africa at the national, provincial and local levels. It is facilitated by international experts and is based at the School of Development Studies, University of Natal Durban. The project has two important features. Firstly, it focuses on critical issues that are impacting on the competitiveness of manufacturing sectors that are under threat from increased international competition and the liberalisation of the South African trade regime. Secondly, it is action-oriented in design. The findings that have been generated have, for example, been presented to numerous industry stakeholders, including government, business associations and trade unions. The project consequently has the support of various regional and national stakeholders.

This particular report/working paper has arisen out of both new research and the cumulative knowledge that has been generated from previous studies. These cover a number of IRP reports, working papers, journal articles and conference papers. Some of the themes covered include South Africa's manufacturing competitiveness, the automotive industry, the clothing and textiles sectors, footwear, middle-management capacity, human resource development, institutional support for industrial restructuring, and business services for manufacturing competitiveness. Enquiries regarding IRP material should be addressed to: The Librarian, School of Development Studies, University of Natal, Durban, 4041. Tel: 031 2601031; Fax: 031 2602359; email: smithm@mtb.und.ac.za.

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The Department of Trade and Industry has given its approval for its publication as a SoDS research report in order to ensure its widespread dissemination to stakeholders in industry. This approval is also hereby acknowledged.

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The views expressed in this report are, however, solely those of the authors. All responsibility for its content therefore lies with the authors alone.

INTRODUCTION

The purpose of this research report is to go beyond the conventional focus on firm level efficiency or macro economic analysis in discussing international competitiveness. Although there is a strong strand in the international literature stressing the interconnectedness of firms within and between industries, there is a dearth of studies which examine in a detailed empirical manner (i.e. measuring the impact of one firm's activities on another) how such interrelated activities actually impacts on competitiveness. The literature tends to assert the obvious correctness of the value chain approach and discusses it at a theoretical/strategic level (Hines 1994, Lamming, 1993). Alternatively it engages with the issue through empirical analysis at the firm specific level (Humphrey et al 1998). Neither approach empirically traces the actual movement of a particular product (or it could be a service/operation) between firms as a way of understanding the systemic impact of different value adding and non-value adding activities on overall competitiveness within the specific value chain.

Our purpose in this research report is therefore twofold. First, we present the undertaking of such a product pipeline analysis in a particular sector in the South African manufacturing industry, and second, we explore the virtues of a general value chain and specific product pipeline research approach for understanding issues of competitiveness. As will be highlighted, the findings from the pipeline research illustrate the inter-relatedness of firm level competitiveness issues in a particular product's value chain. Notwithstanding the fact that the undertaking of micro and macro level analyses are still crucial for understanding competitiveness issues, it would appear from the product pipeline case study that research of this nature fills an important conceptual gap between the macro and the micro levels. Critically, it clearly exemplifies the linkages within value chains and as such it provides manufacturing researchers with a complementary research tool in their endeavours to both understand competitiveness issues and influence policy regarding competitiveness improvements.

Whilst the theoretical underpinnings of the pipeline study emerge broadly from the "lean supply" of Lamming (1993), the "world class suppliers" of Hines (1994) and more recently from the work of Womack and Jones (1996), certain elements of the research methodology employed for the study were developed independently. To date, as far as we are aware, no studies of this nature have been carried out in South Africa. The study is therefore, in many ways, a pilot.

In order to explore the various facets of the pipeline research undertaken, this research report is divided into three sections. In **Section One**, the theoretical underpinnings of the research methodology employed for the study are explored in some detail. This exploration leads to an in-depth analysis of the key findings generated during the course of the research undertaking in **Section Two**. The usefulness of the research for understanding manufacturing competitiveness

issues is then discussed in a brief **Conclusion** that also draws together the main findings and arguments presented in the research report.

SECTION ONE: THEORETICAL UNDERPINNINGS OF THE PIPELINE APPROACH

THE FIRM AS THE CENTRAL FOCUS

It is generally accepted that the most important determinant of competitive advantage for any firm is the value attributed to its particular product(s) by its customer(s) (Porter 1990, Womack and Jones 1996, Brown 1996, Bessant 1991, Kaplinsky 1994). If a firm is to survive in the era of intense global competition it is therefore essential that it fully comprehends the increasing value (in terms of quality, price, time to market, conformance to standards, packaging) attributed to the product(s) it is producing, and that it endeavours on an on-going basis to continuously re-assess its performance relative to such value demands.

Firms need to be fully cognisant of the market demands being placed on them, and they need to react in such a manner as to ensure that as market demands become more stringent so they are better able to respond (Barnes and Kaplinsky 1999, Kaplinsky and Morris 1998, Brown 1996, Humphrey et al 1998). For example, as markets become more demanding in terms of quality, price, delivery reliability, conformance to standards and flexibility, firms need to analyse mechanisms that could be employed to better meet such demands.

There is a plethora of literature on what firms need to do in order to meet these new challenges (Kaplinsky 1994, Womack, Jones and Roos 1990, Lamming 1993, Hines 1994, Brown 1996). The discourse around lean production is therefore playing a critical role in highlighting to industrialists the need for a fundamental re-orientation in the way in which production takes place at the firm-specific level (away from mass production principles). The central argument is that a paradigm shift has occurred in the production environment: production has shifted from being supply driven to demand led. If firms are to compete successfully it is consequently imperative that they fundamentally re-orient their production organisation in line with such demands. It is argued that if firms are to compete successfully in the future then they need to shift from mass production to the lean production (or flexible specialisation) production paradigm[1]. The following table (adapted from Kaplinsky and Humphrey 1995) summarises the organisational changes necessitated by the new demands placed on producers.

[1] The authors are aware of the small differences between the flexible specialisation model put forward by Piore and Sabel (1984) and the lean production model as conceptualised by theorists such as Womack, Jones and Roos (1990). Analysing the minor and often insignificant variances between these conceptual positions goes beyond the scope of this research report, however, and as such they are conflated here into a single alternative to the mass production model hegemonic during the course of the Fordist production era.

Table One: The principles of mass verses flexible/lean production for manufacturing organisation	
Mass Production	**Flexible/Lean Production**
Standardisation of products	Diversity of products
Maximum machine utilisation	Machine's operate to order
Functional factory layout/process organisation	Cellular layout/product organisation
Long runs	Short runs
Large batches	Small batches
Production pushing/make to forecast	Production pulling/make to order
Quality and rectification at end of production process	Quality built in at source
Long throughput times	Short throughput times
Large stocks	Minimal stocks
Complex controls	Simple controls
High proportion of indirect labour	Low proportion of indirect labour
Single skilled and single tasked workers	Multi-skilled and multi-tasked workers

THE VALUE CHAIN AS THE CENTRAL FOCUS

A number of these firm level activities characterising flexible production depend on the activities of other firms feeding into their production operations. Competitive advantage therefore arises not only as a result of internal firm organisation but also from the way in which firms organise discrete activities along a value chain. In his highly influential work Porter (1990) stressed the importance of viewing firm competitiveness as part of an integral system of value added production, which is more than the simple sum of its parts.

> *'A firm is more than the sum of its activities. A firm's value chain is an interdependent system or network of activities, connected by linkages …(which) occur when the way in which one activity is performed affects the cost or effectiveness of other activities' (1990: 41).*

The linkages between firms within value chains affect the cost, efficiency, quality, product differentiation, as well as the ability to reap the benefits of flexible production systems. Recognising the importance of value chains therefore impacts on firm strategies. Kogut (1985) in stressing the importance of designing the appropriate strategies for different value chains differentiates between chains governed by low cost and those by product differentiation. He emphasises that firms in a highly competitive industry in which products are qualitatively similar tend to adopt strategies that are low-cost oriented. In this case the value-added chain is best defined in terms of each links contribution to total cost. Thus through comparing the costs incurred by each link as well as

against competitors (i.e. benchmarking) individual firms within a value chain can locate the 'critical success factors' that they need to address. In less cost competitive value chains driven by firms differentiating products the key element is the contribution of each firm link to market value and the consequent adoption of value chain strategies which maximise correspondence to (ever changing) consumer demand.

From this perspective the key issue is whether value chains are accidentally or purposively organised. In any given value chain it is likely to be a combination of both, and the key issue is where the balance lies between spontaneous and purposive intervention. The focal point for reducing costs and obtaining benefits in a value chain lies in good co-ordination of the various linkages comprising the combined activities. This requires both complex organisational co-ordination and the resolution of difficult trade-offs between the various component activities making up the value chain. The benefits that are reaped from such co-ordination are:

- Creating better access to, and utilisation of, information necessary for linked activities,
- allowing just-in-time down the supply chain to impact on inventory at particular firms within the chain,
- creating the possibility of substituting less costly operations in one activity for more costly ones elsewhere, and
- reducing the overall value chain waste in terms of activities dependent on time, space allocation, and transport.

Not all firms locked into organisational linkages are capable of perceiving these issues and reaping the benefits. It requires knowledge, will and power to give effect to them. Often the knowledge does not exist, for the changes at stake are marginal and require detailed examination of minor parts of a linkage. The will is absent for firms that are too inwardly focused and it is much easier to adopt the short-term alternative of constantly switching suppliers. Finally firms often do not have sufficient leverage over other linkages in the chain to ensure systemic efficiency. The success of the Japanese has been to manage such linkages and persuade or force firms in a value chain to make the requisite changes to reap the substantial benefits accruing (Cusumano 1988, Lamming 1993, Hines 1994).

If 'a firm's cost position is its collective cost of performing all the required activities relative to its competitors ..(and) ….. successful cost leaders …. draw cost advantage from throughout the value chain' then this has major methodological implications for research into competitiveness. For the 'value chain provides a tool for understanding the sources of cost advantage' (Porter 1990: 43). The filiere approach utilised in analysing food commodity chains adds another methodological dimension (Bernstein 1996). For in tracing the movement of commodities along a chain it stresses three additional dimensions: the importance of different markets linking activities within a chain, the

institutional arrangements that facilitate these, and the power relations that govern them.

Notwithstanding the by now accepted methodological importance of viewing firms as interlinked and located in value chains, the literature is not overburdened with detailed analyses of such linkages. In an overview of the features of 'supply networks' Zheng et al (1997: 3) conclude that 'to date much of the research in supply networks has been observational and anecdotal, describing case examples of firms that appear to have managed their networks and achieved some form of competitive advantage'.
Many of the supply chain studies undertaken (Addis 1997, Beaudet and Nishiguchi 1998, Hines 1994, MacDuffie and Helper 1997) have been highly effective in exploring the competitiveness dimensions of supply chain relationships. However, although they have highlighted the important competitiveness link between firms in particular value chains, their central focus has always been on the firms that constitute the particular value chain being explored. This firm-level focus, whilst important as a mechanism for highlighting the inter-relatedness of firm-level competitiveness in value chains, has failed to quantify the extent to which value adding activities at specific links in particular value chains contribute to the overall competitiveness of the products being manufactured.

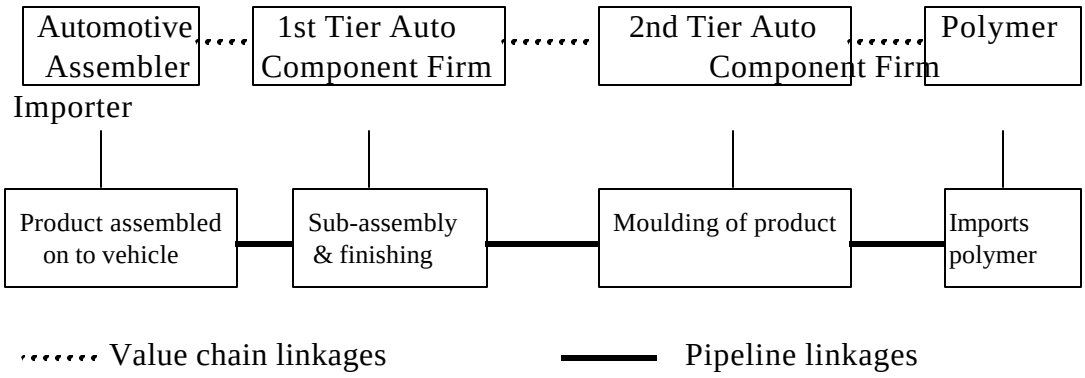
THE PRODUCT PIPELINE AS THE CENTRAL FOCUS

Womack and Jones (1996) take the issue one step further through focussing on an empirically measurable dimension the flow of products in a value chain. They raise the important issue that whilst lean production is capable of playing a critically important role in restructuring individual firms and, via appropriate Supply Chain Management (SCM) programmes, their suppliers, the focus of analysis is still limited to "the firm". And yet the value attributed to a particular product is exactly that - value attributed to a product and not the firms involved in the production process itself. They argue that it is the production processes utilised at firms in a particular production pipeline that create the value attributed to the product, and yet such processes have no inherent value outside of the final product produced for a particular market.

By focusing on firms only insofar as they contribute to the value adding process of particular product pipelines one is able to overcome this limitation. By following the value-added process of a product through a number of firms that constitute a specific value chain one is able to quantify the extent to which the value transformation process at each firm contributes to the overall competitiveness of the product being manufactured. For example, Figure One presents the case study automotive plastics production pipeline to be analysed in-depth in Section Two. As is clear there are four links in the South African leg of the production pipeline. The first link is the automotive assembler that assembles the product on to the vehicle, whilst the second link, the first tier automotive component firm, carries out some sub-assembly and improves the aesthetics of

the product in order for it to better meet market requirements. The third link moulds the product into the form needed, and the fourth link imports the polymer from the foreign manufacturer.

Figure One: Case Study Production Pipeline



Each of the firms contributes an important cost to the value of the case study automotive component. And yet the value of the product to the final consumer lies not in the firms producing the product (the value chain linkages in Figure One) but in the product itself (the pipeline linkages in Figure One). As argued by Womack and Jones (1996: 19):

> *"Lean thinking ... must start with a conscious attempt to precisely define value in terms of specific products with specific capabilities offered at specific prices through a dialogue with specific customers."*

Whilst focusing on firm-specific issues is still obviously critical for the restructuring of firm enterprises it therefore also makes considerable sense to focus on the competitiveness of the product being produced - in this instance the case study automotive component - in order to fully comprehend the overall competitiveness of the production pipeline through which the product emerges.

Obviously focusing on the value of the product rather than the firms producing the product leads one to carry out much of the same analysis. One cannot, for example, analyse the production processes leading to the final product without focusing on the various firms involved in the production pipeline. The central critical difference, however, is the scope of the focus. By focusing on an individual product one is better able to assess the ability of its production pipeline to meet its particular market demands. By focusing on the product rather than the firm one is therefore capable of generating a systemic picture of the competitiveness of the pipeline as a whole. The synergies or inconsistencies between and within each link in the production of the product are clearly highlighted, with this contributing, on a broader level, to a more detailed understanding of how pipeline issues impact on the ability of firms and industries to improve their competitiveness.

It has been argued in much of the previous literature[2] that no one firm can be internationally competitive when its customers and suppliers are not; thus necessitating the establishment of supply chain management programmes to drive competitiveness improvements through the entire production pipeline. It has, however, been difficult to ascertain in a detailed and quantitative manner the overall competitiveness of the products emerging from such production pipelines because of the lack of a product focus. It may be obvious that improving internal processes at one firm is contingent upon performance improvements amongst its suppliers and customers[3], but such an approach does not quantify the exact extent of the inter-relatedness of competitiveness issues up and down the production pipeline in which it is situated.

Firm-based value chain analyses, whilst undoubtedly very useful, do not therefore fully highlight the systemic nature of the linkages that determine the competitiveness of a particular manufactured product, hence the need for a product-based production pipeline analysis as a **complementary** research method for understanding production pipeline issues.

UNDERSTANDING PRODUCT-FOCUSED COMPETITIVENESS

Assessing the competitiveness of a product's production pipeline is possible in two ways. Firstly one could analyse performance in the pipeline relative to a similarly constituted pipeline elsewhere. Benchmarking the competitiveness characteristics (cost, quality, etc) of the product being produced with that of the same, or a similar, product being produced elsewhere would be an obvious method. Unfortunately, breaking the competitiveness characteristics down in terms of the processes employed for its production could be difficult at the pipeline level, particularly when a certain production pipeline is unlikely to be mirrored elsewhere. The case study plastic automotive component is, for example, unique to one South African automotive assembler, thus making a comparative production pipeline benchmark difficult.

Secondly, and far more importantly for Womack and Jones (1996), one could assess the performance of the production pipeline against the notion of perfection. They contend that benchmarking one product's production pipeline with another is unnecessary given the fact that the real strength of the approach is its ability to highlight the waste in a production pipeline - with perfection entailing the complete eradication of all waste.

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[2] See, for instance, Kaplinsky (1994), Humphrey and Kaplinsky (1995), Morris and Kaplinsky (1999); Hines (1994), Lamming (1993), Barnes (1997, 1998).

[3] For example, if a firm is to improve its overall inventory holding it is imperative that it improves its own internal operations and that its suppliers deliver their inputs with perfect quality, in small lot sizes, and increasing flexibility. Supplier failure to do so will undoubtedly result in the firm failing to substantially improve its own performance.

Womack and Jones (1996) contend that there are a number of necessary steps that need to be undertaken in order to analyse the waste in a product's production pipeline. The first step is to ***specify the product's value*** to the customer. The second step is to ***identify the value stream*** of the product. This involves identifying each step that takes place in the process of producing the product's specific value. Such an identification allows one to ascertain whether the steps are necessary or not. Those steps that are necessary are those that "unambiguously create value" (Womack and Jones, 1996: 20) - as defined by the final customer. Those steps that are unnecessary but cannot be done without because of the use of existing technologies are considered to be Type One waste, whilst those steps that create no value whatsoever and are immediately avoidable are classified as Type Two waste.

The third step involves an assessment of how production ***flows*** through the pipeline. Are the various links in the production process synergised in such a manner as to ensure the smooth flow of the product through the various production stages? Or are batches produced, and lots sizes transferred from one stage of the production process to the next, in such a manner as to create a build up of inventory in the pipeline, with this contributing to the creation of non-value adding waste? This step fits in very closely with the argument presented by Kaplinsky (1994) and Brown (1996) concerning the importance of Just-In-Time (JIT) production for the eradication of non-value adding waste in a firm. Womack and Jones (1996) have merely extended this understanding in order to take full cognisance of its importance for a product's entire production pipeline.

The issue of ***flow*** ties into the fourth necessary step: an assessment of whether the product is being ***pulled*** through the production pipeline. As argued by a number of lean/flexible production theorists (including Womack and Jones 1996, Womack, Jones and Roos 1990, Kaplinsky 1994, Lamming 1993, Bessant 1991 and Hines 1994) production is only able to flow through a process if it is being pulled by the next link in the value chain. This link is moreover itself being pulled by the link it feeds into, and so on, with the product ultimately being pulled by demand from the final market.

Taking all four steps together leads Womack and Jones (1996) to the fifth and ultimate step - an identification of ***perfection*** as it pertains to the particularities of the production pipeline being analysed. By identifying the specific value of the product, its value stream, the manner in which production flows through the process, and the way in which production is pulled through the system, they assert that a clearer picture of what perfection actually entails for that particular product becomes increasingly clear.

Three of the five steps raised by Womack and Jones (1996) are widely used in assessing firm-level performance in the lean production literature. The issues of identifying the value of one's products through the eyes of one's customers, of ensuring the smooth flow of production through the various processes employed,

and of pulling such production in line with customer demands, have all been extensively explored in the lean production literature and as such do not need additional clarification. Womack and Jones (1996) have merely adapted the issues to fit in with their pipeline approach.

The two important new concepts put forward by Womack and Jones (1996) that do need additional clarification are the concepts of value stream analysis and production perfection. Value stream analysis lies at the heart of the pipeline approach, as it takes as its central hypothesis the notion that "the whole is greater than the sum of the parts". Understanding the competitiveness of a production pipeline consequently entails more than simply understanding the levels of competitiveness of the individual firms that constitute the pipeline. As highlighted by Womack and Jones (1996: 44) in their analysis of the value chain leading back from a Tesco[4] can of Cola, it takes 319 days to bring a can of cola from bauxite (the raw material constituent of aluminium) to Tesco; and yet the entire processing time for all of the stages of production amounts to only three hours. Whilst each of the firms in the production pipeline may be performing adequately in terms of their own internal processes this does not mean that the pipeline is operating adequately in terms of the value attributed to the can of cola:

> *"More than 99 percent of the time the value stream is not flowing at all: the muda* [waste] *of waiting. Second, the can and the aluminium going into it are picked up and put down thirty times. From the customer's standpoint none of this adds any value: the muda of transport. Similarly, the aluminium and cans are moved through fourteen storage lots and warehouses, many of them vast, and the cans are palletised and unpalletised four times: the muda of inventories and excess processing. Finally, fully 24 percent of the energy-intensive, expensive aluminium coming out of the smelter never makes it to the customer: the muda of defects (causing scrap)" (Womack and Jones; 1996: 43).*

All of these factors contribute to the cost of the can of cola, with the linkages between the various firms involved in the production of the product playing a critically important role in determining the extent of the waste evident in the pipeline. Whilst eradicating such waste may be contingent upon a number of firm-specific factors, such as the initiation of closer relationships with other firms in the pipeline, the use of more appropriate technologies in the processes utilised, a restructuring of the organisation of production, and skills upgrading for the labour force and management teams involved in the product's manufacture, the critical point is that a value stream analysis allows one to ascertain the dimensions of each of these issues relative to the product being manufactured.

Quantifying the extent of waste in a product's production pipeline is contingent upon ones view of perfection for that particular pipeline, thus bringing us to an exploration of the notion of **perfection**. Womack and Jones (1996) iterate that perfection is an unattainable goal - a notion based on the assumption that all waste

[4] Tesco is one of the world's leading supermarket chains.

can be removed from a production pipeline. The fact that it is unattainable is its very strength, however. As noted by Womack and Jones (1996: 94):

> *"Paradoxically, no picture of perfection can be perfect. If...[*a*]...value stream ...could be reconfigured as we suggest, it would then be time (immediately!) to imagine a new perfection which goes even further. Perfection is like infinity. Trying to envision it (and to get there) is actually impossible, but the effort to do so provides inspiration and direction essential to making progress along the path".*

Perfection is consequently synonymous with another lean production term - continuous improvement - as it provides a vision that is necessary for endogenising amongst individuals the need for continuous improvement (Bessant and Caffyn 1997).

IMPLICATIONS FOR RESEARCH METHODOLOGY

The research methodology employed for the automotive plastics pipeline case study followed the "product as the central focus" theoretical position closely. A product was chosen for analysis and the various processes in, and between, the firm's involved in the manufacture of the product were analysed only in so far as they related to the product. The central purpose of the case study was to generate an understanding of product-focused competitiveness, and to analyse whether such an understanding complemented and built on the firm-based and value chain analyses conducted during the course of previous and present IRP research.

Generating research via the medium of such a methodology is difficult as it entails researching one particular product through a number of firms in one specific value chain. Such firms are often suspicious of one another and consequently nervous of providing information that could potentially be used to compromise their relationships with other firms in the production pipeline. Suspicions of this kind were allayed in the case study by promising the confidentiality of all information provided; and by ensuring that each one of the researched firms had a clear understanding of the objectives of the study. The fact that the researchers had been involved in researching the KwaZulu-Natal automotive industry for two years prior to the launch of the study and as such had developed relationships of trust with the majority of firms in the industry also helped enormously with regards to ensuring firm participation.

SECTION TWO: THE CASE STUDY AUTOMOTIVE PLASTICS PIPELINE

INTRODUCTION

The automotive plastics component chosen for analysis is differentiated into two variants, with the variation stemming from the fact that it fits on to two different types of light commercial vehicle (LCVs) - although both LCVs are manufactured by the same assembler (Original Equipment Manufacturer - OEM). Both variants have exactly the same production pipeline, are manufactured using the same production processes, and are comprised of the same types of raw material inputs. The marginal differences between the two relate primarily to their weight and visual appearance. Due to the fact that the two variants over-lap so closely with one another it was not possible to differentiate performance indicators between the two at every link in the pipeline. In most instances the variants are consequently analysed as one component in the analysis presented below.

The case study, moreover, only covers the pipeline from the arrival of the plastic polymer from South Korea - and does not attempt to present an understanding of how the South Korean link of the production pipeline contributes to the product's overall competitiveness. The focus of the case study is additionally only on the most important raw material constituent of the component - its plastics pipeline. One other significant pipeline also leads back from the product - the paint pipeline, which branches off at the first tier automotive component manufacturer. This pipeline is not analysed, other than to highlight the extent of its cost contribution.

The primary research component of the pipeline analysis was carried out in August/September 1997, and comprised of numerous firm-level visits, where the various activities that lead to the manufacture of the component were analysed. The sequencing of the firm-level visits tied in with the notion of demand-pull. The product was followed from its assembly on to the vehicle at the OEM back through the OEM's plant, to the first tier component supplier, then second tier supplier, and then finally the raw material importer. The basic tenets of the lean production/lean supply paradigm were adhered to. The product was assessed in terms of its **value**, its **production flow**, the nature of production relations through the supply chain (to assess whether **production pulling** was taking place), and finally whether **waste** existed in the pipeline (thus undermining the overall efficiency of the product's manufacture).

The firm level visits were very focused in terms of these particular aspects of the product's manufacture, with only the value stream of the product receiving detailed attention. All the findings that were generated were only focused on the product itself, although they do highlight key firm-level issues as well.

Once the key findings had been generated they were presented back to each of the firms involved in the study, with these presentations taking place in early 1998. Detailed discussions took place during the course of these presentations, with firm level management being asked to comment on the findings. On the basis of these comments additional interviews were carried out with management during the course of mid-1998. Due to delays in the provision of certain pieces of critical information, and other commitments by the authors, the writing of this research report only commenced in May 1999.

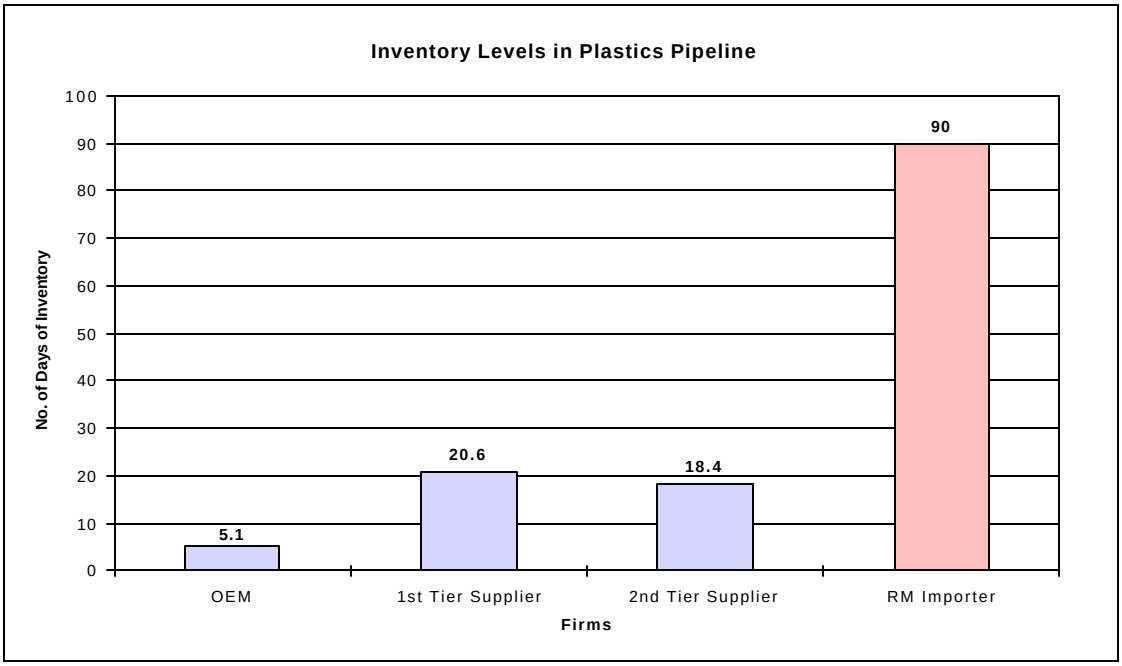
KEY FINDINGS

The value of the case study component lies almost exclusively in its aesthetic appeal. The key values attributed to the product by the final assembler were consequently its quality (finish and durability when in service), cost (very important given its non-safety critical function) and its availability (the product is fitted directly on to the OEM's production line). The assembler felt that if these performance criteria were adhered to, it would consider its suppliers, as well as its own assembly function, successful in meeting market demands.

Whilst some of the key characteristics of the product were being met, certain shortfalls in the flow of the product highlighted the existence of significant amounts of waste in the system. For example, the quality of the product was clearly meeting market expectations. The assembler had, for example, never experienced a vehicle return because of quality problems related to the component. Significantly, the non-delivery of the component had also never led to an assembly line stoppage, thus satisfying the assembler's delivery reliability requirement. However, and critically, although these important demands were being met, the cost issue was clearly not being dealt with optimally. Value definitely did not flow through the pipeline, with a massive build-up of inventory evidenced through the various links. This is illustrated in Figure Two, which considers inventory holding through the product-specific production pipeline.

Figure Two[5].

[5] Average days of inventory were calculated by taking total materials or component storage (raw materials, work in progress and finished goods) at each stage of the pipeline and dividing them by average daily usage.



Whilst the OEM was holding on to "only" 5.1 days of total stock for the product, cumulative stock holding for the product in the entire value chain was 134.1 days. The reasons underpinning these high inventory levels relate to the fact that there was no pull system in operation through the value chain. Whilst production was being "pulled" from the OEM to the first tier supplier via their Electronic Data Interchange (EDI) link, the second tier supplier operated on monthly forecasts from the assembler – with this resulting in production being forced through the pipeline from the second tier supplier. The second tier supplier moulded the product in large monthly batches before pushing it onto the first tier supplier[6]. Due to the power dynamics of the production pipeline, as well as the nature of the institutional relations between the firms, the assembler controlled all communication transfers[7]. This undermined the communication link between the first and second tier suppliers. As a result, there was no possibility of entrenching a production pull system between the two firms.

The poor value co-ordination in the production pipeline is further borne out by the fact that the OEM received the product in lots of 20 from the first tier supplier, who painted and assembled it in batches of 80. The first tier supplier in turn received the moulded plastic product from the second tier supplier in lots of 800, which was the same as its manufacturing batch size. Whilst some level of

[6] Whilst the first tier supplier was holding more inventory than the second tier supplier, this was purely because the second tier supplier "dumped" inventory on them on a monthly basis. The firm has no control over the deliveries of the second tier firm and is forced to hold the stock in its overflowing raw materials warehouse.

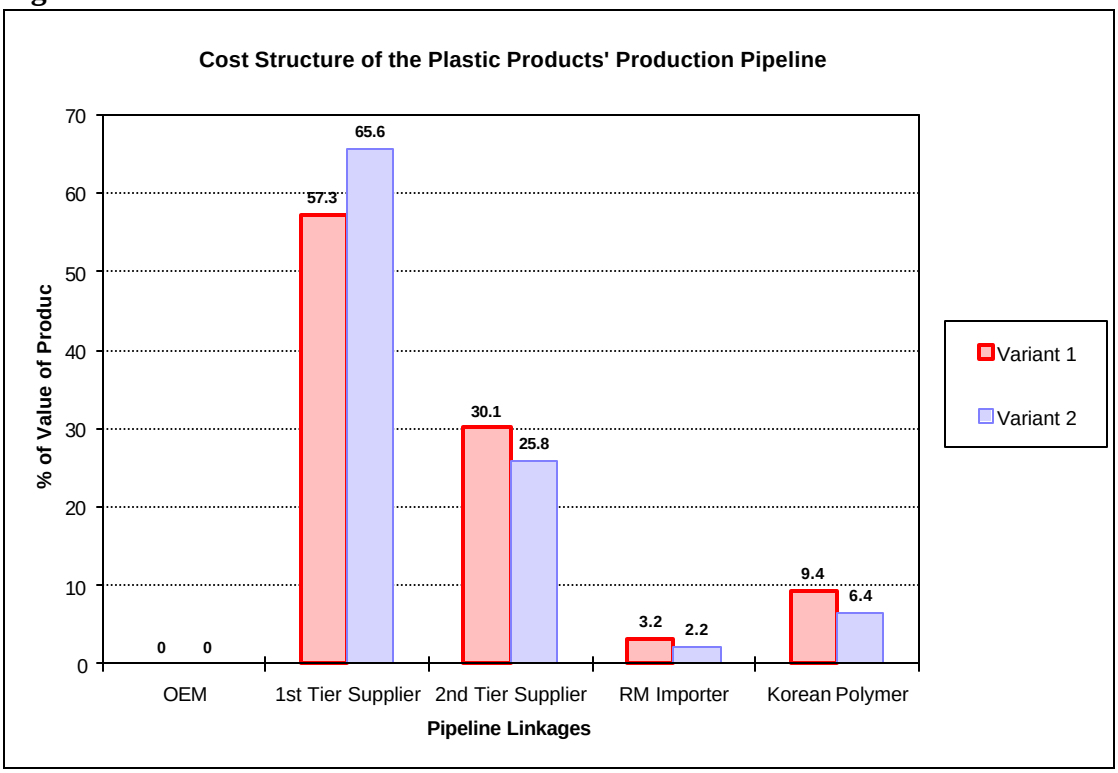
[7] This finding is important as it supports Henry Bernstein's (1996) notion that filières are as informed by political economic factors as they are by rational economic determinants. Whilst Bernstein was referring to the political economy of the maize filière, his argument appears to have as much relevance to manufacturing pipelines as it does to agriculture value chains.

inventory control was being practised at the end of the production pipeline, this control was quickly dissipated through the production pipeline.

The principal reason for the second tier supplier's large batch production related to its long machine changeover times (two hours for the plastic injection moulder concerned) and infatuation with manufacturing Economic Batch Quantities (EBQs)[8]. Despite the important fact that machine utilisation levels at the company were not particularly high (roughly 60%) and because Single Minute Exchange of Die (SMED) principles were not being adhered to batch sizes were kept as large as possible. Batch sizes therefore reflected customer order sizes plus a few extra percent in order to take into account possible internal defects and customer returns. Production was clearly taking place on a Just-In-Case, rather than Just-In-Time basis.

Importantly, if one considers the cost breakdown of the component, it becomes clear that its principal value lies in the assembler's supply base. The assembler merely bolts the product onto the vehicle. No other value adding activities take place. Production weaknesses in the earlier stages of the production pipeline are therefore critical in undermining the overall competitiveness of the product. This is clearly illustrated in Figure Three.

Figure Three.



[8] See Bessant (1991) for a critique of manufacturing according to EBQs.

In addition, whilst the final quality of the product cannot be called into question given the fact that the assembler had never replaced the component for a final customer, the defect rates within the value chain were very high. The assembler's return rate to the first tier supplier was, for example, 2,500 parts per million (ppm), whilst the first tier supplier's return rate to the second tier supplier was a very high 26,000 ppm.

Additionally, internal rejects and reworks were noted to be high, although neither the first tier nor the second tier supplier actually measured their internal quality performance.

Whilst final quality to the consumer may therefore have been adequate, the cost implications of the large number of defects through the value chain were critical. The accumulated quality problems were significant, with these issues being compounded by their prevalence at the most important value adding stages (i.e. at the first and second tier suppliers). The waste of inventory holding and poor quality (and therefore reworks) was clearly evident throughout the product's production pipeline[9].

The actual production flow through the pipeline, both internal and external to the firms was also very poor, as highlighted in Figures Four and Five.

[9] For excellent outlines of the relationship between excessive inventory holding and poor quality performance see Bessant (1991) and Brown (1996).

Figure Four.

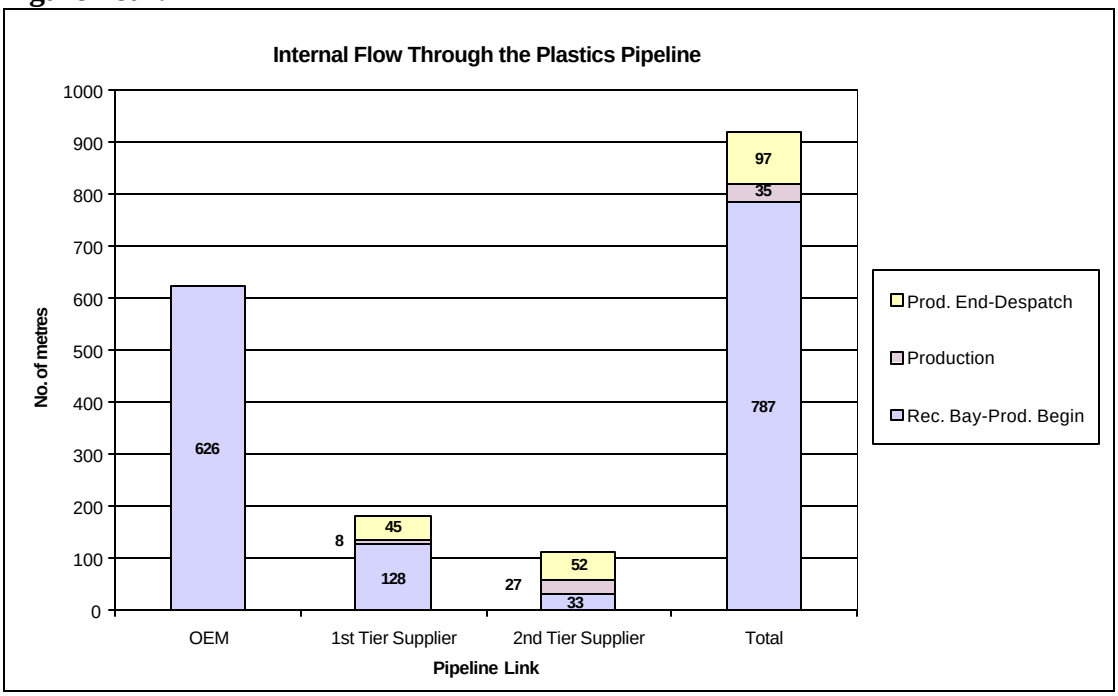
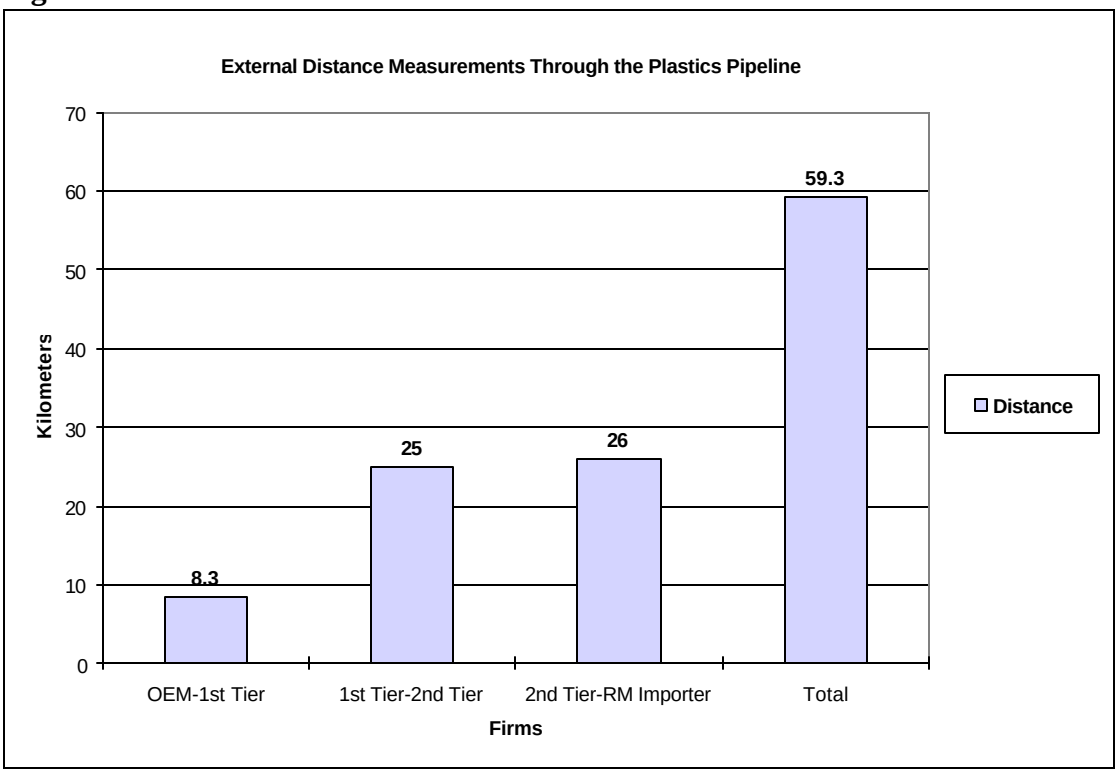


Figure Five.



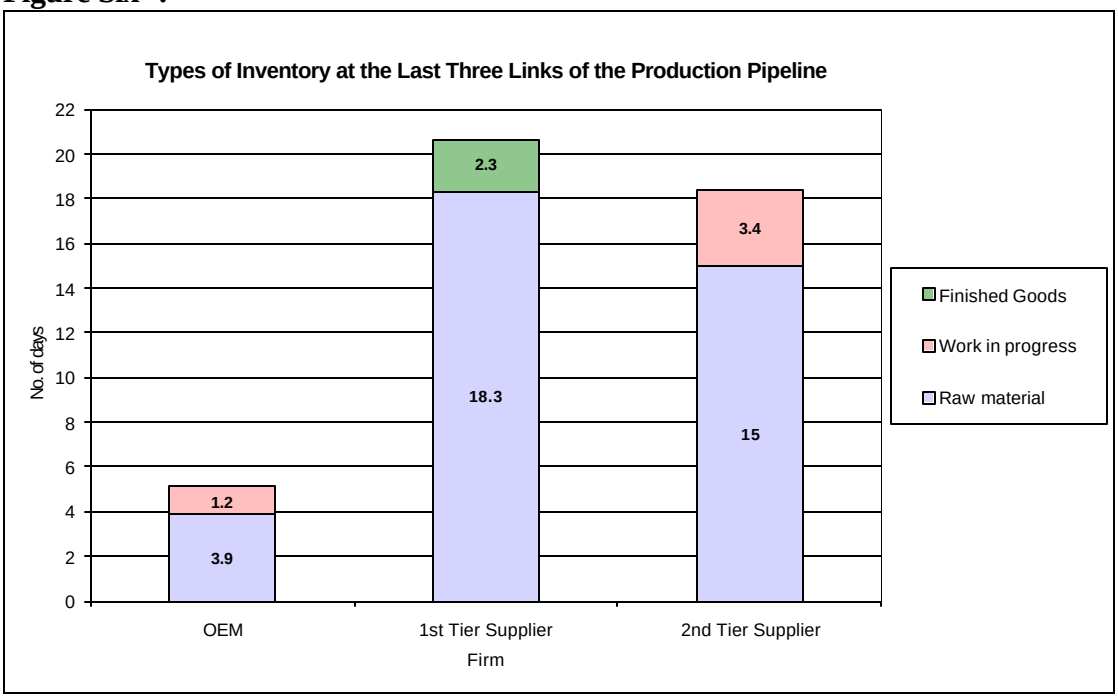
As illustrated in Figure Four, the total production distance of the product was only 35 metres, and yet it travelled a total of 919 metres within the firms and 59.3 kilometres external to the four firms (Figure Five). The waste of distance was clearly evident, as all distance apart from value adding production is waste. The irony here moreover is that both the first and second tier suppliers are

capable of carrying out each other's activities. There was therefore little need for the product to "flow" between and through both operations, particularly given its low cost (roughly US$10.00) and low volume production (40-odd units per day).

Even more strikingly, the total production flow of 35 metres, although low in comparison to total flow, was also far from optimal. Neither the first tier nor the second tier supplier operate integrated manufacturing cells or production flow lines, with this resulting in the excessive movement of the product even during the four value adding processes that constitute its manufacture[10]. Given this excessive flow the product spent an enormous amount of its "production" time in storage, with this resulting in the generation of additional waste – that of time wastage!

For example, and as illustrated in Figure Six, of the 44.1 days of total stock in the last three links of the production pipeline, raw material constituted 37.2 days or 84% of total stock holding. If one includes the 90 days of raw material stock that was being held by the polymer importer, an even bleaker picture of material handling and hence optimal use of time emerges.

Figure Six[11].



Another important constraint in the production pipeline largely escapes quantification, however, pertaining as it does to the poor levels of human resource development at the first and second tier suppliers. Neither of the two

[10] Excluding the very brief assembly activity at the OEM, of the four value-adding processes, two take place at the first tier supplier and two at the second tier firm.

[11] Please note that once the product had been bolted on to the vehicle at the OEM assembly line, we stopped measuring it, hence the non-existence of finished goods stock at the OEM.

firms were using innovative management techniques (i.e. strong visual management, green areas, self-directed work teams, suggestion schemes etc.) to improve the efficiencies or commitment of their labour force, with this being clearly evident during the observation of the product's manufacture. Apart from the fact that poor housekeeping was evident at every link of the production pipeline, very few signs of continuous improvement were evident. For example, there were no Statistical Process Control (SPC) charts evident, nor any quality or production records at any of the workstations through which the product passed. And yet this is a critical issue confronting both component firms. As highlighted by Barnes (1998: 30):

> *"Perhaps the most important determinant of future success for South African automotive component firms, is*…(their)…*capacity to change in line with ever increasing market demands. The automotive industry both domestically and internationally is becoming far more demanding. Whether firms fail or grasp the opportunities afforded by these demands will depend largely on their ability to use their resources effectively, with the most important of these being their human resources."*

Evidence that continuous learning was not taking place optimally within the production pipeline can be found in two areas. Firstly, personnel at the OEM observed that the product's quality performance (measured in terms of supplier return rates) had not improved over the last couple of years. Secondly, nominal price increases for the product had been passed on to the OEM every year over the period 1994 to 1997. This is shown in Table Two. Despite the fact that the product had experienced a real price decrease over the period 1994 to 1997, its extent (5.2%, 1.8% and 2.7% respectively) was deemed insufficient by the OEM, who claimed that the suppliers concerned had not given enough focus to the generation of process improvements. Both management interviews and independent observation at the suppliers verified this.

Table Two: Year on year price increases in nominal and real Rand terms (%): 1992 to 1997

Year	Nominal price increase (%)	Automotive component production price index (PPI)	Real price increase (%)
1994-5	4.8	10.0	-5.2
1995-6	3.5	5.3	-1.8
1996-7	2.3	5	-2.7

One of the important reasons for the relatively poor cost control performance of the production pipeline related to the standard costing procedures that were applied through its various links. Despite its own value adding/value engineering (VA/VE) activities the OEM did not, for example, have a structured supplier development programme for the suppliers involved in the manufacture of the product. At the time of the study, the component firms were consequently largely

unaware of the importance of VA/VE, or other continuous improvement activities.

In summary, the plastic product's production pipeline was characterised by a significant amount of waste. Womack and Jones' (1996) various forms of waste – which they defined as any activity that consumes resources but creates no value – were all evident in the production pipeline explored, as highlighted in Table Three.

Table Three: A summary of waste in the plastics production pipeline

Type of waste	Evidence in plastics pipeline
Mistakes that require rectification	Reworks and customer returns
Inventory build-up	High levels of stock holding, especially raw materials
Processing steps that are not necessary	Raw material importer link
Excessive movement of goods and people	Anomalous link between first and second tier suppliers. Production distance is only 35 metres, out of total distance of over 60 kilometres
Waiting due to push production systems	Build up of inventory. No production pulling. Second tier supplier produces a month's production at a time
Products that do not meet customer needs	High cost, due to limited continuous improvement and year on year nominal price increases

Importantly, then, if perfection were the benchmark against which we were to compare the performance of the plastics pipeline, there would clearly be massive scope for improvement. This is clear, not only in terms of production flow within and between firms, but also in terms of quality and inventory control through the various linkages. Much like the can of Tesco cola that was followed by Womack and Jones (1996), there is enormous scope for improvement, not only in terms of firm-specific weaknesses, but also in terms of the actual configuration of the plastic product's pipeline as a whole.

CONCLUSION: IMPLICATIONS FOR RESEARCH INTO MANUFACTURING COMPETITIVENESS

The production pipeline study generated a number of very important competitiveness findings that will complement the macro, firm-level and value chain research being conducted in the South African automotive industry by the Industry Restructuring Project. The principal strength of the study clearly lies in its attention to product-specific detail. As with the Tesco cola study conducted by Womack and Jones (1996), the plastics pipeline study unpacked the critical competitiveness issues impacting on the case study product chosen.

The inventory, quality and continuous improvement dynamics underpinning the manufacture of the product through the various links in the production pipeline were laid bare. It was, for example, revealed that significant levels of waste existed in the production pipeline and that intra and inter firm operational dynamics were sub-optimal. Using Womack and Jones' conceptual position, the approach allowed us to identify the product's value to the customer (in this case OEM), its value stream, the manner in which it flowed through the pipeline as a whole and the extent that production was pulled from customer demand. Finally we were also able to assess the extent to which the various performance indicators suggested the attainment of pipeline competitiveness (and perfection).

Perhaps more importantly than identifying overall competitiveness issues within the plastics production pipeline, the study also pinpointed the relative weight of competitive issues within each link. It was shown, for example, that competitiveness interventions at the OEM link in the value chain were of little consequence to the overall competitiveness of the product being manufactured and that the focus therefore needed to rest heavily on the first and second tier suppliers. The importance of intra-firm competitiveness at each link of a product's pipeline was therefore highlighted, as was the critical fact that inefficiencies at any one stage leads to further inefficiencies through the pipeline as a whole.

Critically, the political economic factors undermining the competitiveness of the production pipeline were also exposed. The irrational logic controlling the interface between the first and second tier suppliers quickly became transparent through the methodology employed, thus supporting Henry Bernstein's (1996) argument that value chains (or filières as he calls them) are as informed by political economic factors and institutional relationships as they are by rational economic decisions. The OEM in the case study, despite its own relatively sound competitiveness, exerted undue influence on the product pipeline as a whole, thus leading to a communication dislocation between the two suppliers that most influence the competitiveness characteristics of the product.

For researchers involved in value chain research the product pipeline approach is clearly then a very useful complementary research methodology. Whilst macro, firm-level and value chain studies are still critically important for understanding competitiveness, it is clear that the production pipeline approach adds an additional dimension to analyses of competitiveness. By focusing exclusively on product-based measurables, and by considering firm-level and broader value chain issues only insofar as they directly impact on the product pipeline studied, one is able to better unpack intra and inter-firm complexities, thereby more accurately pinpointing key competitiveness strengths and weaknesses through the pipeline as a whole.

In many ways, however, the analysis that needs to be carried out as part of such a methodological approach is very similar to the type of analysis that would arise from following a value chain approach. Although product-based competitiveness is an important theoretical concept that needs additional attention, much of the analysis still has to take place at the firm-level, following value chain principles. Disaggregating a product from the firms through which it flows is impossible and as such the product pipeline approach does overlap significantly with value chain analyses.

Importantly, the production pipeline research methodology is very research intensive, with both detailed measurables and qualitative insights needing to be generated. This is both a strength and a weakness. It is a weakness in the sense that data is not easily and widely obtainable thus slowing down the research process. It is also, however, an important strength in that significant conclusions can be drawn once information is generated and the methodology followed through to its conclusion.

The rolling out of this type of research methodology will therefore continue as part of the Industrial Restructuring Project's endeavours to further understand manufacturing competitiveness issues broadly and product-specific competitiveness issues more specifically. As has hopefully been highlighted in this research report the type of analysis (Section Two) that arises out of a production pipeline methodological approach (Section One) offers both researchers and policy makers alike an extremely useful complementary view on competitiveness.

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