New technologies in Emerging Markets:
Understanding Technology, Market and Policy Constraints to the Adoption of
Advanced Automotive Technologies

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Abstract

The paper analyses how technology, market and policy issues condition the adoption of aluminum in the manufacturing of auto engine blocks in Brazil. Due to important weight savings, there is a clear tendency in the auto industry to change engine material from iron and steel to aluminum. This tendency has started in the triad market area, mostly because of scale issues, but the increasing global perspective of the industry is now leading to expansion of these practices into emerging areas such as South America. The paper uses a methodology developed at MIT entitled Technical Cost Modeling to explore the key issues conditioning the adoption of this technology in Brazil and assess potential supplier strategies for this market.

The analysis identifies scale of production and local policy conditions, in particular the tax structure and the interest rate, to be the key drivers of differences in component sourcing cost. The study concludes that casting engine blocks in Brazil seems viable for production volumes above 65,000 engines per year for foreign investors and 100,000 for local manufacturers. To overcome diseconomies of scale arising from the small volume of engine production in the region, OEMs may need to subcontract the same local supplier, set up investments to the export market or find alternative applications to fill unused capacity in the casting line.

1. Introduction

During the past decade, the automotive sector evolved to become a true global industry. Until the end of the eighties, competition between the major international automakers would be mostly within regional automakers, with American automakers dominating the US market or Japanese the Asian market. During the nineties, growth in the number of transplants changed this picture dramatically. Nowadays, virtually all original equipment manufacturers (OEMs) are present in every corner of the globe, both in developed areas, as well as in emerging regions. Moreover, OEMs are organizing operations at a world scale, planning and deploying identical vehicles in several regions simultaneously, or running supply bids for suppliers around the globe.

Global operations and similar vehicles led OEMs to demand that their direct suppliers also have a strong international presence. Suppliers are increasingly expected to have substantial responsibilities in the design and engineering of complex systems and to coordinate the supply chain necessary to manufacture and assemble equivalent products across multiple locations.

The paper analyzes technological, market and policy barriers to the adoption of aluminum castings in the manufacturing of automotive engine blocks in Brazil. Due to important weight savings, there is a clear industry tendency to change engine manufacture from cast iron to aluminum. This tendency has started in larger displacement engines and in the triad market area, mostly because of scale issues. Nevertheless, automakers are now interested in expanding this technology into emerging areas such as South America. It uses a methodology developed at MIT entitled Technical Cost Modeling to explore the key issues conditioning the adoption of this technology in Brazil and to assess potential supplier for this market.

The paper has four additional sections. The next section highlights the major trends in the automotive industry and the supplier challenges that set the stage for the opportunity of using cast aluminum engine blocks in Brazil. The third section explains the tendency towards the adoption of aluminum in the manufacturing of automotive engines across the world and outlines the current market conditions in Brazil. Section 4 describes the scenarios and methodology used in the analysis. The fifth section presents the results of the analysis and the last section discusses the conclusions.
2. Global trends in the auto Industry

The evolution of consumer demands, the need to have a global presence and the fast pace of technological change place important requirements on the participants in the automotive industry. OEMs have been the players directly affected by these trends. Nevertheless, the strategies they have pursued as a response to these challenges are having far-reaching effects on the whole supply chain. The industry is undergoing a period that could be characterized by four major trends: Globalization, Standardization, Disaggregation and Consolidation.

The first clear characteristic of today’s auto industry is Globalization. Until the end of the eighties, despite some overseas presence of OEMs, competition would still be mostly within regional brands. This picture changed completely during the nineties. A growth of transplants during the beginning of the decade led to a presence of all competitors in virtually every region [1]. This has become particularly important in emerging markets, where all OEMs are fiercely disputing market shares as the market grows. As a result, automakers are now planning operations on a global scale. This means having similar models being launched at the same time in different locations with similar standards.

An intense degree of similarity in the vehicle manufactured across regions has led automakers to try to replicate successful existing supply chain structures in new locations. This often means inviting, or sometimes demanding, their suppliers to be present in regions where OEMs are investing. Suppliers have often seen the OEM globalization trend as an excellent opportunity to improve their market presence and expand sales volume. As a result, they have followed the OEMs in expanding to new regions. Nevertheless, suppliers are still far behind any of the OEMs as true global players. Most of these firms have either total sales or total installed capacity of less than 50% outside their home markets [2].

The second critical issue that conditions the evolution of the auto industry is standardization. Declining sales and continuous restyling of models prevent automakers and suppliers alike from reaching economies of scale in manufacturing, with important adverse impacts on cost. The solution has been to share components and systems across models and OEMs. This involves the development of common platforms, the deployment of common processes and the use of common systems [3].

The idea of ‘common platforms’ that homogenize basic structures of the car (like the Golf/A3 VW platform), while allowing adaptations of exterior body is now a prevailing concept among OEMs. Another important aspect of standardization is the construction of plants able to produce multiple and varied models, thereby being able to respond to sudden shifts in consumer demands, or to easily fit in a global capacity management strategy. A similar logic is applied to components. Suppliers are trying to market systems such as the ABS or the seat frame across car models and even different OEMs. This possibility could yield important returns, not only due to scale efficiency, but also because the important costs associated with the development of challenging innovative solutions can be split among several automakers and a much larger number of manufactured units.

The third aspect that characterizes the industry is value chain disaggregation [4]. OEMs are focusing their attention on designing and marketing vehicles, as well as servicing the customer. They wish to reduce the asset intensity of their operations to boost shareholder return on assets, while improving quality and reducing manufacturing cost. Their strategy has been to transfer increased responsibilities to existing suppliers and generate opportunities for the emergence of suppliers with new roles. Part of this transfer of responsibility involves manufacturing tasks that were previously done by the assembler. The stamping of doors and fenders are a good example of an activity the OEM has traditionally done, but that is increasingly being considered for outsourcing. Another dimension of the disaggregation trend is the divestiture of assemblers from supplier units, which have grown to be full-fledged businesses of their own. While Visteon and Delphi are the most prominent examples, there are also a myriad of other smaller players that were spun off from OEMs.

The other industry characteristic, consolidation is directly coupled with the concept of value chain disaggregation. The need to be present all over the world, the increasing regulatory and consumer requirements and the need to continuously tackle new technologies, all of this at low cost, created a tremendous financial pressure in the automakers. As a result, a vast wave of consolidation is happening among automotive assemblers. It is estimated that, within the next 5 years, less than 10 independent automakers may survive. As OEMs integrate and shed their involvement in manufacturing, they also concentrate their efforts on working with a smaller number of players. The new direct suppliers are large global firms, which are either specialized in complex systems, or integrators of several simpler subsystems. They are expected to have a substantial responsibility in the design and engineering of these systems and to coordinate the supply chain necessary for their manufacturing and assembly.

Traditional suppliers were not equipped to respond to this new set of challenges. They were mostly regional, focusing on particular components, and had limited resources to withstand financial outlays on product development for up to 3 years before receiving returns on investment. As a result, during the past few years, the supplier industry has also been undergoing increasing
consolidation. The number of US suppliers with sales between 1 and 5 billion dollars went from 28 firms in 1992 to 47 companies in 1998. Likewise companies with sales higher than 5 billion dollars increased from 5 to 13 in the same time frame [own calculations from 5, several years]. The value of merger and acquisition deals peaked at an astounding US$30bn in 1999, representing close to 7% of the total sales of the autoparts industry.

One of most interesting aspects associated with the recent trends in the auto supply chain is the fact that industry expansion and innovation is happening in emerging regions. OEMs and suppliers are expanding rapidly in areas like South America, Eastern Europe and Asia, where they are also trying some of the most innovative solutions in manufacturing and supply chain organization. For example, the most innovative modular supply approaches, where suppliers assemble entire modules directly in the OEM plant are happening in Brazil [6]. This means that, contrary to what has been observed in the past, multinational automotive companies are trying new solutions outside their core markets. It has also meant that local, often smaller firms have been active players in new areas of the auto supply chain. A good example of this situation is the Brazilian steel maker Usiminas. In 1993, Usiminas agreed with Fiat to take over most of its stamping operations. This agreement is part of a recent OEM trend to increase the level of outsourcing at the stamping level, an area traditionally done in-house by the OEM. The interesting aspect is precisely the fact that the early adopter was a local firm rather than a multinational.

Despite the facts outlined in the previous paragraphs, research assessing how technological, organizational and market factors condition the entry of suppliers in areas traditionally assured by the automaker is still in its infancy, particularly in what concerns events taking place in emerging market areas. Most of the research has addressed the strategy, conditioning factors and impact in the automaker [1, 3, 7]. But the analysis has seldom been done from the perspective of the supplier. Several anecdotal evidence exits, reporting some of the most important cases, but few or none analytical study has been performed. This paper aims to contribute to a growing body of literature focusing on supplier strategies for entering in new technological and market areas, particularly those traditionally done by the OEMs. The case analyzed is the substitution of steel by aluminum in the manufacturing of engine blocks. This is a growing trend that is also associated with outsourcing. Moreover, as explained in the next section, it is a particular challenge in emerging regions like the Mercosur.

3. The growing use of aluminum in the manufacturing of engine blocks

The substitution of steel and iron by aluminum in engine manufacturing is an important technological change in the automotive industry that promises important weight savings and greater fuel efficiency. General Motors, for example, has declared that it expects to have completely “ironless” engines by 2010. To fulfill their promise, they announced that production of aluminum engine components would increase by 300% during the next five years. All other OEMs have plans that are close to those of GM.

The use of aluminum in the car engine started in the head. The technology is easier to control because of smaller size of the component and less exposure to high temperatures during engine use. As a result, most modern engines have an aluminum head. In North America, for example, the use of aluminum in the engine head will reach 90% in 2003 [8]. But the most recent challenge to the industry has been the use of this material in the manufacturing of engine blocks. During 1999 and 2000, most automakers announced plans to begin using aluminum as their material of choice in engine blocks. As a result, expectations are that 24% of the engine blocks produced in 2003 in North America will be made of aluminum, a figure that is expected to grow to 50% in 2007 [8]. So far, the OEM most committed to the use of aluminum in engines in Volkswagen. This firm was already using aluminum blocks in a number of gasoline engines with displacements greater than 2000cc. Last year they announced that, starting in 2000, all their smaller displacement engines (1.0 – 1.8l) would also have aluminum engine blocks. This means roughly 800,000 engines per year, by far the largest number of blocks made with this new technology for a single automaker. Most of these will be subcontracted to outside suppliers.

Ford announced a large expansion of its unit in Brook Park, Ohio to start manufacturing cast aluminum blocks for its 6 and 4 cylinder engines. This unit is expected to produce as many as 400,000 new blocks starting in 2001. GM and DaimlerChrysler announced similar volumes of blocks for their V6 engines, with production starting in the year of 2002. Both automakers are subcontracting companies located in Mexico to manufacture the blocks. One of these firms (Nemak) is also investing in a new plant in the Czech Republic to supply VW. The Japanese automaker Honda has likewise announced that 120,000

1 Except when noted otherwise, the data presented in this section was collected in multiple issues of the magazines American Metal Market and Foundry Management and Technology.
and 240,000 aluminum engine blocks will be produced in 2002 and 2003 respectively.

Until now, this trend has been mostly associated with manufacturing in North America, Europe or Japan, the regions of the world with high scale of manufacturing operations, strong firm technological capabilities, as well as demanding customers. Moreover, each new operation announcement made by the OEMs has implied an additional production of 200,000 to 400,000 aluminum engine blocks a year. This means that these new or expanded plants will be able to produce component at volumes that enable them to reach full economies of scale and therefore competitive prices. But, given the global configuration of today’s auto industry described in the previous section, similar technological solutions need to be available across all the regions of the globe where the automaker is present. The difficulty is that in emerging areas as Brazil or China, volumes of manufactured cars are much smaller. This situation implies that local firms starting to cast aluminum engine blocks for particular models may be severely hurt by scale or inefficiency problems.

A potential alternative would be to import these components from the US or Europe, where volumes enable full economies of scale. The problems are that, not only are these large and heavy components with significant logistics costs, but they are also subject to taxes and duties often found in most emerging areas, which may be as cost penalizing as low production scales. Moreover, automakers are often required to have levels of domestic content that condition their ability to import components. Therefore, the balance between local manufacturing and imports becomes a crucial trade-off for OEMs.

This is precisely what is seen in today’s Mercosur context. In the region, like in the rest of the world, a large share of the cylinder heads used in engines assembled locally is already made of aluminum. Moreover, firms sited in the region, either locally owned or part of a multinational, manufacture these heads. This is a good indicator that companies in the region have already some knowledge of aluminum casting technologies. Nevertheless, there is still no local casting of aluminum engine blocks.

In the absence of regional supply capabilities, the OEM decisions regarding the local incorporation of aluminum blocks in engines where these components are indeed employed in the Triad equivalents have been very diverse. GM, for example, is importing aluminum engine blocks for relevant models, to make sure that it aligns engine characteristics internationally. On the contrary, VW uses iron heads and blocks subcontracted to the local manufacturer Fundição Tupy; precisely the opposite of what has been its recent decision in Europe for the same engines. Despite these different strategies, automakers are increasingly looking at Brazil as a potential location for the manufacturing of aluminum engine blocks, in particular after the devaluation of the Brazilian Real.

Given this context, investment in the technology in Brazil seems to be the next logical step, in particular because industry experts concede that moving from the casting of engine heads to the casting of blocks is not a major technology shift but rather a natural evolution. The key question that this paper addresses is what are the issues that affect this potential investment decision and how should OEMs and suppliers deal with them? Two major aspects will be dealt in detail: production volume and local policy conditions, in particular the tax structure and the interest rate.

It has been noted above that all major announcements for new investments in facilities for casting of aluminum engine blocks have been associated with scales above 200,000 units and, with the exception of VW, for medium displacement engines. The problem is that the production volume of medium displacement engines in Brazil is 60,000 to 80,000 units per major engine group for each OEM, about a third of the minimum volume considered for new facilities in the Triad. Only the small and popular 1000cc car reaches 200,000 a year in some brands. This situation is bound to generate important diseconomies of scale that may severely affect local manufacturing cost.

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2 The information regarding Brazilian market conditions was obtained through direct telephonic interviews with local industry leaders and consultants.
The alternative is to import cast aluminum engine blocks. The problem, illustrated in Figure 1, is the heavy tax burden associated with importing components to Brazil. For OEMs working within the national automotive regime, i.e. complying with government regulations on local production quantities and national content, imported components with a base cost identical to locally produced ones are subject to an additional 29% cost burden. If the automaker does not comply with the objectives of the automotive regime, this extra cost reaches an additional 35% when compared to the local cost structure.

Scale and taxes are, therefore, key factors conditioning the opportunity for a foreign firm to invest in the region, or for local firms to enter this particular type of manufacturing activity. The next section details the methodology to analyze these trade-offs.

4. Scenarios and Methodology

The analysis will compare the two major options that automakers are facing when considering the adoption of aluminum engine blocks in Brazil:

- Breed local manufacturers of cast aluminum blocks
  This option aligns local engine characteristics to the overall industry trend. It also enables automakers to take advantage of local cost structures that have become favorable to the manufacturing of aluminum blocks. Finally it provides lighter – more efficient cars, a plus in Brazil due to high gasoline price. The downsides are the large investments necessary to develop local capabilities, with uncertain return and low production scale, which may require several automakers to commit to one supplier. Upon considering this scenario, we will evaluate both the situation of having a locally owned firm enter the business and having a foreign firm invest in Brazil to manufacture the component.

- Import aluminum blocks.
  This option has important advantages. It enables taking full advantage of economies of scale in facilities located elsewhere and does not require local investment, or the need for a long term commitment to one supplier chosen to enter the technology. It also has some disadvantages. The logistics costs are expensive, since they entail sending heavy and bulky components from overseas. It is also subject to significant import costs due to the Brazilian tax regulation.

  The evaluation of these two scenarios entails choosing a Brazilian mass production engine that can potentially have a block manufactured in aluminum; but also one that is produced outside of Brazil to assure competitive manufacturing costs. After choosing and determining the characteristics of the component, the manufacturing and logistics costs necessary to compare the scenarios considered have to be computed. The calculations of the manufacturing and logistics costs were done using technical cost models (TCM).

  Technical cost modeling is a powerful tool to understand manufacturing cost elements. TCM decomposes the manufacturing process places in steps (casting; trimming and transportation for this particular case) and assigns a monetary value to every contributing element in the process. For each step, it uses data about standard manufacturing practices and engineering principles to estimate both the variable and fixed costs associated to particular processes. Variable costs include material, energy, and direct labor costs. Labor costs account for wages and benefits and considers the effect of downtimes. Fixed costs are associated with the capital equipment needed to the physical processing of a component and encompass, among others, tooling, machinery, building, indirect labor overhead and engineering personnel. Further, capital costs are treated as having an opportunity cost associated with them and are discounted according to standard accounting techniques. Likewise, logistics include fixed costs, such as trucks, as well as variable ones such as fuel and labor. By summing the estimated values of each processing step, TCM gives the aggregate manufacturing and logistics costs for a specific product [for more detail on the technical cost modeling method see for example 9; for a similar application of the method to analyze firm internationalization strategies see 10].

<table>
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<td>Max Part Height</td>
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<td>Wage /h</td>
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</tr>
<tr>
<td>Reject Rate</td>
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</table>

Figure 2: Technical Cost Model assumptions for component geometry and factor conditions
To calculate the manufacturing and logistics costs associated with each of the scenarios described above, cost models to evaluate the aluminum casting process and the logistics process were developed. The casting model uses component characteristics to estimate the cost of the casting and trimming line, as well as the die cost. Component size, mass, wall thickness and complexity level are inputs to regression models that estimate the characteristics of the equipment needed to cast the engine block (press clamping force and tool area) and therefore, its investment cost. The component characteristics and the estimated casting equipment parameters are then inputs to engineering calculations of the casting cycle time. Once obtained, this information enables an evaluation of the press and labor utilization needed to fulfill desired production volumes. The information on factor conditions associated with a particular location of the manufacturing plant permits the estimation of the unit processing cost of the casting operation.

The assumptions used in the calculations for the scenarios described above are presented in Figure 2. The component information corresponds to the physical characteristics of the engine block. The factor conditions described in the figure correspond to the two situations we are assuming in the analysis: a plant located in Brazil producing for the local market and a plant located in Germany exporting to Brazil. The values were obtained through direct consultation with local industry. The production volumes considered correspond to full line utilization in Germany (i.e. available production time in a year divided by cycle time) and the expected volume of a medium displacement engine in Brazil.

The logistics model built for the analysis accounts for costs associated with shipping the engine blocks from the casting plant to the assembler plant. It uses industry data on transportation times and costs for truck and boat (across the ocean) to estimate equipment, labor, packaging and inventory cost. The two situations considered, illustrated in Figure 3, stem from the assumptions of plant location.

The total cost for each of the two scenarios is calculated by adding the results of the casting and logistics models. In addition, as it will be further detailed below, tax and duties are added to the manufacturing cost estimated with the models. For all major assumptions considered in the model, a sensitivity analysis will be performed to understand how much the results depend on the particular values that were assumed.

5. The tax and scale trade-off

Figure 4 shows the comparison between die casting in Brazil at scales that are geared only to the local demand and in Germany, at a factory producing for multiple clients and, therefore, working at high volumes. As indicated, the manufacturing cost in Brazil is 62% higher than the cost in Germany. Moreover, there are virtually no cost differences in terms of materials and the contribution of labor to the overall cost is rather small. The important cost difference is driven, to a large extent, by the high cost of capital that local firms face when receiving capital from local sources. The financial uncertainty in the region has prompted interest rates to 30%, which generate important financial burdens that make the equipment and tool extremely expensive. The low production volume of the Brazilian operation that increases the unit cost of the cast engine block further penalizes the additional cost of capital. These are the key determinants for the local cost penalty, although higher reject rates in Brazil also contribute to the additional local cost.
The relative importance of each of the cost drivers considered in Figure 4 can be further assessed through the sensitivity analysis presented in Figure 5 (volume sensitivity will be detailed below). As it can be seen, interest rate and cycle time are the key determinants for overall cost. If any of these variables are changed, there are important consequences to the overall cost result. Since cycle time is mostly determined by the characteristics of the press and component, this leaves the interest rate as a major influencing factor. Material cost can also have a significant impact, but since the market for the aluminum material is global, any potential changes are likely to affect both locations equally. Machine and Tool cost rank next in potential influence to the overall cost. While their base characteristics and price are determined by the component and therefore similar across the two locations, potential deviations from the estimated value will be more reflected in the unit cost of the Brazilian operation because of the dedicated low volume characteristic of the operations.

The sensitivity analysis also reveals a number of other aspects. The low importance of the wage is probably the most striking one. It is very clear from the figures that aluminum casting is a very capital-intensive activity, where labor plays only a marginal role. The arguments for moving this operation to the Mercosur region must therefore lie elsewhere, as it will be further detailed ahead. It can also be seen from the graph that die change over time and energy price are of minor importance for the overall cost. Improvements in the levels of rejects can have some impact on final cost, but only to a limited extent.

Figure 4 described only the strict manufacturing costs associated with the die casting operation. Figure 6 incorporates the total sourcing costs associated to the two scenarios considered: sourcing from a German plant and buying from a plant located in Brazil. It includes manufacturing and logistics costs, as well as the tax burdens associated with each of the purchasing situations. Moreover, two distinct situations are considered for the plant located in Brazil. The first and more penalizing one assumes that local firms that only have access to the local capital market own the firm. Therefore, the 30% base interest rate that was used to compute the values presented in Figure 4 is considered. The alternative scenario assumes that a foreign firm invests in the local market and that this firm is able to borrow money at the same interest rate as the German manufacturer.

What can be seen is that, at the base production volumes assumed for the analysis, imports from Europe have a competitive cost when compared to Brazilian manufacturing. This situation is particularly relevant for the case where local firms produce the component, as the huge gap in manufacturing cost is not compensated by the logistics cost and the additional tax burden that is imposed in imported components. Because the German base cost is rather low when compared with the Brazilian one, even after the logistics costs, the 29% additional tax load associated to imported components is only slightly larger in absolute value than the one that a local component faces. As a result, Brazilian engine blocks are 22% more expensive than German ones.
Contrary to the previous findings, if the capital is brought from Europe at lower interest rates, the situation is inverted and it becomes less expensive to produce locally (see Figure 6). Under these new factor conditions, the capital cost penalty associated with higher interest rates is removed, leaving low volume and inefficiency (higher reject rates) as the key drivers for a local cost that it is still higher than the German one. Nevertheless, the logistics costs of bringing the component from Germany and the heavy tax burden for imports make up for the differences in manufacturing cost. On the other hand, it is also easy to see that, if the level of import taxes is reduced (a scenario not unlikely, given increasing WTO pressures), imported aluminum engine blocks will again be competitive when compared with local production.

Despite these results, as shown in the previous paragraphs, the cost model results depend on the assumptions used. Most of the relevant issues were evaluated through the sensitivity analysis described before. In addition to these, the results have also an important dependence on the production volume of the plant in Brazil. Because the scenarios considered a dedicated plant, if the volume of cars manufactured in the region using aluminum engine blocks increases, or the facility is set-up with export objectives, the manufacturing cost will be substantially different.

Figure 7 shows how the manufacturing cost depends on the volumes of engine blocks cast in Brazil, for both the situation of a local firm sourcing capital in the region and a foreign investing locally. As it can be concluded from the graph, Brazil seems to be viable for production scales above 65,000 engines per year for foreign investors and 100,000 for local manufacturers. Nevertheless, the advantage is never very large, and it is even reversed for a production volume of 140,000, when a new casting line might have to be added.

As a consequence, if a potential investor adds these results to the risk associated with a market as volatile as Brazil, the decision to enter the region with a new plant is not easy to justify, and it is probably the major reason why one has not yet seen any investment in the manufacturing of aluminum engine blocks in the Mercosur area.

6. Conclusions and recommendations

The analysis presented in the previous section shows that, with current market conditions, importing cast aluminum engine blocks from Europe to Mercosur is cost competitive when compared with local manufacturing. The major drivers for this result are the low production volumes and the high interest rates in Brazil, which offset the heavy tax burden that the government imposes on imported components. This is probably the reason why no investment in the manufacturing of aluminum engine blocks has yet taken place in the region.

Volume may be the critical variable where automakers and suppliers could act to reverse the current situation. Some of the conditions and strategies that could make local manufacturing attractive include:

- Targeting the 1000cc engines for the use of aluminum engine blocks; these engines have much higher production volumes, thus diminishing the scale problem identified in the analysis; this solution...
depends on the widespread adoption of the technology in these engines throughout the world;

- OEMs agree to subcontract the same local supplier to overcome diseconomies of scale:
  - Most OEMs agree to subcontract the same local supplier;
  - At least two major OEMs commit to buy from a foreign supplier investing in Brazil;
- The investment is set up from the beginning to have global export objectives;
- Local producers find alternative applications for the unused press line capacity, potentially in the manufacturing of aluminum engine heads and pistons.

Despite the limited power of individual firms to influence it, it is important to note that the discount rate required by the firm for a particular project, which reflects, among others, interest rates and perceived risk, is a major factor affecting manufacturing cost, particularly for firms sourcing capital locally. Likewise, the tax structure can be a key determinant of the competitiveness of imported and local components. Therefore, changes in the policy environment may have dramatic influences in the economics of a particular project. For the case detailed in the paper, an important decrease in local interest rate, or in the tax penalty for imported components, would change completely the component cost structure and therefore the OEM sourcing decisions.

The overall conclusion is that global trends in technology adoption in the auto industry have the potential to generate important changes in characteristics of the supply chain. Nevertheless, understanding the challenges and opportunities requires a careful assessment of how technology and market conditions affect the evolution of the industry and the potential strategies of the players. As shown in the paper, this becomes particularly important in contexts of emerging markets where issues such as scale and government policies have significant impact in the market.

7. Acknowledgements

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8. References


