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THE INFLUENCE OF NEW TECHNOLOGY IN THE RELATIONAL STRUCTURE OF JAPANESE AUTOMOTIVE INDUSTRY

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1 INTRODUCTION

When we talk about autonomous cars, we cannot account the enormous amount of changes that must overcome with the Schumpeterian “creative destruction” induced by a “disruptive” platform. We believe in certain kind of innovation, because goes from vehicles driven by people to partially driven by people or completely autonomous, or from internal combustion engine to hybrid combustion-electrical or complete electrical. Perhaps from the labor perspective certain classes of workers will categorize this change as “creative destruction”, other classes could categorize it as “creative construction”. We are not searching for that dichotomy.

Apart from technical and social changes needed for the transformation, we have also to pay attention that the organization level is only part of a game. What the organizations do individually are part of the change, but this game will also be disputed in the field level (FLIGSTEIN e MCADAM, 2012). On the field level, we will find a multiplexed network composed by ties of interests and self-preservation. At the interplay of these multiplexed ties, the induction of an innovative platform will happen. Then, this platform will not be a pure conception in any sense, but socially skilled actors will mediate the conception among other actors. Which makes this change away more complex than a simple matter of technology change. Them, what is this platform, a real “disruptive” or some sort of evolution? In addition, how the actors arrangement affect and are affected by this change?

The purpose of this paper is to analyze the influence of new technologies in the relational structure of automotive fields. We are using a construction of Strong Connected Component as proxy of an action field. To accomplish our objective we used two SCC analytical corpus, (1) the Production field, (2) the R&D field and (3) semantic analysis of Toyota, Google and Apple patents with data from 1995 to 2016. The longitudinal approach is important to identify changes and its nature at strategic action field. We identified changes through the identification of global metrics inflection and alternations. The global metrics chosen was the reciprocated relations ratio, network modularity and network density. Regarding the nature of change, we used the power position of intermediation through the nodal metric of betweeness and the number of patents cross tabulated with automakers and technology.

2 THEORETICAL REVIEW

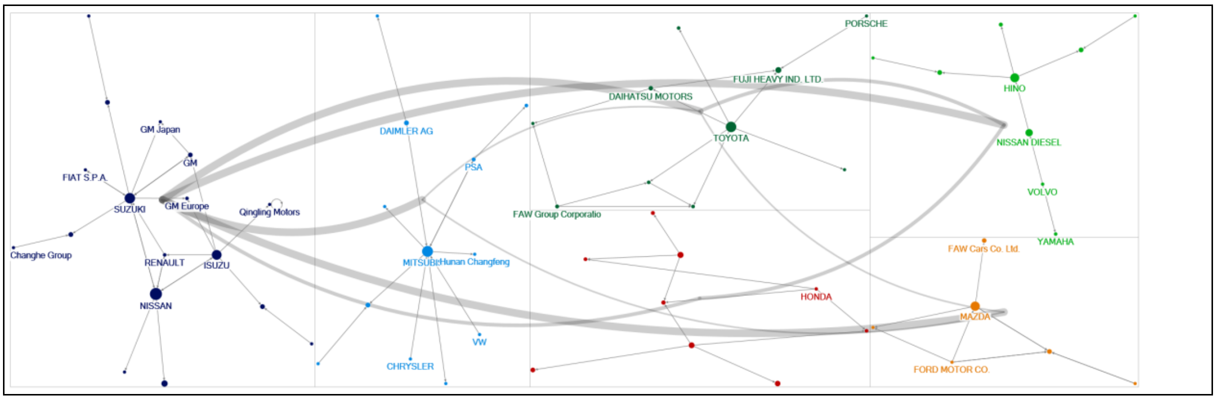
The theoretical lenses considered to the results interpretation is the field theory from the perspective of Fligstein e McAdam (2012) and Bourdieu (2011). Both theories have differences in their construction, the assumptions of action is one of them. But we see complementarities in certain perspectives.

The action conceived by Fligstein e McAdam (2012) is constructed over the idea of skilled social actor. This category of actor is that actor that can compose a coalition among other actors from the field. Going in this way, the skilled social actor can take simbolic and material advantages from the field. In the center of this ideia is the field conception as a political system, because the skilled social actor will keep the cooperation among coalitions until it can grant value rewards to its members (FLIGSTEIN e MCADAM, 2012, p. 110). The actors of a field interact in the basis of a comom undestand about the purposes of the field. For these authors the sense of keepeing the field stabilized is the logic that drives the action. Then, compete is also coupled with cooperation. In this sense, the groups formation is by-product of the strategic action field.

The action from Bourdieu (2011) perspective is based on habitus, which is an individual set of perceptions cattegories. The actor, when facing objective structures, re-act according its categories of perception. The field from Bourdieu (2011) perspective is a power structure based on types of capital and its accumulation. In certain way habitus and field are unconected, unless when structural positions are incorporated on the actor's perceptions cattegories. The domination of a field is related to the hability to leverage more capitals then others. Minimally, the possession of capitals is the reference for the dominance in a field. Then, the instrumental way to understand the domination on the field is to undestand the possession of capitals. The capitals according to Bourdieu (2011) are mainly four: economic capital – refers to monetary accumulation; cultural capital – which referes to a objectified knowledge; social capital – is the stable social relations; and symbolic capital – is a structural position that becomes a category of perception. The conception of capitals has an circular interplay, for instance the cultural capital can be converted into social capital, as well as economic capital can grant access to cultural and social capital. This interplay, in time because it's a cognitive base, suports the formation of simbolic capital which is any of other capital incorporated as perception category (BOURDIEU, 2011, p. 150).

This concept of field structuration throught capitals acumulation is not present in the field conception of Fligstein e McAdam (2012), but it's complementary when we express a field as Strong Connected Component - SCC (VARIANO, MCCOY e LIPSON, 2004). Our perspective with this articulation refers to the conception of SCC, even being a network corpus strongly connected, it is divided into groups. Exactly this internal groups composition is what confers to the SCC establity. Then, an SCC can be seen as a field according to Fligstein e McAdam (2012). From the network composition is possible to extract nodal metrics which diferentiate actors and allow a researcher to mesure social capital. From Ravasz e Barabási (2003), groups "are the consequence of a hierarchical organization, implying that small groups of nodes organize in a hierarchical manner into increasingly large groups", which is also in line with the constitution of estability in a strategic action field.

Figure 1 – Example of SCC and its groups division (by color) in the Japanese Automakers Production Field in 2008.



Note: Bold lines are combined ties connecting groups.
Source: Prepared by the authors

At this time is important to state that in our understand an SCC is a proxy for a field if it is representative not only by the presence of a relation. We have to pay attentio to the fact that the relation shall represent certain kind of durable institutional relation. For this research we selected contracts for automobil production and manufacturing, and/or contracts that represents interorganizational dependence. To this SCC construction we named the Japanese Production Field. The second SCC we considered as tie formation the co-assignment of patents. This SCC constructs the Global Research & Development Field. Our interest was to represent, with the Japanese Production Field, the political system and with the Global Research & Development Field an objectified knowledge system. With this systems we can represent the political and intellectual assets that the actors possesses and at the same time evaluate the circular capital exchange among social and cultural, so far.

2.1 Network Metrics

A social netwok analysis (SNA) as a method that enphasizes entities, relations and the structure formed. The principle is to identify a social structure as “regularities in the patterns of relations among concrete entities; it is not a harmony among abstract norms and values or a classification of concrete entities by their attributes. [A network is an] aggregate [of] these regularities in a fashion consistent with their inherent nature” (WHITE, BOORMAN e BREIGER, 1976, p. 733s).

The method identify regularities in the patterns through matrix metrics, and the metrics (HANSEN, SHNEIDERMAN e SMITH, 2010) considered in this study are:

(1) the number of automotive entities, which are the nodes;

(2) the number of relations or ties;

(3) a connected component is a set of vertices that are connected to each other but not to the rest of the graph – Figure 2;

(4) Maximum Nodes in a Connected Component is the number of vertices in the connected component that has the most nodes;

(5) Maximum Ties in a Connected Component The number of ties in the connected component that has the most edges;

(6) Maximum Geodesic Distance (Diameter) is the maximum geodesic distance among all nodes pairs, where geodesic distance is the distance between two nodes along the shortest path between them;

(7) Average Geodesic Distance is the average distance among all nodes pairs, where geodesic distance is the distance between two nodes along the shortest path between them;

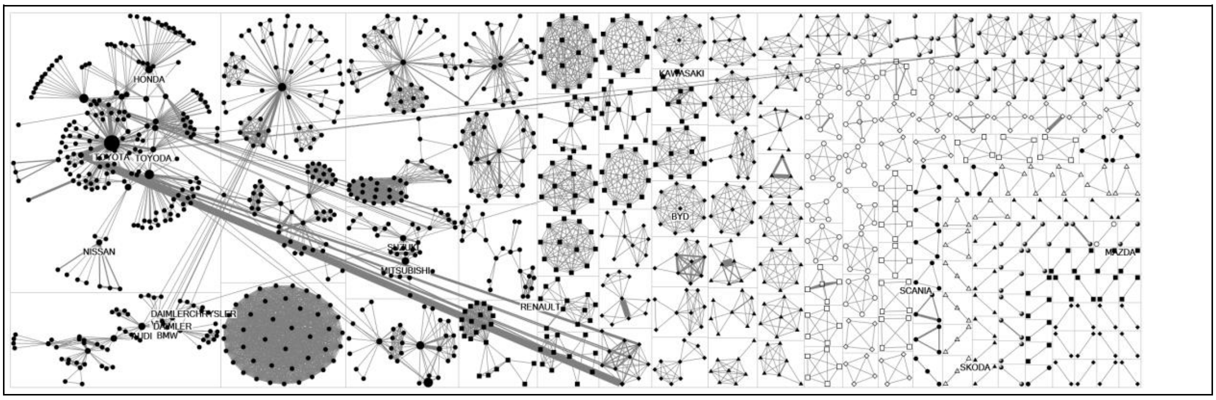
(8) Reciprocated Nodes Pair Ratio In a directed graph, this is the number of nodes pairs that have ties in both directions divided by the number of nodes pairs that are connected by any tie;

(9) Reciprocated Ties Ratio In a directed graph, this is the number of ties that are reciprocated divided by the total number of ties;

(10) Graph Density is a ratio that compares the number of ties in the graph with the maximum number of ties the graph would have if all the nodes were connected to each other;

(11) Modularity – when the graph has groups, this is a measure of the "quality" of the grouping. Graphs with high modularity have dense connections among the vertices within the same group but sparse connections among vertices in different groups.

Figure 2 - Example of connected components among patents assignees in 2008.



Source: Prepared by the authors

The last, and probably the most important metric considered in this research is the betweeness centrality. “The Betweeness concept of centrality concerns how other actors control or mediate the relations between nodes pair that are not directly connected. Actor betweeness centrality mesueres the extent to which other actors lie on the geodesic path (shortest distance) between pairs of actors in the network” (KNOKE e YANG, 2008, p. 67).

2.2 Innovation typology

In order to support our analysis of a R&D field we have decided to adopt the innovation typology of Shuen e Sieber (2009). This typology crosses old and new technologies with old and new markets. In this typology disruptive innovation is new technology in old market; incremental innovation is old technology in old markets; radical innovation is new technology in new or emerging markets; and architectural innovation are old technologies in new markets. For this typology the classification of the environment, or field, depends on the position of the actors. Automotive actors will stand on the field stability side, and design all the barriers to eliminate threats keeping the innovation in incremental or architectural compass of their competence enhancing. If the actor is an automotive outsider (like ICT actors), its action could be to introduce disruptive or radical innovation. The outsider actor’s main strategy is field’s competence destruction. However, for Shuen e Sieber (2009) this kind of competition is zero-sum at the best for incumbents and outsiders. Then, the authors proposes that the non zero-sum an the idea that compete is also coupled with cooperation. Then, the most profitable choice should be recombinant inovation platform.

Nevertheless the dinamic capabilities has some terminology resemblance with strategic action field from Fligstein e McAdam (2012). Both theories lies on strategy, but minimally they are not compatible on the analysis level. So, in this research we are considering only the innovation typlogy to suport our interpretation of the finds.

3 METHOD

We considered two major longitudinal data sources covering the period from 1995 to 2016; (1) the annual report from JAMA- 1998 to 2016; and (2) the Derwent World Patents Index – 1995 to 2016, which includes data about intellectual property of automakers. We have found about 1,300 contractual ties among JAMA automakers, and also involving the same set of automakers, we mapped circa 7211 tetradic patent applications related to the B60 categories of automobile that covers the complete set of automobile technologies.

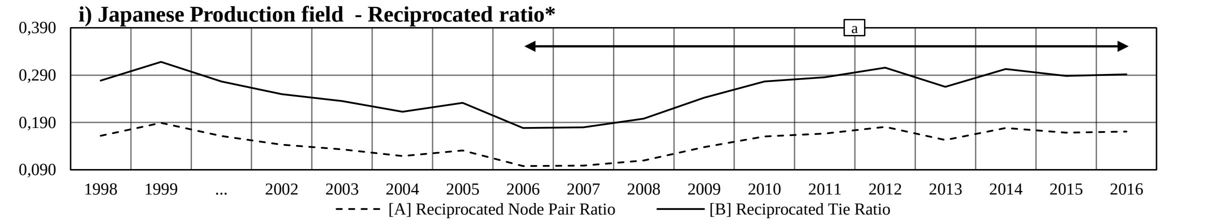
We built the networks[i] through the contractual ties to form the corpus for Production Field, and to form de R&D Field we have constructed through the automakers as signatories of patents.

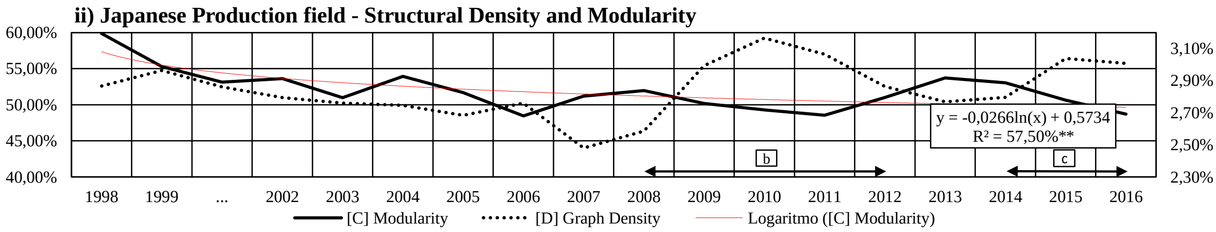
The tetradic patent is the set of patent, which has priority in the four (4) main regions/countries – Japan, USA, Europe and China. The complete set of patents from 1995 to 2016 for the B60 CPC class is above 150K patents worldwide. Those, the most cited (46K patents) filtered by tetradic occurrence gave us 7211 registrations we believe is the technology coupled with production. With this two analytical corpus, we adopted a descriptive form of the strategic action in both fields.

4 DISCUSSION

4.1 The Japanese Production Field

Infographic 1 - Historical data of Japanese automaker’s contractual relations.





(iii) Graph Metric	1998	1999	...	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Nodes	53	55	55	54	56	59	60	61	64	63	58	55	55	59	60	60	57	57
Ties	78	85	81	75	78	92	90	93	94	98	97	92	87	93	95	94	92	91
[A]	0,16	0,19	0,16	0,14	0,13	0,12	0,13	0,10	0,10	0,11	0,14	0,16	0,17	0,18	0,15	0,18	0,17	0,17
[B]	0,28	0,32	0,28	0,25	0,24	0,21	0,23	0,18	0,18	0,20	0,24	0,28	0,29	0,31	0,27	0,30	0,29	0,29
Connected Component	3	2	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1
Nodes at SCC	46	53	54	54	56	59	60	61	64	63	58	55	53	59	60	60	57	57
Geodesic Distance	3,67	3,77	3,68	3,64	3,59	3,56	3,56	3,36	3,51	3,52	3,46	3,48	3,38	3,47	3,47	3,49	3,38	3,43
[C]	59,9%	55,3%	53,1%	53,6%	51,0%	53,9%	51,7%	48,4%	51,2%	52,0%	50,2%	49,3%	48,6%	51,0%	53,7%	53,0%	50,6%	48,7%
[D]	2,9%	3,0%	2,9%	2,8%	2,8%	2,7%	2,7%	2,8%	2,5%	2,6%	3,0%	3,2%	3,1%	2,9%	2,8%	2,8%	3,0%	3,0%

Note: (i) Structural Density and Modularity - , (ii) Reciprocated relations, and (iii) metric table
Source: Prepared by the authors

We designed the Infographic 1 to demonstrate the temporal crosstab metrics of the Japanese production field. The crosstab data is on the Infographic 1.iii. However, we are looking for inflections and alternations, and then the crosstab data is not efficient to show us the variations we are looking for. For this reason, we prepared the graphs on the Infographic 1.i – reciprocated relations and Infographic 1.ii – the pair, network modularity and density. Inflections and alternations on this model means field’s changes.

About the Infographic 1.i, in this graphic we can see the evolution of reciprocated relations through the node pair and ties’ ratio. What we see is the progressive reduction of reciprocals relations from 1998 to 2006, and from 2007 to 2016 – at the “a” box – a progressive establishment of new reciprocal relations. These relations have been intensifying since 2007, establishing a strong connected component (SCC) uniting groups hierarchically (Ravasz and Barabási, 2003) in the field. Mainly intermediated by Toyota and Nissan. Toyota by the way is the main responsible for the inflection described in the box “a” – 2007 to 2016. This demonstrates that the relational extent of actors might be associated to strategies to create a new model of robustness and stability in the field, and explains the formation of the SCC and the field stability trend.

The Infographic 1.ii is the automobile production field expressed by the global metrics of network modularity (Q) and density (D). The main aspect shown by the contrast of this two metrics is the dynamic of the field. Each oscillation of these metrics is connect to a complex set of exogenous and/or endogenous changes. However, we can identify a structured transformation on the field. We can see this in the logarithmic curve. The evolution of the modularity (Q) from 1998 to 2016 shows a trend of stabilization in a Strong Connected Component (SCC). The years 1998 and 1999 shows a graph organized into 3 and 2 components respectively. From 2002 to 2016 the data shows a single component . Other important aspect is in the Infographic 1.iii, where we can see at the line of Nodes at SCC another evidence, a progressive number of automakers connected to the SCC.

We can describe the field dynamic by the combined view of Infographic 1.i and ii. The main responsible for the network modularity reduction from 1998 to 2006 is the systematic reduction of reciprocated relations on the same period. From 2007 to 2016, the main responsible for the asymptotic trend are (1) the systematic increase of reciprocated relations and (2) hierarchization of the network around two main actors (Ravasz and Barabási, 2003). Hierarchical group formation in a SCC are evidence of the strategic action of the automakers to stabilize the Japanese production field.

Table 1 - Japanese automaker's contractual Betweeness.

Betweeness AUTOMAKER	1998	1999	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
TOYOTA	88	562	1161	1286	1040	1017	834	1080	952	930	903	961	1302	1365	1427	1216	1199
NISSAN	531	907	1137	988	1059	1238	872	1062	1285	1040	988	754	1065	987	1084	892	871
ISUZU	825	1110	736	934	1057	734	1008	1055	822	662	648	550	872	1055	946	967	968
SUZUKI	272	541	750	693	713	881	904	1102	950	816	807	720	795	919	762	611	520
MAZDA	336	545	789	861	1087	830	794	881	736	594	558	619	716	731	963	776	818
MITSUBISHI	494	482	414	432	662	787	802	1061	1046	563	368	268	304	315	295	276	283
HINO	0	0	304	316	224	448	507	502	685	538	444	491	588	617	579	454	454
FUJI	496	520	377	386	313	324	327	210	244	215	207	172	251	259	245	211	195
HONDA	376	588	204	297	235	223	243	254	12	25	36	19	24	24	29	167	168
UD TRUCKS											391	303	418	445	292	291	292
NISSAN DIESEL	174	164	113	106	156	159	164	183	425	555							
RENAULT		0	0	0	0	0	32	29	25	13	0	0	19	15	116	110	110
GM	288	801	160	164	122	473	433	454	107	75	42	120	114	116	116	325	326
DAIHATSU	10	394	206	318	358	29	75	70	94	89	0	0	0	0	0	0	0
PSA			350	355	167	113	42	51	45	34	33	10	28	33	117	106	105
FAW GROUP	0	0	2	2	359	348	77	113	53	50	28	8	8	8	8	8	24
FAW CARS							58	69	99	70	55	40	52	43	53	48	66
FORD	22	22	0	0	111	114	40	2	2	2	2	2	59	55	2	0	0
DAIMLER								124	122	0	0	0	114	1	2	8	8
CHRYSLER	120								0	0	0						
FCA																	13
FIAT	66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
DAIMLERCHRYSLER		253	104	0	0	116	118	0									
BMW AG													0	0	0	0	0
CHANGHE GROUP			0	0	0	0	0	0	0	0	0	0	0	0	0		
PORSCHE AG	0	0			0	0	0	0	0	0	0	0	0	0	0	0	0
QINGLING	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TESLA												0	0	0	0	0	0
VOLKSWAGEN AG	0	0				0	0	0	0	0	0	0					

Note: Betweenes presented as conditional format of color (from light grey to dark grey). This is presented with a conditional format of color – no color means no intermediary position, light grey means low intermediary position and dark grey means strong intermediary position in the network.
Source: Prepared by the authors

The respectively. From 2002 to 2016 the data shows a single component . Other important aspect is in the Infographic 1.iii, where we can see at the line of Nodes at SCC another evidence, a progressive number of automakers connected to the SCC.

We can describe the field dynamic by the combined view of Infographic 1.i and ii. The main responsible for the network modularity reduction from 1998 to 2006 is the systematic reduction of reciprocated relations on the same period. From 2007 to 2016, the main responsible for the asymptotic trend are (1) the systematic increase of reciprocated relations and (2) hierarchization of the network around two main actors (Ravasz and Barabási, 2003). Hierarchical group formation in a SCC are evidence of the strategic action of the automakers to stabilize the Japanese production field.

Table 1 above, we have the automaker's metric of Betweeness. The cells empty means absence of Betweeness means that actor has no strategic action based on intermediation (Betweeness). In the cells where we see zero (0), Betweeness means the strategy of intermediation enclosed inside a small group or in the edge of a group. It is not a strategy of being an intermediary of groups. In the cells, where we can see a dark grey we will see the most important intermediaries in the field. A high Betweeness means that the actor uses the strategy of being a coalition point. The most important players in this position are Toyota and Nissan.

At this point is important to mention that this is from the perspective of Japanese automakers. Since we elaborated the construction of production field from Japanese automakers contracts. Then we can say that the intermediation (Betweeness) of groups is an important strategic action in the Japanese production field.

In this sense, a player in the Japanese Action field should position itself in the production field as intermediary, or be reciprocally connected to an important Japanese player. The respectively. From 2002 to 2016 the data shows a single component . Other important aspect is in the Infographic 1.iii, where we can see at the line of Nodes at SCC another evidence, a progressive number of automakers connected to the SCC.

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Table 1 shows the list of actors, which in certain moment presented itself as intermediaries.

It is important to remark what we cannot see on this list. We cannot see the presence of any information and communication technology (ICT) actor. The absence of ICT actor until 2016 shows an important aspect, there is no game yet.

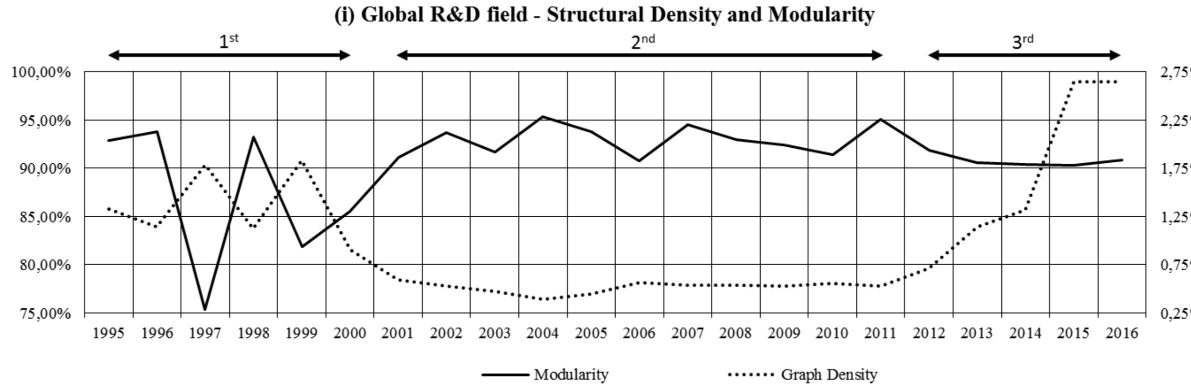
The Global R&D Field

As already mentioned at the METHOD section, we have gathered R&D data from tetradic patent from 1995 to 2016. Means that we selected from the entire set of patent assigned on Japan, USA, China and Europe, totalizing 7211 patents that represents 60-70% of the tetradic patent population, around 20 years of IP protection. This could not be different for an analysis of the Japanese automakers field. The field of Japanese automakers is multinational and strongly oriented to exportation. This shows that the patents represents a field per see. Then the R&D is a field, as we will see on the data.

We designed the Infographic 2 to demonstrate the temporal crosstab metrics of the Japanese R&D field. The crosstab data is on the Infographic 2.ii. However, we are looking for alternations, and again the crosstab data is not efficient to show us the alternations we are looking for. For that we prepared the graphs on the Infographic 2.i – the pair, network modularity and density. Inflections and alternations on this model means field's changes.

On the Infographic 2.i we have a network formation based on the cooperative ties among the patent assignees. In the beginning of this project, we were expecting to treat the data only via descriptive statistics. According to our expectation, the IP could not be cooperative. However, we were wrong. Through the community of individual assignees, which has also the inventors, we could find a global R&D network. The Infographic 2.i shows R&D field dynamic.

Infographic 2 - Historical data of Japanese automaker's R&D relations



(ii) Graph Metric	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Nodes	293	311	447	388	484	936	1209	1333	1594	1515	1487	1381	1317	1354	1394	1335	1295	1118	804	726	384	320
Unique Ties	568	552	1782	848	2145	3944	4346	4731	6035	4496	4949	5425	4661	4911	5163	4915	4449	4457	3691	3479	1950	1351
Connected Components	79	84	96	86	80	115	132	145	178	195	194	172	167	162	162	161	160	140	109	99	53	46
Max Nodes in a SCC	16	22	42	32	42	309	362	456	479	315	305	486	386	269	480	471	241	297	115	69	37	33
Max Ties in at the SCC	120	102	861	170	861	1264	1363	1438	1757	1116	1040	3049	1722	909	1740	1652	933	1192	1158	1161	378	315
Max Geodesic Distance (Diameter)	2	4	3	4	3	10	8	12	9	9	7	14	11	8	14	15	9	10	7	4	4	3
Average Geodesic Distance	0,91	1,11	1,04	1,27	1,20	4,62	4,09	5,36	3,95	3,60	3,53	5,91	4,39	3,17	5,84	5,66	3,33	4,32	2,39	1,65	1,21	1,17
Graph Density	1,3%	1,1%	1,8%	1,1%	1,8%	0,9%	0,6%	0,5%	0,5%	0,4%	0,4%	0,6%	0,5%	0,5%	0,5%	0,6%	0,5%	0,7%	1,1%	1,3%	2,7%	2,6%
Modularity	93%	94%	75%	93%	82%	86%	91%	94%	92%	95%	94%	91%	95%	93%	92%	91%	95%	92%	91%	90%	90%	91%

Note: (i) Structural Density and Modularity - , (ii) Overall graph metrics
Source: Prepared by the authors

4.1.1 Three distinct moments

The field of Global Automotive R&D shows three (3) distinct moments, and it can be seeing on the Infographic 1.i:

- (1st) is the period of 1995 to 2000 where the alternation of Q and D demonstrate a significant instability, which we can see through the oscillation of network modularity and density. This happened by the dynamic formation and dissolution of R&D groups. What is curious is the direct relation among automakers in this period.
- The second period (2nd) goes from 2001 to 2011, this period represents a long and stable time. The main observable characteristic is the absence of alternations. Seem us a field protected to the exogenous oscillation, especially when happened strong exogenous shock like financial depression of 2008. No alternation happened as we observed on the Production Field – Infographic 1. This caught our attention because no action field stability or instability is unconnected to the bureaucratic field (FLIGSTEIN e MCADAM, 2012, p. 71). In this period from 2001 to 2011 shows such stability that will be no possible without a close cooperation with the governments.
- Finally, we have the third (3rd) period from 2012 to 2016 when started a structured reduction on the R&D activity.

4.1.2 Strategic action of intermediation

Along the period of this research, is described an important aspect of the R&D field by the lines Connected Components and Max Vertices in a Connected Component in the Infographic 2.ii. We see that exist an annually high number of connected components. This means that there is great amount of standalone groups. Just to remember, a connected component is a component without connections out of the group. By contrast, on the line Max Nodes in a Connected Component we can see that exist at least one group, which congregate 20-30% of the total nodes per year. In this sense, we have a Strong Connected Component (SCC). Again, from inside the group or even among groups, the most central position is the actor with the higher Betweeness (intermediation). This shows that the intermediation of technological capital is an important strategic action in the Japanese R&D field.

We can see this point in the Table 2 and Table 3, comparing both tables, we see a correlation between the position of being intermediary and the number of patents is assigned to an automaker. This also means that the way the players of this field has to convert the social capital into cultural capital is being part of the elite who acts as intermediary in the field. We are not saying that the players only need social capital, but we are seeing that the intermediation as social capital is an important strategy and interplays with technological and economic capitals, as written by Bourdieu (2001).

4.1.3 Global essence of the field

At this point is important to remark that, the R&D field here is not restricted to the Japanese automakers. The R&D field described here is global. When the reader see in the Table 2 below, a predominance of Japanese automakers, it means that in the R&D field the Japanese automakers are better positioned compared to American, European and Chinese automakers.

Table 2 - Automaker's Betweeness on the field of R&D

Betweeness AUTOMAKER	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
TOYOTA	20	117	67	74	252	13510	32084	72918	62582	29304	20730	56261	33126	25125	52969	56002	20107	33995	4267	680	98	0
TOYODA	0	6	6	0	21	1167	7121	12689	9447	3166	1066	976	6351	1557	635	16117	469	14	0			
HONDA		0	2	8		14239	18530	23457	14836	15089	9389	6	5667	4214	53199	48053	312	8823	0	182		0
SUZUKI					0	1709	10435	11808	6542	5788	9879	24957	26054	2071	51660	11787	8959	16103	2584	32	0	0
MITSUBISHI		0			0	54	0	17799	9274	1967	5615	1309	9466	4013	8662	2334	1421	1749	581		0	0
NISSAN						23296	6055	80	2027	1860	3203	1929	97	1846	7040	8837	67	5667	791		0	
FORD			0	0		0	0		0			33299	0		146	0	0	0				
VW				2	0	9	0		0	1401	83	32	3	1326	0	9064	0	0			0	
AUDI													2646	3564	15	0	400					
RENAULT								0						0	5166		31	0	0			
DAIMLER	3	0	12							0		0	0	741	80	699	84	2				
MAZDA										6	1524	66		0								
BMW					1				0	0		0		0	0	0	166					
GM	0	2	0	0	0	36				0	0	20	0		0	0						
TESLA													10		0							
ISUZU								1	0													
CHRYSLER			0	0	0	0						0			0							
DAIMLERCHRYSLER	10	5	12	7		9				0		0	0	3	80	699	0	2				
DAIHATSU					0		0	0				0										
FUJI						0	0		0	0					0	0						
HINO				0				0		0	0	0										
NISSAN DIESEL						0	0	0	0	0					0							
UD TRUCK										0					0	0	0		0			
VOLVO									0	0			0		0	0		0				

Source: Prepared by the authors

Table 3 – Automakers number of patents by year.

# Patents	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
TOYOTA	17	30	32	24	21	27	32	43	83	89	134	157	134	141	125	112	146	68	52	65	7	4
TOYODA	4	7	11	8	8	6	9	4	9	10	7	6	9	6	10	9	10	12	1			
NISSAN		1	1			12	11	26	44	47	41	44	40	41	45	41	48	24	20	3	1	1
HONDA	2	5	14	14	13	22	29	25	29	32	29	19	30	44	41	33	18	21	9	6	1	1
MITSUBISHI	2	3	4	1	6	6	1	6	8	8	7	15	27	18	25	27	12	9	9	2	1	3
MAZDA								4	7	11	17	15	11	4	5	2		1				
SUZUKI					1	3	5	4	5	6	7	7	5	3	2	7	12	11	3	3	1	1
VOLVO		2	1	1			1	1	3	3	5	6	5	7	7	4	8	2	1	3		
VW				5	4	2	2	2	3	7	5	3	3	3	1	3	3	1		2	1	
DAIMLERCHRYSLER	3	2	2	3	1	3				1		1	2	3	6	6	1	2				
RENAULT								1			1	2	2	4	7	6	12	3	6	4		
DAIMLER	2	1	2							1		1	2	4	6	6	2	2	3	1		

Note: The list of automakers inside the top 100 assignees.
Source: Prepared by the authors

Then, what we can see is a clear distinction between the Japanese automakers and the others automakers – American, European and Chinese –, and what differs them is the relational strategy based on intermediation (betweeness). This is a find in this research, which were not expected. Just to remember, the first was the network formation itself. In two different fields, the Japanese automakers reproduce the same relational model.

Final find, but not least, in this analysis is the total absence of Information and Communication Technology (ICT) actors as players in the field of production and in the field of R&D as an intermediary actor. Apparently, the ICT sector develops marginally in the field of automotive R&D.

4.2 ICT actors on Automotive R&D and Production fields

From the perspective of autonomous driving technology, ICT actors are newcomers in the automotive field. As newcomers, ICT actors are not central players in the Automotive Production or even in the R&D field. Here I am anchoring on the need to have a platform on which an innovation must be built. The symbolic capital of the ICT actors comes from internet action field. In this field ICT actors such as Google, Apple and Microsoft are perceived as powerful actors, this can lead the common sense to interpret them as powerful actors in any other field of action. However, what we can see in this analysis, especially on the R&D field, is that these actors play a marginal role. One salient aspect in the graphs is the absolute absence of Google in the collaboration matrices, as well as Apple and Microsoft. Nevertheless, they are assignees of automotive patents.

Table 4 – Top 20 automotive technical assignments.

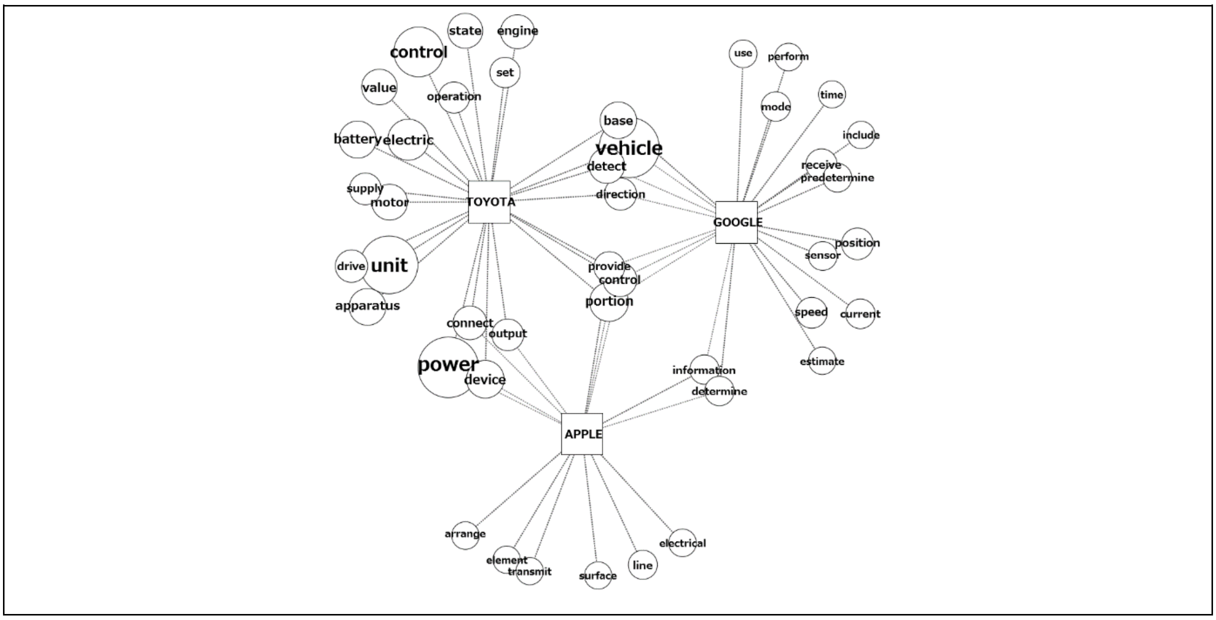
B60 CPC subclass - # patents		**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
B60L	Electric propulsion	10	20	15	16	23	29	51	62	73	100	138	129	156	168	187	191	89	65	38	8	4
B60K	**Electric power train in vehicles**	16	28	20	29	42	47	51	94	108	133	138	125	125	137	98	120	52	48	36	6	7
B60W	**Vehicle drive control systems**	0	1	2	7	15	13	23	39	62	103	135	102	118	98	82	112	47	39	52	8	3
B60R	**Hybrid vehicles**	20	18	18	18	31	38	61	128	113	130	116	109	103	82	98	87	72	45	36	6	4
H02J	Vehicle parts	2	5	3	4	7	4	10	10	6	17	51	48	59	70	79	112	52	31	12	4	1
H01M	Power generation fuel cells	1	4	5	7	12	6	17	18	12	34	53	50	61	80	100	81	50	26	2	4	4
G06F	Electrochemical storage	4	4	4	8	14	13	24	43	41	47	48	73	63	51	63	38	25	17	15	6	3
F02D	Electrical digital data processing	10	14	11	19	25	20	24	24	40	46	57	51	40	33	28	35	11	13	16	1	2
B62D	**Controlling combustion engines**	11	6	3	11	13	12	20	41	52	43	42	42	45	41	34	29	23	15	14	5	1
G08G	**Motor vehicles**	0	1	0	5	8	7	10	24	28	30	44	29	26	21	32	23	16	19	21	4	1
B60T	**Traffic control/monitoring Navigation**	11	8	4	6	16	11	16	28	30	35	32	38	31	21	33	22	12	16	12	1	2
F16H	Vehicle brake control systems	5	4	2	4	8	11	13	26	37	44	33	28	23	33	23	25	12	9	12	0	0
H02P	Transmissions	5	5	2	5	5	8	9	19	23	31	25	20	28	18	21	7	5	6	0	0	0
G05D	Control or regulation of electric motors	0	3	3	2	2	4	10	19	22	21	16	23	11	13	19	12	23	12	13	2	1
B60N	Passenger accommodation	0	0	1	0	1	3	4	9	11	21	22	23	24	11	13	15	7	7	1	1	0
B60G	Vehicle suspension arrangements	5	5	5	1	6	9	16	21	13	17	17	15	14	14	13	3	8	6	5	0	1
B60Q	**Arrangement of signaling**	8	13	10	0	5	3	0	12	22	13	16	9	9	9	5	3	10	2	7	0	0
G01C	**Measuring distances; Gyroscopic instruments**	2	4	2	3	3	8	7	19	29	32	25	19	24	18	14	16	8	10	9	2	0

Note: This cross table considers Google and Apple technological B60 subclass descriptors.
Source: Prepared by the authors

In the Table 4 above, we have an extraction of the subclass of assigned technology through the last 21 years of patents. This table represents the Top 20 automotive assignees plus Google and Apple. The lines in black are the technology where Google and Apple are present with tetradic patent[ii]. The automakers, especially Japanese, are in all the lines. Another important metric is that Google and Apple together represents 1,7% of the technical description. Toyota alone represents 40% of this extraction.

When we cross connect the technologies descriptors of Toyota, Google and Apple we can see that an subjective intermediation occurs in the technology ratio level. The Figure 3 below is a semantic evaluation of a technological narrative in the abstract of the patents. In fact at certain level Toyota, Google and Apple are interested in provide control, detect direction and be connected. However, besides this, each player is imprinting its own technological concept.

Figure 3 – Patents' abstract semantic[iii] analysis.



Note: This is based on the abstract of all patents from Google, Apple and Toyota. Toyota has circa 40% of the field's patents, while Google and Apple together has 1,7%.
Source: Prepared by the authors

The standalone words shows the distinctive direction of each one interest. For sure, the R&D needed to get a car done goes far to develop the accessories needed to make it autonomous or electric. At the same time, to transform the car in an open and innovative platform to connect it to an internet ecosystem, the ICT actors has different R&D effort. Looks that, we are in front of an architectural innovation. From both, automakers and ICT actors. This is architectural because the vehicle itself is being subject of competence recombination. The ICT actors and automakers are creating a point of competence integration. Therefore, this is not a disruptive, nor radical innovation from the auto industry perspective.

5 DISCUSSION AND FINAL REMARKS

Our objective was to analyze the influence of new technologies in the relational structure of automotive fields. The relational structures analyzed in this research showed us that hierarchical group formation in a SCC are evidence of the strategical action of the automakers to stabilize the Japanese production field (RAVASZ e BARABÁSI, 2003). In both fields, we can see different evidences of stabilization. In the Production field the stabilization is showed by the logarithmic trend line[iv]. We have to remember that the production field is predominantly influenced by market uncertainties. The R&D field shows stability for more than ten years. Perhaps this is a connection with Japanese government. We cannot be sure since this is one of our limitation. We do not have relational which connects R&D field to Japanese government. What we have is a piece of 90's decade where automakers are the main assignees of patents. This period was marked with high instability on the R&D field. Evaluate what makes the R&D field stable in 2000 decade is in our research lineup.

The intermediation (Betweeness) of groups is an important strategic action in the Japanese automotive field. Not only at the production field, but also at the R&D field. In addition, the intermediation as social capital is a strategy that interplays with technological capital – the cultural capital according Bourdieu (2011). This empirical evidence corroborates to the theory forms of capitals and its circular exchange.

Another important find in this research is a clear distinction between the Japanese automakers and the others automakers – American, European and Chinese –, the relational strategy based on intermediation (betweeness) distinguishes them. Looks that cooperation is not in the competition ratio for American, European and Chinese automakers. At least in the degree this happens with Japanese automakers.

Finally, if we look at the automotive industry as a whole, it is an "architectural innovation, [where] old technologies in new markets, recombining and repackaging existing technologies within redesigned system and product architectures to reach new markets segments and niches." (SHUEN e SIEBER, 2009, p. 131), whose end may be an innovation platform where "companies have innovated by providing platforms from which externally generated innovations can result, and where users as well as ecosystems of affiliates, third-party developers, and Service providers-can form innovative communities. " (SHUEN e SIEBER, 2009, p. 140).

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[i] With support of NodeXL (HANSEN, SHNEIDERMAN e SMITH, 2010)
[ii] Patent with IP protection in Japan, USA, Europe and China.
[iii] Made with use of KH Coder - http://khc.sourceforge.net/en/
[iv] Moderated correlation rate of 57,5%