Progress of the dies and molds industry and the role of the German immigration network in Brazil: Case studies in ABC districts in Sao Paulo, Resende, and Joinville

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Key words: "dies and molds industry," "supporting industries," "production and innovation," "international competitiveness," "global value chain," "supply chain," "supply and demand," "industrial clusters," "capacity building," "technological education," "engineers and craftsmen," and "immigration."

1. Introduction: Purpose and background of this research

The aim of this paper is to consider the progress of the dies and molds industry in Brazil. Dies and molds are the apparatus used to realize automotive ideas and designs into actual products. Dies and molds are metallic tools that produce many copies of the same product precisely and speedily. Many types of materials can be processed and formed in dies and molds, such as plastic, metal, glass fiber, glass, rubber, and polystyrene foam.

Automobiles are manufactured to be assembled from many different components and parts, most of which are made through the use of dies and molds. Many dies and molds are needed to make any mass-produced commodity. To produce one automobile, we need several tens of thousands of dies and molds.

Dies and molds contribute not only to qualities such as appearance, performance, and accuracy, but also to improvements in productivity and stability. For the automobile industry, which many developing countries would like to promote and expand, dies and molds are essential. In many developing countries, they cannot supply a sufficient quality of dies and molds, so they depend upon imports from advanced countries.

Also, for advanced countries, the dies and molds industry is very important, not only for production itself but also in the research and development (R&D) process. One needs to bear in mind the following. How can one make the designed shapes precisely

with the materials one desires? Is it possible to stabilize mass production? Is it possible to attain a desirable level of performance? These issues are solved by developing methods to process new materials, the unification of plural processes with many components and parts, substantial weight reductions, improved resistance to corrosion, better strength and productivity, methods to cut and shape difficult working materials, the manufacture of complex shapes, integral molding using more than two types of materials, cost reductions, and so on. This can all be achieved through the development of suitable dies and molds. No matter whether the R&D is an "integral type" or a "module type," dies and molds are essential tools for realizing new ideas for making a design for a competitive commodity. The development stages of industrialization in a country are deeply connected to the ability to develop and make suitable dies and molds.

2. Research questions, methods, and data

In this research, the author would like to analyze the following research questions. How competitive is the Brazilian dies and molds industry internationally? How do the Brazilian dies and molds fit into the global dies and molds value chain? How do global automobile players evaluate Brazilian dies and molds? Where is the Brazilian dies and molds industry positioned in terms of the global development stages? Does Brazil have strong dies and molds clusters such as in advanced countries? How is the Brazilian dies and molds industry positioned in terms of the level of its technologies and skill of its engineers and craftsmen? How does the industry learn skills and technologies?

In order to analyze the international competitiveness and global value chain of the Brazilian dies and molds industry, the author uses UN Comtrade[i] trade statistics from 1989 to 2017. The trade total for dies is the sum of HS820720 and HS820730, and for molds it is HS8480. HS is an abbreviation of the Harmonized Commodity Description and Coding System, where a code indicates each commodity. The explanation of each HS code is as follows:[ii]

-HS8207: Interchangeable tools for hand tools, whether or not power-operated, or for machine tools (for example, for pressing, stamping, punching, tapping, threading, drilling, boring, broaching, milling, turning or screw driving), including dies for drawing or extruding metal, and rock-drilling or earth-boring tools.
-HS820720: Dies for drawing or extruding metal.
-HS820730: Tools for pressing, stamping or punching.
-HS8480: Molding boxes for metal foundry; mold bases; molding patterns; molds for metal (other than ingot molds), metal carbides, glass, mineral materials, rubber

or plastics.

To consider the research questions, several field studies were conducted and tens of dies and molds users and suppliers in Brazil were visited. To analyze the international competitiveness of dies and molds, the Global Competitiveness Index (GCI)[iii] is used. The GCI ranges from -1 to 1; with values close to 1 indicating strong international competitiveness and close to -1 indicating weak international competitiveness. As described in a later section, the GCI of Brazilian dies in 2017 is calculated as "-0.57." The GCI of Brazilian molds in 2017 is calculated as "-0.56." This means the competitiveness of both Brazilian dies and molds are very weak. Many dies and molds are imported from countries such as China, South Korea, and Japan. The GCI values of these countries indicates that the competitiveness of Brazilian dies and molds is weak.

Why is this the result? Dies and molds are an essential industry for automobile production. Automobile production in Brazil has a long history. It began as early as the 1920s. After the 1950s, the Brazilian government struggled to expand the automobile industry. Has the dies and molds industry not developed well with developing of automobile industry? Do they not have enough skill and technology to make high-quality dies and molds for automobile production? Are there any other reasons that have caused the above result? To consider these questions, the author has conducted case studies of the ABC districts in Sao Paulo(Santo **A**ndré, São **B**ernardo do Campo, and São **C**aetano do Sul), Resende, and Joinville in Brazil. Joinville, which is a city settled by German immigrants, has one of the biggest dies and molds clusters in Brazil, the author found that the German immigration network was very important in building skills and technologies for the dies and molds industry in this area.

3. International competitiveness and the Global Value Chain of Brazilian dies and molds

The trade statistics and international competitiveness of Brazilian dies and molds from 1989 to 2014 are described in Baba (2017).[iv] Here, the author would like to add the newest data, until 2017, and to re-analyze it.

(1) Overview

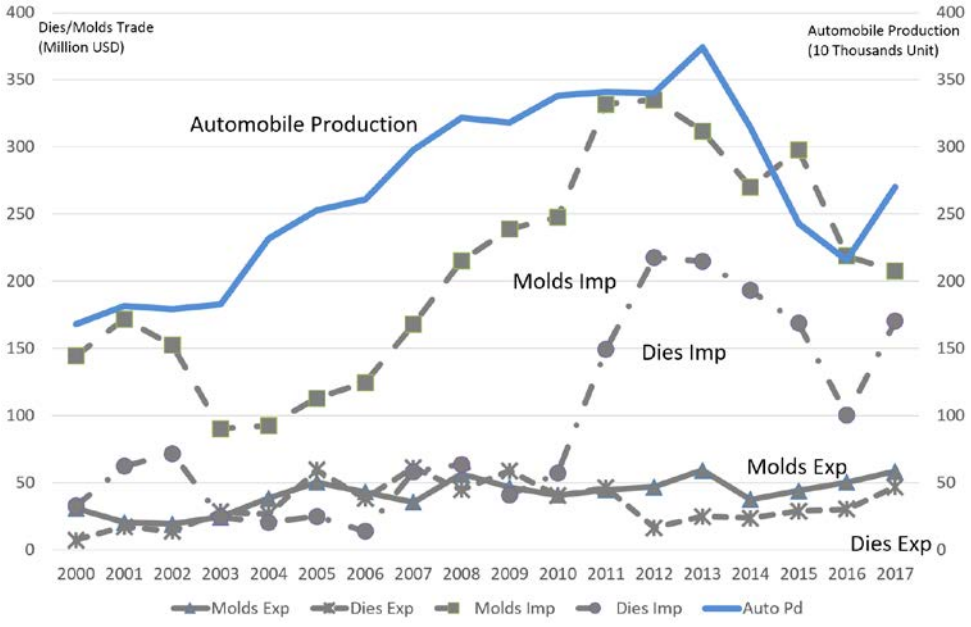
The dies and molds trade and automobile production from 2000 to 2017 are described in Fig. 1. There are two remarkable features. One is that there seems to be a relationship between automobile production and dies and molds trade. Another is that

the situation of the Brazilian dies and molds trade balance is substantially deficit.

The correlation coefficient from 2000 to 2017 between automobile production[v] and dies imports is 0.52; the coefficient correlation between automobile production and molds imports is 0.71. There are obviously positive correlations between automobile production and dies and molds import. The more automobile production increases, the more dies and molds are imported. This may mean that dies and molds suppliers in Brazil cannot supply the necessary volume of dies and molds required in this time period. However, we can observe interesting behaviors from 2016 to 2017. Automobile production increased from 215.6 thousand units to 270.0 thousand units. Dies imports increased from 100.2 to 170.4 million USD. In addition, molds imports decreased from 218.8 to 207.9 million USD. Though this is not a certain pattern because of the very short term, it may show an increasing ability of the domestic molds supply.

Regarding the second feature, the differences in exports and imports are as follows. In 2017, Brazilian dies exports were worth 58.5 million USD and molds exports were worth 46.9 million USD, a combined total of 105.3 million USD. On the other hand, dies imports to Brazil cost 170.4 million USD, while the molds imports cost 207.9 million USD, a combined total of 378.3 million USD. The differences between imports and exports are quite large, and the Brazilian trade in dies and molds has remained in deficit recently.

Fig 1. Dies/Molds Trade and Automobile Production in Brazil (2000-2017)



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（2）Brazilian Trade Situation for Dies and Molds

In Brazil since the 1990s, suppliers of high-grade dies and molds have not provided enough quality and quantity to meet the expanding demands of users such as the automobile industry. This is because imports of dies and molds are much bigger than exports (Fig.2). As demand increases, imports increase further, because the domestic market cannot keep up with demand.

Fig 2. Dies/Molds Trade Situation for Brazilian Dies and Molds（1989～2017）

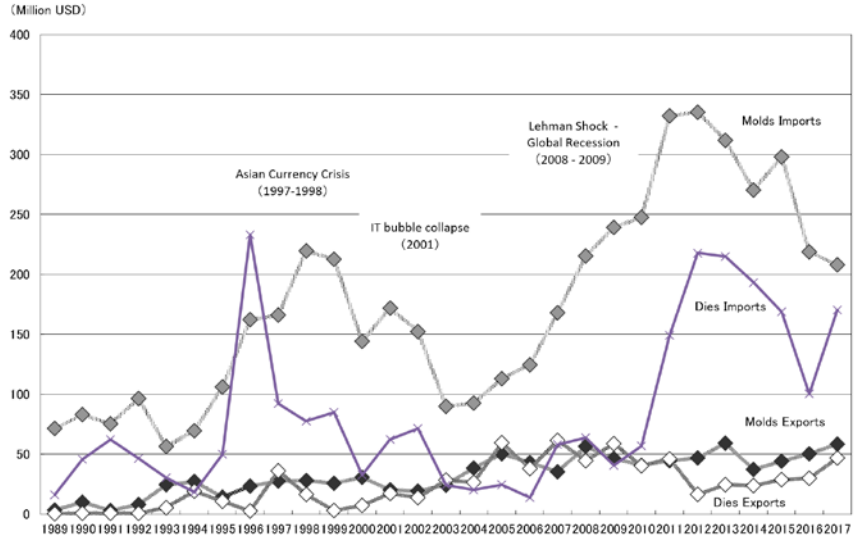

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Fig. 3 shows the trade surplus and deficit for the dies and molds trade in Brazil. In the latter half of the 2000s, the trade deficit for both dies and molds became bigger because of the increase in imports as shown in Fig.2. This was the period when each automobile manufacturer introduced new models and Hyundai's big expansion of automobile production was supported by favorable economic growth.

After 2012, trade deficits in dies and molds trade fell because imports fell. There are several possible reasons for this, such as the effect of INOVAR-AUTO[vi], the expansion of domestic procurement, and a fall in demand caused by a slackening economy. From 2016 to 2017, automobile production recovered. As mentioned, dies imports increased and molds imports decreased. It might be possible to say that this is due to an increasing ability of the domestic molds supply.

Fig 3. The Trade Surplus and Deficit in Brazilian Dies/Molds Trade（1989～2017）

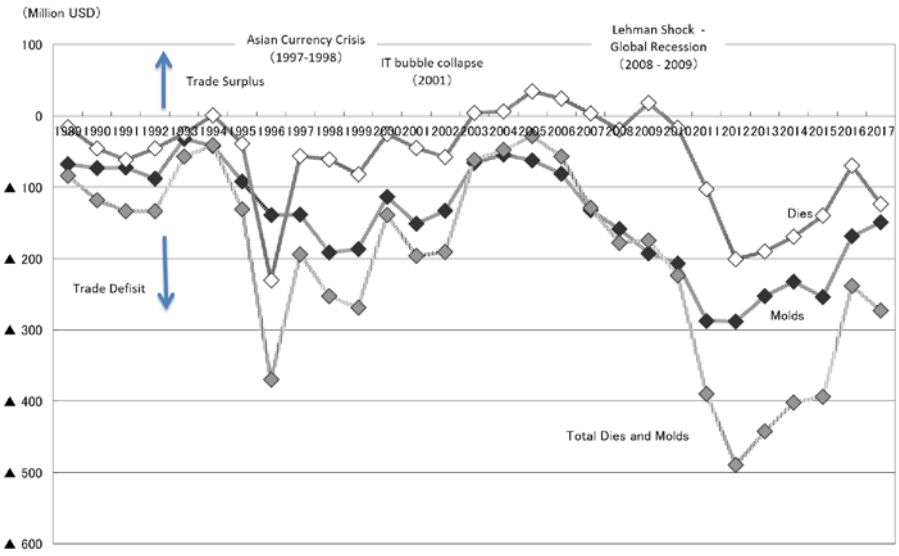

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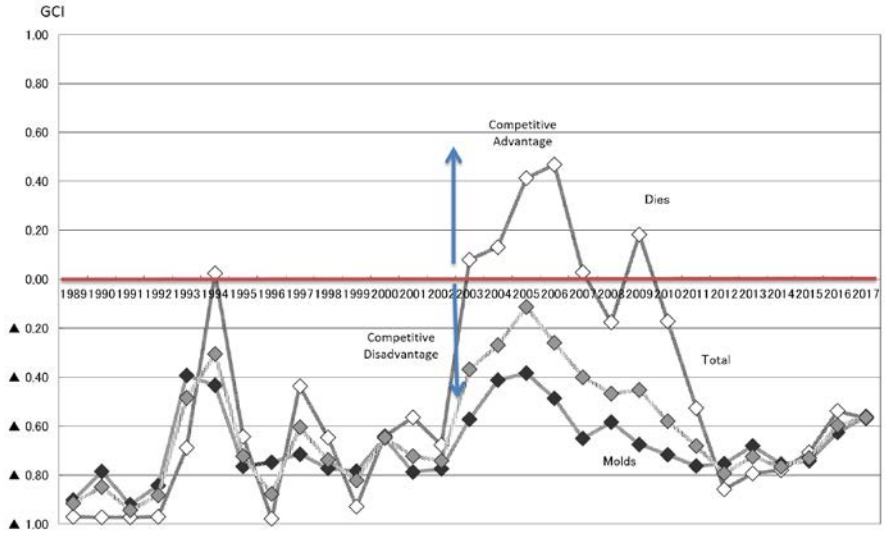
Fig 4. International Competitiveness of Brazilian Dies and Molds（1989～2017）



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（3）Brazilian International Competitiveness in Dies and Molds

Fig. 4 shows the trend in GCI values, which indicates Brazilian international competitiveness in dies and molds. GCI values generally had an upward trend with some fluctuation from 1989 until around 2005 in both dies and molds. Regarding dies, the GCI showed plus values in 1994, from 2003 to 2007, and in 2009. This was a period of comparative advantage in dies. However, GCI values for dies dropped dramatically

between 2010 and 2012. The values of molds also dropped from 2006 to 2012. In 2017, GCI values were -0.56 for molds and -0.57 for dies, -0.56 in total. The international competitiveness of Brazilian dies and molds dramatically dropped in the latter half of the 2000s. Recently, though the GCI values have remained in a weak position, their values have been gradually increasing, thus showing signs of recovering.

(4) The Global Value Chain of Brazilian Dies and Molds

①Major Partners in Brazilian Molds Trade

From around 1990 until the first half of the 2000s, the major import partners in Brazilian molds were Italy, Germany, Japan, and the USA. These countries had moved into Brazil and were producing automobiles such as Fiat, VW, Benz, GM, Ford, and Toyota. For example, in 1992, the major partners in Brazilian molds imports and their shares were Italy 21%, Germany 17%, Japan 16%, Panama 10%, the USA 8%, and France 6%.

Since the latter half of the 2000s, molds imports from China and Korea have risen dramatically. Molds imports from Korea ranked 5th in 2003, but after 2010 to 2016 they formed the 2nd largest share. Hyundai Motors moved to Brazil in 2005. They rapidly increased their automobile production and held the 4th largest share of the Brazilian automobile market in 2016. This may be an important factor in the increase in molds imports from Korea. On the other hand, molds imports from China ranked 4th in 2005, and were top from 2006 to 2017. There are no Chinese automobile manufacturers operating on a large scale in Brazil. Companies import Chinese molds because of the cost advantages. People in the Brazilian dies and molds industry felt a sense of danger from this rapid increase in Chinese imports. They founded "ABINFER," which is the Brazilian association of the dies and molds industry, in 2011. In 2017, the major partners in Brazilian molds imports and their shares were China 28%, Japan 14%, Korea 10%, Canada 8%, France 6%, the USA 5%, and Germany 4%.

Molds exports are quite small compared to imports. Many of these countries are near Brazil or members/affiliate members of "Mercosur" (the Common Market of South America). In 1992, the major trading partners in Brazilian molds exports and their shares were Mexico 17%, the USA 14%, Argentina 13%, Uruguay 13%, Venezuela 11%, and Chile 8%. In 2017, the major trading partners in Brazilian molds exports and their shares were Argentina 43%, the USA 15%, Mexico 9%, and Colombia 5%.

②Major Partners in Brazilian Dies for the Stamping Trade

The major dies (HS820730) import partners were Japan, Italy, Argentina,

German, Spain, the USA, and France from the 1990s to the early 2000s. In 1991, they were Japan 34%, Italy 27%, Argentina 17%, Spain 15%, the USA 5%, and Germany 1%. Of these, the portion of imports from Japan was great. Japan ranked 1st for 12 out of the 25 years between 1990 and 2014. The other countries that ranked 1st in this period included Italy 4 times, Argentina 4 times, Germany 2 times, Spain 2 times, and the USA once. Japan continued to come 1st from 2011 to 2014. In 2015 it dropped to 2nd, then became 1st again in 2016 and 2017. The presence of China and Korea has also increased, as happened with molds, from the latter half of the 2000s, when dies imports dramatically expanded. Korea was ranked in 4th in 2005. It was 2nd in 2011, 2015, and 2016. It was 3rd from 2012 to 2014, and in 2017. China suddenly ranked 3rd in 2007 and has remained 2nd from 2012 to 2014. Recently it ranked 1st in 2015, then 3rd in 2016 and 2nd in 2017. In 2017, the major dies import partners and their shares were Japan 35%, followed by China 21%, Korea 15%, Spain 9%, Italy 6%, the USA 4%, and Germany 3%. The reason for the present increase for China and Korea is thought to be the same as for molds.

Die exports from Brazil are quite small, as can be seen in Fig. 2. In 2017, the major partners and their shares were the USA 54%, Mexico 22%, Argentina 15%, South Africa 3%, and China 2%.

4. Case Study 1: Big companies in Sao Paulo and Resende

(1) Factory visits and interviews conducted in February 2015

◆Company A, Automobile Manufacturer

Company A is a famous global automobile manufacturer. As of 2012, the localization ratio of their automobiles was 64%, on a cost basis. In their factory, they use dies for producing skin panels using huge transfer stamping machines. They use molds for producing big plastic parts such as bumpers. Their dies and molds are imported from Japan, Korea, and China. Though they have a plan to increase localization of their automobile parts, they do not have plans to procure dies and molds from domestic companies at present. The reason is the quality and specialty of their dies and molds. The dies and molds used by the company are extremely large in size and very high quality. On the other hand, they welcome the use of domestic dies and molds for their auto parts suppliers if there is an increase in quality of their auto parts and a decrease in production costs. They hear many of their auto parts suppliers use local dies and molds.

◆Company B, Automobile Manufacturer

Company B is a famous global automobile manufacturer. They say that,

generally speaking, the level of the Brazilian dies and molds industry is high. They say that the Brazilian dies and molds industry exited for a long time, especially in particular molds industry. They hear that many automobile parts supplier use domestic dies and molds. On the other hand, the dies they use for big transfer stamping machines are all imported from Japan. The reason is the Brazilian dies of this kind do not meet their standards at present.

◆Company C, Tool Shop of an Automobile Manufacturer

Company C is a famous global automobile manufacturer. They have 12 tool shops around the world. There are nine in the EU, China, Brazil, and Mexico. They say that there is a good domestic dies and molds industry in Brazil. Major dies and molds clusters in Brazil include the ABC districts in Sao Paulo, Joinville, and Porto Alegre. The company employ around 500 people in their tool shop, including the stamping shop. They produce large dies in-house such as for large stamping machines for skin panels. They also procure dies and molds domestically and import them from Japan, Korea, and the EU. The big problem of Brazilian dies and molds is the high price. It is rather cheaper to import them from Korea.

SENAI (Serviço Nacional de Aprendizagem Industrial: The National Service of Industrial Training) is located inside Company C. In SENAI, they teach die making. Employees of Company C support this training. Excellent graduates will be hired by Company C.

◆Company D, Tool Shop of an Automobile Manufacturer

Company D is a famous global automobile manufacturer. They have several tool shops around the world. There are around 200 people employed by this tool shop. The total number employed by the stamping shop is around 700 people. They produce large dies in-house such as for skin panels, and extremely high-quality dies. Medium and small dies are procured domestically and imported.

◆Organization E

The staff of organization E had interviewed people from "The Big 4" (Fiat, VW, GM, and Ford) regarding dies and molds. They say that there are dies and molds clusters in Brazil. Automobile companies can procure dies and molds domestically. However, Brazilian facilities are old fashioned, which causes low productivity. This means that their dies and molds do not reach a high quality in the newest technologies and their production periods have become long. In addition to this, a variety of costs, such as interest, human resources, taxes, import duties,

domestic transportation, and security fees, are quite high in Brazil. They said that these are can be summarized as “Brazilian costs.” This leads to high prices for domestic dies and molds. Thus, generally speaking, Brazilian domestic dies and molds are evaluated as being high priced with long production periods by using old-fashioned equipment and facilities.

(2) Fact findings of Case Study 1

In the four automobile companies, companies A through D, they use large sized special dies, such as for skin panels, in their factory. Some of them use large sized special molds such as for bumpers or console panels. Two companies import them from Japan, Korea, and China. Another two companies produce these by themselves in-house. This situation is quite usual for global automobile companies, because the dies and molds used in their factories are quite special. They need high quality and large facilities as well as specially trained professional engineers in order to produce them. On the other hand, they said that their automobile parts suppliers normally procure dies and molds domestically, and some of these automobile companies also often procure normal dies and molds from local dies and molds companies.

The staff of organization E summarized that the problems of the local dies and molds industry are high prices, long production periods, and old-fashioned equipment and facilities. These problems are caused by two factors. One is old-fashioned facilities and old methods used to make dies and molds. The other is the so called “Brazilian costs.”

5. Case Study 2: Automobile parts companies and a dies company in Sao Paulo and Resende

(1) Factory visits and interviews conducted in February 2015

◆Company F, Automobile parts manufacturer

Company F is a global automobile stamping parts supplier. They have over twenty sites all over the world. In Brazil, the company employs are around 100 people. Five people are assigned to the tool shop. Here in Brazil, they stamp metal components, assemble them, weld them, and add a cation electrodeposition coating to them. Their products include suspension members or links. For metal stamping, they use 1,520-ton transfer stamping machines, 800-ton blanking stamping machines, and 200-ton tandem stamping machines. Their metal automobile parts need to be high quality, high strength, and high rigidity for safety in case of automobile crashes.

Almost all the metal parts required to assemble their products are produced in their factory by stamping metals. The localization ratio is around 85%, on a number of

parts basis. On a cost basis, the localization ratio is about 50 to 70% because they import metal sheets from Korean Posco. They are discussing changing their metal sheet supplier from Korea to Usiminas of Brazil to increase the localization ratio.

They use around 100 die units in their factory. Ten of the progressive dies are imported from Thailand, and the rest of the units are imported from Japan. The Thai company is an affiliated engineering company. In their evaluation, local dies are of sufficient quality, but the delivery terms and prices are not fit their standards. The delivery time is nearly double compared to Japan. The factory price is also double compared to Japan. Thus they cannot procure dies domestically at present.

◆Company G, Automobile parts manufacturer

Company G is a global automobile stamping parts supplier. They have over 30 sites around the world. Here in Brazil, they produce large metal parts for automobiles such as skin panels, chassis, and structures parts. From 2012, a Japanese automobile metal parts company was made an equity partner and the company restarted as a joint venture.

There are large stamping machines of 2,000 or 800 tons. The types of stamping machines include transfer, progressive, fine blanking, and tandem. Though many of their dies are imported, some of them are procured from domestic companies. They evaluate domestic dies as not sufficient. One problem is quality. The facilities of their dies suppliers use old machines, which are decades old. The accuracy is not sufficient and the quality is uneven. Some of them cause burrs or distortions on their products after the stamping process. Another problem is price. The price for domestic dies is higher than for those imported from Japan or China. In some cases, there are additional problems in the cost reduction process because of the used of old fashion technology. For example, domestic producers sometimes use cushion pins, whereas the newest technology is usually the use of gas cushions. This causes quality trouble. Another problem is long the delivery term. A delivery term for one die is 140 days, domestically. That same die, can be imported from Japan in only 90 days. It takes a Japanese company 60 days to make that die and 30 days to transport it to Brazil, including sea travel, customs, and land transport.

◆Company H, domestic die manufacturer

Company H is a die making manufacturer. It was established in 1985. They produce large dies for parts such as trunks or doors. The size of a die for a trunk is 2 m by 2.5 m. Its main customers are automobile manufacturers and the electronics industry. It employed around 600

people in 2010. They produced 200 sets of dies annually, at that time. The number of employees was reduced to 230 people in 2015. The production was also reduced to less than 100 sets annually. There are two reasons for this business scale down, according to a company representative. One is economic recession and a decrease in production by automobile companies. Another is decreasing orders due to the influence of increasing Chinese dies imports.

The founder learned die making technologies in a metal stamping manufacturer in Sao Paulo. He left that company and started his own company in 1985. From 1988, he supplied to big automobile manufacturers such as GM and VW. Now, many automobile companies are his customers. Currently, all of its dies are for domestic use. In the past, some of their dies were exported to Argentina.

Many of company employees learned die making technologies in SENAI. They produce dies the German way. This is because the stamping company the founder learned from used a German method of production. In Sao Paulo, from 1950s, VW started fully producing automobiles and promoting localization there. Thus, in the 1980s, it was normal to produce automobile parts in the German style. In terms of learning technology, the company is conscious of the latest German styles of production, the representative said.

Their process accuracy is to the sub-micron mm. The life of their dies is around 1.5 to 2.0 million shots. The representative said that, normally, dies from Japan or Germany last about five years. Their dies last about three years. The production term to make dies that are copies of existing dies is 30 days. It takes nine to twelve months from design to completely finish a new die. To design dies, it takes 30 to 120 days, including ordering a mold base. For metal processing, it takes 30 to 120 days. Then, it takes 30 to 60 days to assemble, test, and adjust them. Payment is divided as follows, 10% for first order from customer, 30% for ordering mold base, 30% for finishing metal processing, and then 30% for testing. In some case, 20% is required for testing and the final 10% is obtained when a customer starts normal production using the dies.

The price range of their dies is around 70 to 140 thousand USD. Since around 2009, customers have urged for a reduction in price to match the target price set by Chinese imports. The final price, including delivery, for Chinese dies for metal stamping is 60% of the price of equivalent dies from Brazil, and Chinese molds are 40% of the price of equivalent Brazilian ones. Company H would like to improve technology and reduce cost by introducing the newest machines. However of this, they can not to do so. There is no governmental incentive policies, the import duty is extremely high, and interest rates are also extremely high in Brazil.

(2) Fact findings of Case Study 2

Here the author conducted a case study on both the demand side for two die users and the supply side for one die maker. On the demand side, company F does not

procure domestically and company G already procures domestic dies. The reason company F avoids the domestic procurement of dies is long delivery terms and high prices compared to imported dies. On the other hand, company G's evaluation of domestic dies is harsh in all QCD (Quality, Cost, Delivery) areas, which are the three aspects normally used in considering the level of suppliers in the automobile industry. Company G indicates that old-fashioned facilities and technologies have caused insufficient quality and long delivery terms.

On the supply side, company H said that their technologies are based on the 1980s. They noticed that their production style is old fashioned, and they would like to introduce the latest technologies in order to enhance quality and shorten delivery terms. However, high import duties and high interest rates prevent additional investment.

6. Case Study 3: Dies and molds manufacturers in Joinville

(1) Factory visits and interviews conducted in September 2017

◆Company I, molds manufacturer

Company I is a molds manufacturer established in 2000 by two owners. In 2017, the number of employees was 82 people. They operate in two shifts. Until recently, they mainly produced molds for aluminum (AL) die-casting. Recently, they have primarily produced molds for plastic injection. This shift was caused by market shrinkage of molds for AL die-casting. There were two main reasons for this. One is customers have increased in-house mold making. Another is an increase in Chinese molds. At present, 80% of their sales is molds for plastic and 20% is for AL.

Joinville is the biggest dies and molds cluster in Brazil. Dies and molds companies have been supported by two core companies. One is Tigre[vii], the other is Multibras[viii], Tigre is a big manufacturer of thermoplastic pipes for the water supply. It acts as a Core Company for growing mold technologies. Mutibras is a big electric manufacturer, it has now merged with Whirlpool. It functions as a Core Company of expanding dies and molds technologies. The owner of company I worked in Tigre and learned about mold technology; he then started his own business in 2000. The owner is German Brazilian. He often goes Germany to learn the latest molds technologies.

In company I, they think machine investing is important. They have invested in two wire electrical discharge machining (EDM) machines and two Machining Centers, or die-sinking EDM machines. The wire EDM machines are from Age-Chamilles in Switzerland, and one of the Machining Centers is from DMG Mori Japan. They also bought cheaper Taiwan machines. They use them properly, in accordance with the

precision prescribed. They also bought a German cutting tool adjuster in order to maintain the preciseness of the cutting edge and to maintain good axial rotation balance. These are important to keeping machining accuracy. They bought premium 3D measuring apparatus to maintain the accuracy of their products. They abolished paper drawings and put several big size monitors inside the factory. Employees can check 3D drawings and the result of a simulation whenever they need to do. The company makes an effort to plan suitable production controls and step-by-step checks in order to shorten delivery terms. The delivery term is two months at present.

◆Company J, dies manufacturer

Company J is a dies manufacturer established in 1997. The number of employees is 40 people. In 2016, they made 111 sets of dies. They can make transfer dies, progressive dies, and tandem dies. The delivery term from order to delivery is 150 days for transfer dies and 120 days for tandem dies. It takes 45 days for designing. They introduced 10 machining center (MC) units. The MCs were imported from Korea, Germany, and China. They use them properly, in accordance with required quality.

Company J was started by 6 people. The owner worked at Multibras and started his own business. At first the main business of company J was metal processing. From 2002, he tried to make dies and in 2004 he successfully took the first order for die making.

The academic background of the factory workers is high school level graduate. Some of them are graduates of SENAI. Designers are university graduates. After entering the company, training and learning is done mainly through on the job training (OJT). It takes two to three years to master the machining process. It takes five to eight years to master making dies, including assembling and adjusting them. It takes three years to master die design.

The company feels threatened by the increased importing of dies from China. They feel behind China on both price and delivery time. Customers request them to keep quality in line with German manufacturing standards but reduce price to a Chinese level. There are lots of issues for the die making business.

◆Company K, molds manufacturer

Company K is a molds manufacturer established in 2003 by three people. They worked at a mold making company and then started their own business in Joinville. The company employed 30 people in 2007. They introduced the German way of molds making. In 2016, 40% of their sales were for automobiles and 60% were for electronics.

They introduced good machines, such as two Agie wire EDM machines. They

also introduced premium 3D measuring apparatus made in Switzerland. By introducing efficient machines and process controls, they have successfully shortened delivery terms from three to two months. The next issue is how to reduce prices. They are trying to reexam mold design and how to make them efficiently. The target reduction of price is 30%. The average price of eight-ton molds is 75 thousand USD. Payment conditions are 20% at order taking, 20% at finishing designing, 10% at process and assembling, 20% at testing and adjusting, and 30% at delivery.

◆Company L, molds manufacturer

Company L is a mold manufacturer established in 2005 by two owners. The employees are 27 peoples with two shifts in 2017. They made 40 molds in 2016. 40% of their sales are for automobiles and 60% are for electronics. Their target policy is to make large-sized molds with a fast delivery time and cheap price. They also try to make high value-added molds such as multi cavity types. By introducing new machines, they try to reduce labor costs. In 2016, they successfully reduced 30% of their labor costs.

One of owners learned mechanical processing knowledge in SENAI. Then he worked at a mold making company in Joinville before starting his own business. At first company L took orders for metal processing from a mold making company. Then it took orders from Whirlpool and Tigre. After accumulating mold making technology and know-how, they started to make their own molds.

The price of molds with a four-ton weight is 40 thousand USD and with a six-ton weight is 75 thousand USD. The delivery time from order to deliver is 120 days, with three weeks for designing, 70 days for metal processing and assembling, 30 days for testing and adjusting. The payment condition is 30% at order taking, 20% at process and assembling, 20% at testing and adjusting, and 30% at delivery.

(2) Fact findings of Case Study 3

Joinville is a German Brazilian town. In dies and molds factories, most employees are German Brazilian. Their producing style uses the German method. They often go to Germany to learn the latest technologies. The Joinville dies and molds cluster is thought to be growing since the 2000s. There are two main core companies growing the dies and molds industry here. One is Tigre, which is expanding molds making technologies here, the other is Multibras (Now Whirlpool), which is growing dies and molds making technologies here. Some of the owners of the studied businesses worked at these companies and gained experience in dies and molds making, then started their own businesses. Generally, they started metal processing first, then they started making

dies or molds themselves after accumulating experiences.

They introduced new machines to improve quality and processing speed to shorten delivery terms. Many of them introduced high quality machines made in Germany or Japan. They also think measurement is very important for maintaining preciseness, which results in good quality. At present their big issue is how to reduce prices in order to fight Chinese competition.

7. Discussion

As mentioned, the research questions of this paper are as follows. How competitive is the Brazilian dies and molds industry internationally? How does the Brazilian dies and molds fit into the global dies and molds value chain? How do global automobile players evaluate Brazilian dies and molds? Where is the Brazilian dies and molds industry positioned in terms of the global development stages? Does Brazil have strong dies and molds clusters such as in advanced countries? How is the Brazilian dies and molds industry positioned in terms of the level of its technologies and skill of its engineers and craftsmen? How does the industry learn skills and technologies? Here, the author would like to arrange the fact findings according to the research questions and summarize them.

(1) How competitive is the Brazilian dies and molds industry internationally?

In 2017, the GCI value for molds was -0.56, -0.57 for dies, and -0.56 in total. Respectively, the international competitiveness of Brazilian dies and molds are weak at present based on classifications shown in Table 1. The international competitiveness of Brazilian dies and molds dramatically dropped in the latter half of the 2000s. In 2012, the GCI value for molds was -0.75, -0.86 for dies, and -0.79 in total. At that time, Brazilian international competitiveness for the industry dropped to much weaker position. However, recently, though GCI values have stayed in a weak position, they have gradually increased, showing signs of recovery.

Table 1. International Competitiveness of each GCI value

Value of GCI	International competitiveness	Situation of imports / exports
Over 0.75	Very Strong	Most of the applicable items are for exports, and there are very few imports.
0.50 ～ 0.74	Strong	Many of the applicable items are for exports, and there are few imports.
0.10 ～ 0.49	Slightly Strong	There are comparatively more exports.
-0.09～ 0.09	Moderate	Exports and imports are almost the same.

-0.10 ～ -0.49	Slightly Weak	There are comparatively more imports.
-0.50 ～ -0.74	Weak	Many of the applicable items are imports, and there are few exports.
Below -0.75	Very Weak	Most of the applicable items are imports, and there are very few exports.

Author

(2) How does the Brazilian dies and molds fit into the global dies and molds value chain?

The results of the trade statistical analysis of the global value chain for Brazilian dies and molds demand and supply show that Brazilian dies and molds are in a state of excessive supply. In 2017, the trade balance for Brazilian molds was -149.4 million USD and for dies it was -123.5 million UDS, a total of -272.9 million USD. This means the Brazilian dies and molds industry cannot meet the supply needs of the domestic demand. However, recently the trade deficit for dies and molds reduced from -489.5 million USD in 2012.

In 2017, mold imports to Brazil were 207.9 million USD, die imports were 170.4 million USD, and totaled 378.3 million USD. The major supplier countries of molds in 2017 included China, Japan, Korea, Canada, France, the USA, and Germany. In the case of dies, the major supplier countries included Japan, China, Korea, Spain, Italy, the USA, and Germany. Until the early half of the 2000s, the major supplier countries to Brazil were developed countries such as the EU, Japan, and the USA. After the latter half of the 2000s, imports from China and Korea rapidly increased.

In 2017, mold exports from Brazil were 58.5 million USD, die exports were 46.9 million USD, and the total exports were 105.3 million USD. The major countries importing Brazilian molds include Argentina, the USA, Mexico, and Columbia. In the case of dies, these countries include the USA, Mexico, and Argentina. Historically, the above situations have been almost the same. The USA and Mexico are deeply related to the Brazilian automobile industry. Argentina, a neighbor country, is also deeply related in terms of its automobile industry and has a trade incentive due to Mercosur.

(3) How do global automobile players evaluate Brazilian dies and molds?

In the automobile industry, three indicators are used to evaluate and decide upon suppliers. These three indicators are Quality, Cost, and Delivery (QCD). Consumers of Brazilian dies and molds have evaluated the industry as not satisfactory. Especially, price and delivery terms are considered inferior to their mother countries or China. Sometimes, they disapprove of the quality of the Brazilian industry. The high price of Brazilian dies and molds results from “Brazilian costs.” Domestic consumers consider the long delivery term and insufficient quality to be the result of old-fashioned

facilities, manufacturing design, and procedures.

(4) Where is the Brazilian dies and molds industry positioned in terms of the global development stages?

Table 2 shows each stage of progress for the dies and molds industry from the early Stage 1 to developed Stages 5 and 6. From the viewpoint of the supply and demand of dies and molds, by considering the extreme deficit of the dies and molds trade, the development stage of the Brazilian dies and molds industry seems to be positioned in "Stage 1."

On the other hand, there are many domestic dies and molds suppliers in Brazil. The technology level of many of the places where we visited, is the same as that of developed countries; fellow visitors to every factory agreed, one of whom was a predecessor of head of the procurement department of a global automobile manufacturer and another was an executive of a Japanese die manufacturer. Based on their professional evaluation, the development stage of Brazilian dies and molds industry is positioned in "Stage 5 or 6."

According to the case studies, the history of the Brazilian dies and molds industry may be as follows. In the 1950s to the 1970s, industrialization of Brazil was substantially started. At that time, there were no domestic suppliers of dies and molds in Brazil. Domestic dies and molds purchasers would import dies and molds and gradually started to make them in-house. At that time, the development stage was classified as "Stage 1." In the 1980s to 1990s, some of the dies and molds suppliers started their own businesses and began to supply dies and molds to industrial consumers. At that time, it was classified as "Stage 2 to 3." In the 2000s, the demand for dies and molds rapidly increased with the economic boom from the "BRICS" association. On the other hand, the facilities of domestic dies and molds suppliers gradually became old because of issues such as high import duties or high interest rates for buying new machine investments. Though a dies and molds industry existed in Brazil, its competitiveness becomes inferior on the world standard in global age. Thus, as domestic demand for dies and molds increases, the more imports increase. Accordingly, the development stage of the Brazilian dies and molds industry seem to be classified as "Stage 6" or the period of globalization.

Table 2. Standards for Classifying the Developmental Stages of the Dies and Molds Industry

Stage 1: Period of dependence on dies and molds imports	● Global level players are unable to procure dies and molds locally. ● They rely on imports from abroad or produce in-house. ● Even if there are locally-owned companies that produce molds and dies, their products do not meet the standards required by global level players.
Stage 2: Period of dependence on local foreign-affiliated companies	● Global level players are able to procure molds and dies locally due to the entry of foreign companies as well as capital and technical tie-ups. ● The technological level of locally-owned dies and molds companies may gradually improve, global level players may start to procure from them and/or foster their technological level.
Stage 3: Period of segmentation	● Global level players can procure many of their dies and molds locally. ● Dies and molds suppliers consist of a combination of overseas suppliers, local foreign-owned dies and molds suppliers, and locally-owned dies and molds suppliers. ● Procurement of medium- to high-quality dies and molds is from overseas countries, local foreign-owned dies and molds suppliers or are produced in-house by global level players. ● Low- to medium-quality dies and molds are available from locally-owned dies and molds suppliers.
Stage 4: Period of emergence of locally-owned suppliers of high-quality dies and molds	● Certain number of local companies can produce medium- to high-quality dies and molds. ● Development of the local dies and molds industry is becoming evident, and superior local dies and molds makers are emerging. ● Although the level of some superior local dies and molds makers may sometimes nearly reach the technological level of developed countries, the number of these producers is small. ● In many cases, there will still be a technological difference between many locally owned dies and molds suppliers and foreign-affiliated suppliers.
Stage 5: Period of maturity	● Dies and molds of all types from low to high quality are in a general competitive environment in that country's dies and molds market irrespective of whether the dies and molds are sourced from locally-owned dies and molds suppliers, local foreign-affiliated dies and molds suppliers, or imports. ● Locally-owned dies and molds suppliers have reached the stage where they hold an influential position in the market. ● Global level players no longer need to depend on imports and foreign-affiliated suppliers.
Stage 6: Period of globalization	● Imports of dies and molds increase again, and exports decrease. ● This is caused by the globalization of production, R&D, and procurement sites among dies and molds users and suppliers, or increased outsourcing of dies and molds due to the need to reduce costs.

Author

(5) Does Brazil have strong dies and molds clusters such as in advanced countries?

According to interviews, there are some dies and molds clusters in Brazil, such as in the ABC districts of Sao Paulo, Joinville, and Porto Alegre.

Joinville is said to be the biggest dies and molds industrial cluster in Brazil. There are around 350 dies and molds manufacturers in Joinville. According the discussion with the chairman of ABINFER[ix] (Association of the Brazilian dies and molds industry), 30 companies employ over 30 employees, 100 companies have hired between 20 to 30 employees, and 220 companies have hired under 20 people. On a technological level, six companies are classified as top level, 22 companies are medium-high level, 120 companies are medium-low level, and 200 companies are low level.

(6) How is the Brazilian dies and molds industry positioned in terms of the level of its technologies and skill of its engineers and craftsmen?

The author visited some of top-level companies and some of medium-high-level companies in Joinville with the professionals mentioned before. We find their technology levels and facilities to be the same level as in Japan. On the other hand, prices are higher than in Japan and delivery terms are longer than in Japan.

(7) How does the industry learn skills and technologies?

Joinville is a German-Brazilian industrial town. Basic industrial technologies were brought from Germany through immigration. The immigrant network in Joinville and with Germany is still in place. The owners of the companies visited learned basic skills and technologies as employees in dies and molds user or supplier companies. There are two main core companies in Joinville that are growing dies and molds technologies. One is Tigre; the other is Multibras. There also many dies and molds manufacturers in Joinville. Some of them are spin-off companies that have started their own businesses. They continue to learn skills and technologies in daily transactions and manufacturing. When they need the latest technologies, they go to Germany to learn them. Some are visit German factories by using the above mentioned network, and some go to universities or research institutes in Germany.

8. Conclusion

The author conducted field studies and a statistical analysis of the supply and demand of Brazilian dies and molds, in order to ascertain the current status and issues pertaining to the existing industrial cluster of dies and molds and extent of available technical expertise. It was found that there were some industrial clusters with good technological basis in Brazil, such as Joinville; however, in the international value chain of supply and demand status of Brazilian dies and molds, it was a case of excess demand and insufficient supply which is evidently an unbalanced situation. This has resulted in excessive import of dies and molds. There exists a good domestic dies and molds industry, but Brazilian users of dies and molds did not procure the domestic dies and molds.

The author found that there was a good technical basis of metal processing and dies and molds making in Joinville with production of good precision products. There were two main core manufacturers who had built the dies and molds industry. The German immigration network played an important role in introducing and transferring the technology.

On visiting some of the users of dies and molds, the author found that they were

aware of the existence of domestic dies and mold industrial clusters with good technologies. Even so, they chose to use imported dies and molds and avoided usage of domestic ones in contradiction to their highly rated evaluation of them. There are two major reasons for this: one is the high price, and the other is the long delivery terms. These were the causes for the contradictory situation of supply and demand of Brazilian dies and molds.

The factors causing this high price and long delivery terms are summarized as follows: one is the so-called "Brazilian costs", and the other is a deterioration of facilities and technologies. These two factors have also caused the issue of a degradation of quality. Dies and molds made by old fashioned facilities and methods do not measure up to the required quality index of customers. Sometimes, imposing an unreasonable cost reduction, may also cause quality issues in user's factories.

In order to supply good dies and molds suited to a customer's high standards in this advanced industrial technology age, many issues need to be tackled: the quality and effectiveness of processing should be enhanced simultaneously, while the delivery terms and cost should be reduced. These seem difficult issues to be solved all at once, but they are being adopted successfully by many advanced countries such as Japan. It is possible to overcome the problems by introducing new machines embodied many experiences, improving the way of design and working process. There exists a sound education system in Brazil that can produce many capable engineers and this may prove to be an advantage. Indeed, they have begun addressing these issues in Joinville.

In order to introduce new technologies and reduce delivery terms and cost, governmental support is also important. It is desirable to reduce import taxes on the latest metal processing and stamping machines, and measuring apparatus. Offering prime interest as an incentive for new investment is also thought to be a good support.

Dies and molds are essential components of new design and manufacture of value added industrial products. Among the many emerging industrial countries trying to develop the dies and molds industry from the start, Brazil has a good advantage as there already exists a good technical basis for making high precision dies and molds. This is very important considering future development and enhancement of Brazilian industrial products in the international competitive market. On the other hand, it faces the risk of decline and loss of an existing domestic dies and molds industry by losing out to a global mega competitive age. Brazil can break out of this underlying crisis by industry-government-academic collaboration.

(Acknowledgements: All the companies and organizations that allowed us to visit. This research was supported by JSPS KAKENHI 26301024, 18K01768)

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