Acquisition of MAKO Surgical Corp. by STRYKER Corp. Was it worth it?

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***Abstract*— In this report, we analyzed the acquisition of MAKO by Stryker in 2013 from different aspects. We analyze the patents of both companies in order to see any insight into the transfer of knowledge among these companies. The analysis of the patents based on their classification gave no clear insight, therefore we explored the inventors of MAKO and Stryker patents and the cross-citations of each patents. A financial analysis on STRYKER was conducted after the acquisition with focus on MAKO products.**

I. STRYKER Corp.

STRYKER Corporation is a Fortune 500 medical technologies firm based in Kalamazoo, Michigan. STRYKER was founded in 1941 and nowadays it is one of the pillar companies in the medical technology sector. Over the years STRYKER grew bigger and bigger, and in 1979 they went public. Since then the corporation has engaged in many acquisitions and has spread its roots in numerous different industries in the medical technology sector. Nowadays the corporation engages in the production of implants used in joint replacement and trauma surgeries; surgical equipment and surgical navigation systems; endoscopic and communications systems; patient handling and emergency medical equipment; neurosurgical, neurovascular and spinal devices; as well as other medical device products used in a variety of medical specialties [1]. Out of all the acquisitions made by STRYKER, the acquisition of MAKO Surgical Corp. by Styker Corp. in 2013 was quite an important step for STRYKER, as they were to gain MAKO's technology for robot-assisted orthopedic surgery.

II. MAKO Surgical Corp.

MAKO Surgical Corp. was a publicly traded medical device company based in Florida. The company was founded in 2004 and it engaged in the manufacturing of surgical robotic arm assistance platforms and orthopedic implants used by orthopedic surgeons for the use in partial knee and total hip arthroplasty. In 2011 the company was named the fastest growing technology company and it was well known for their intellectual property of devices and for having over 300 patents and patent applications.

III. Acquisition

On 2013, STRYKER acquired MAKO Surgical Corp. and its robotic-surgery platform. STRYKER paid $1.65B for this purchase which is a really high price for this company that was not even 10 years old. This operation was a huge move and gave them competitive advantage over their rivals. With this acquisition, STRYKER was clearly showing that it has ambitious plans for the future through the development and the diffusion of surgical robotics. So, this acquisition was a major milestone in STRYKER's history and its economic development but also its intellectual property strategy. The CEO of STRYKER, Kevin Lobo was quoted saying: "The acquisition of MAKO combined with STRYKER's strong history in joint reconstruction, capital equipment and surgical instruments will help further advance the growth of robotic assisted surgery".[3]

IV. Potential of MAKO Surgical Corp.

MAKO Surgical Corp is a high level company in terms of robotic surgical operation. By investing

substantial resources in research and development in this specialization, they have become the uncontested leaders of robotic surgery. The main product of MAKO Surgical is the Robotic Arm interactive Orthopedic Systems (RIO). This technology offers surgeons an interactive platform that incorporated a robotic surgical arm and a patient-specific visualization technology. The combination was designed to perform minimally invasive procedures that were more exact and repeatable. They did more than 23 000 MAKOplasty in 2012, an operation of the knee, with this technology. This allowed them to assert their technology and show their high potential.

V. Strategic Plans of STRYKER Corp.

Initially, STRYKER's stategy was to integrate MAKO robot in their product catalog. At the begining, it was clearly not an easy task because of the novelty of this product. Stuart Simpson, VP and GM of STRYKER Reconstructive Business, said: "Introducing a disruptive technology to an industry that has historically relied on incremental improvements to implants and procedures has had its challenges" [7]. So STRYKER created a strategy in 4 axis to increase their sales:

- Show the safety and success of MAKO, even if MAKO has already performed a large number of operations, surgical robot still have to prove their efficiency.
- Make the existing STRYKER orthopedic implants and peripherals available via MAKO, STRYKER has to adapt its existing products to MAKO.
- Add therapeutic solutions to the platform, STRYKER developed a new panel of operations using MAKO.
- Assist in the financing of the surgical system purchase.

This strategy allowed STRYKER to conquer the robotic surgery market. In 2017, STRYKER launched MAKO Total Knee and MAKO Total Hip, systems based on the MAKO technology. With these products, they realized more than 60 000 hip replacements and 80 000 knee replacements in 2018.

VI. Patent Strategy

We were interested to see if the patent filings of MAKO and STRYKER give us any insights into the acquisition and integration of MAKO's knowledge into STRYKER's business. Therefore we analyzed the citations of patents between these two companies and inventors of all the patents. In the following sections we present on overview of MAKO's and STRYKER's patents, followed by the analysis of cross-citations and analysis of the inventors. The script for the charts and numbers can be found on GitHub [8]. We used mainly the Google Patents Public Dataset in order to get all the relevant patents, including the classification and inventor list.

A. *MAKO*

One of the reason why MAKO was acquired was specifically for the rich patent portfolio of such a "small" company.

MAKO filed a total of 776 patents as of 2020. As you can see in Figure 1 the number of patents filed were constantly high with a jump in 2016. One explanation is the launch of MAKO *Total Knee operation* was added to the Robotic-Arm which started selling in 2017 [4] and possible securing the inventions covered it.

A breakdown of the patent filing by year and their IPC (International Patent Classification) gives us a better picture in which area MAKO was especially active. As you can see Figure 1, most of the patents were filled in the class 'Medical Or Veterinary Science', as it was to be expected, these consists of 623 patents. We do not see any clear change in classification of the patents after the acquisitions.

We further broke down the 'A61 category' (Medical or Veterinary Science; Hygiene) and analyzed the sub classification. Figure 3 shows the 623 patents by their sub categories. The dominating categories are the following:

- Diagnosis; Surgery; Identification [...]
- Instruments, implements or accessories for surgery or diagnosis not covered by any of the groups , e.g. for stereotaxis, sterile operation, luxation treatment, wound edge protectors.
- Filters Implantable Into Blood Vessels; Prostheses; Devices Providing Patency To, Or

Fig. 1. MAKO patents breakdown by year
Source: Google Patents Public Datasets

Preventing Collapsing [...]

As we can see, there are no patents filed in the second category. We assume there were new categories introduced, as there are new revision of the IPC code published every year. We can clearly verify this also in the data, since there are 8 new categories (e.g. A61B50/30, A61B34/35 etc.) used in the patents after 2016, which were not in use before 2016.

From the 776 patents, only 251 were effectively granted. Figure 2 shows the patents for each year.

B. STRYKER

The same analysis was performed on the STRYKER patents. First we show an overview of STRYKER's patents and the predominant categories. Then we compare if there were any changes in the classifications related to MAKO patents.

A total of 7266 patents were filed by STRYKER. Figure 4 gives a yearly breakdown. Several spikes can be explained by acquisition of other companies, some examples:

- 1999: Howmedia was aquired [5]
- 2006: Sightline Technologies was acquired [6]
- 2016: Sage Products and Physio-Control were acquired [5]

This shows us again, how important patents are as an asset for an acquisition. Further we analyzed the main categories, but focused only on the patents which were filed after 2002, since that is the year the first MAKO patent was filed. Figure 5 shows the breakdown. As for MAKO we see 'A61' as the main category under which patents were filed.

In order to see any relations with MAKO patents, we further focused only on patents which were filed in one of the IPC sub-classes in which

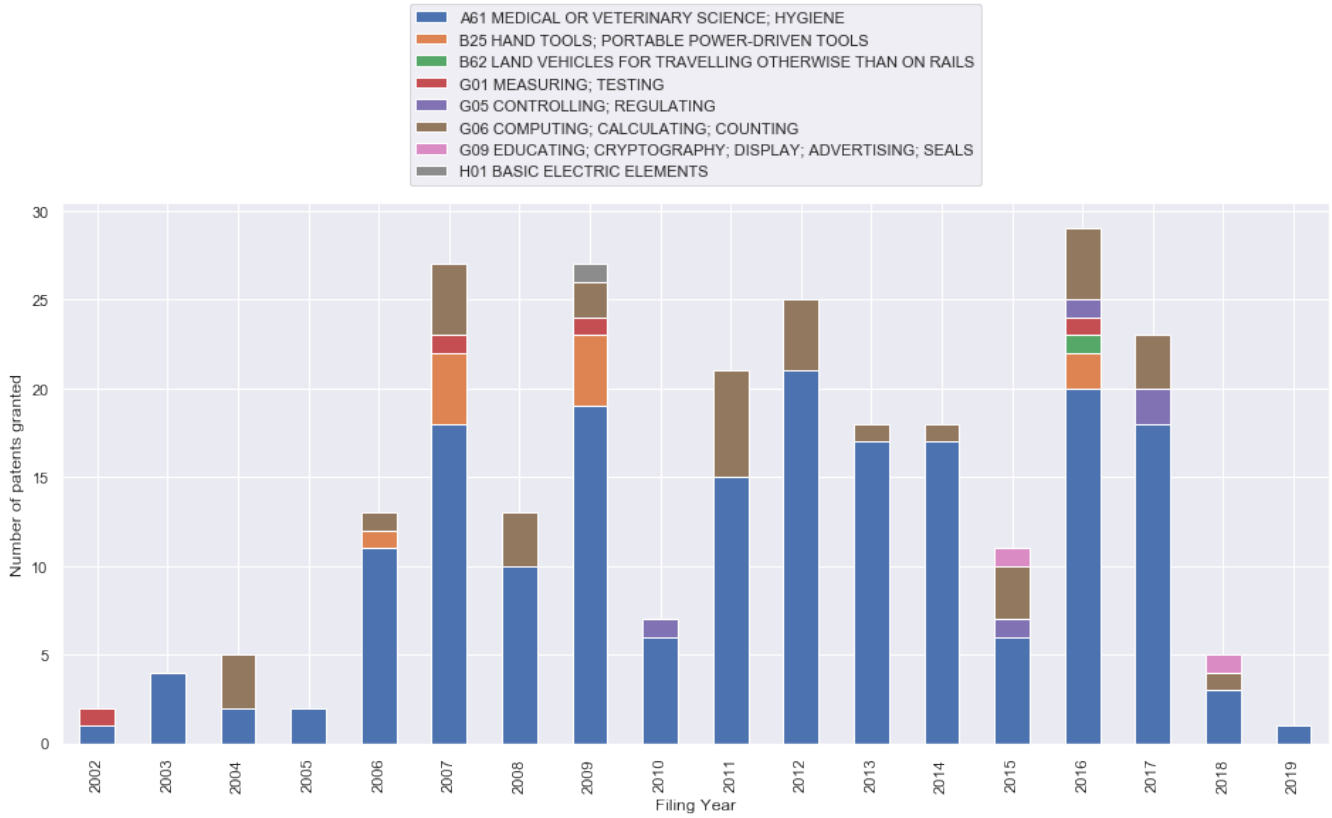

Fig. 2. Granted MAKO patents
Source: Google Patents Public Datasets

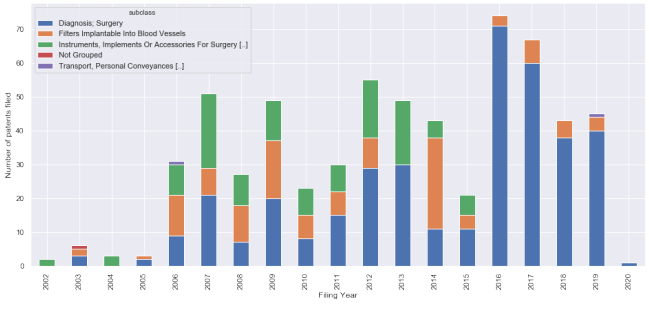

Fig. 3. Medical or Veterinary Science assigned patents
Source: Google Patents Public Datasets

MAKO also filed patents. Figure 6 shows the development of the different categories by each year. Interestingly we see that the "Transport; Personal Conveyance" makes a larger percentage than in MAKO's patents, in which the first patent in the category appeared in 2019, which might be an indication for integration of MAKO's strategy into STRYKER's.

C. STRYKER-MAKO Citation analysis

In this section we analyze the citations of MAKO patents in any STRYKER patents. How does it change after the acquisition. We focus on the citations from MAKO to STRYKER patents, primarily because the number of STRYKER patents were vastly larger.

In Figure 7 we can see a pattern of STRYKER citing constantly one of MAKOs patents. This trend continues until 2019. After the acquisition, the number of citations seems to be reduced - compared to 15 and 1-5 patents each year. On the other hand, we clearly see the other way around, that there were several MAKO patents, which were citing STRYKER patents. Especially in 2016. This is a clear indication for the acquired knowledge of STRYKER. There are 16 patents in which one of the inventors who moved were the inventor of a cited paper.

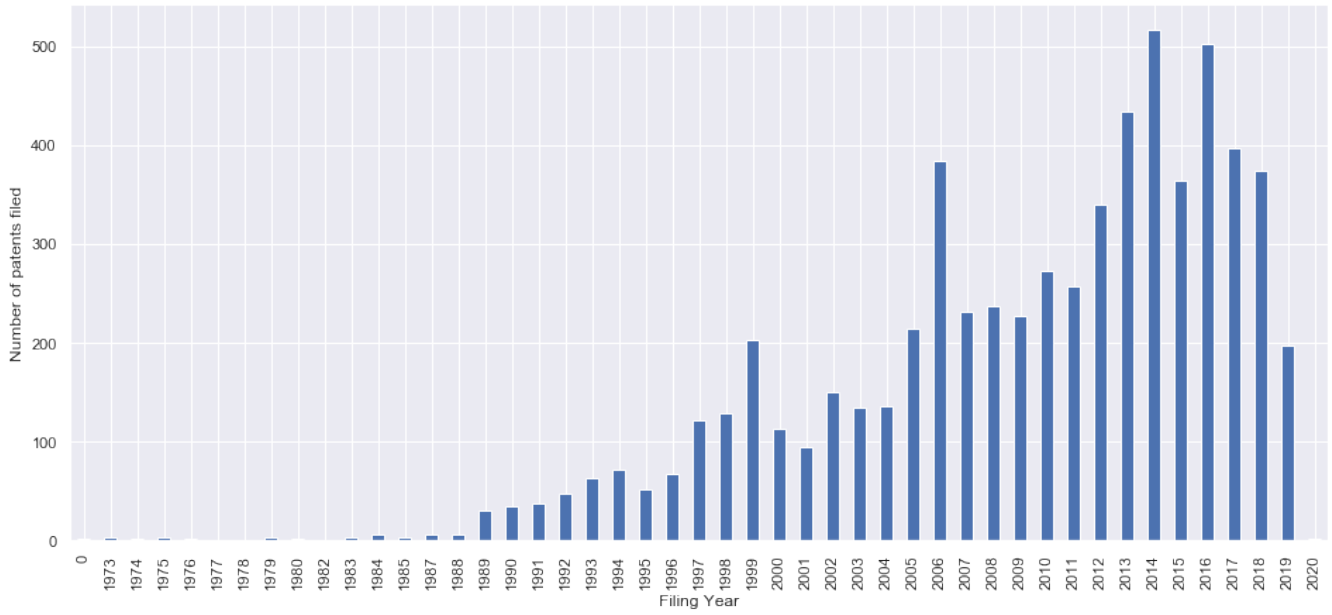

Fig. 4. STRYKER patents breakdown by year
Source: Google Patents Public Datasets

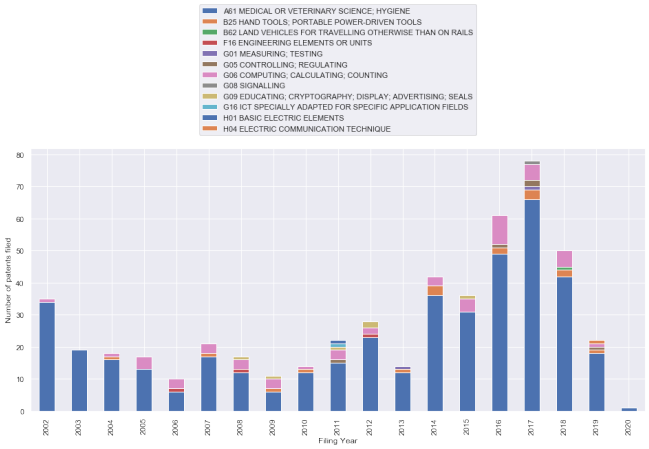

Fig. 5. STRYKER patents breakdown by category since 2002
Source: Google Patents Public Datasets

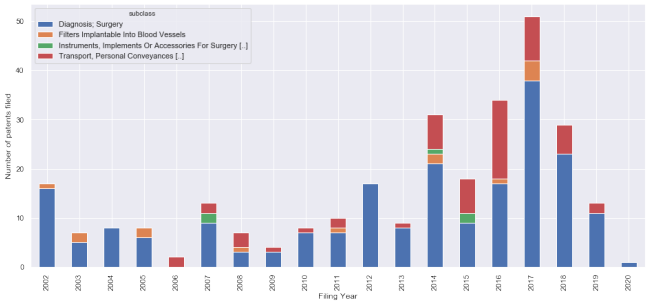

Fig. 6. STRYKER patents subclass breakdown
Source: Google Patents Public Datasets

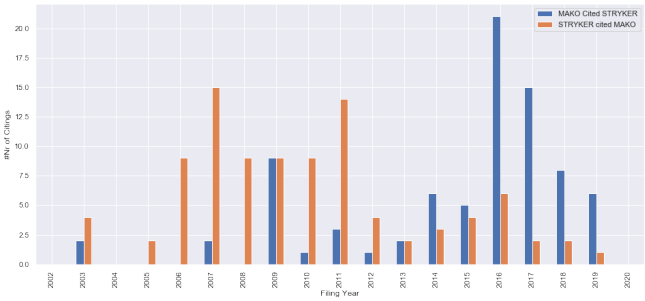

Fig. 7. Citings of patents
Source: Google Patents Public Datasets

VII. STRYKER-MAKO Inventor Relations

In this section we explore the inventor relations of STRYKER and MAKO. To be able to extract useful insights on inventor relations we decided to collect all the patents assigned to STRYKER and MAKO, and used the patents to derive all the inventors that at some point of time worked on STRYKER or MAKO patent's creation. The number of patents created by both corporations altogether is 7266. Exactly 2829 inventors were involved in the creation of these 7266 patents. Out of these 7266 patents, 774 were assigned only to MAKO, 6492 were assigned only to STRYKER

and 2 were assigned to STRYKER and MAKO together. Out of the 2829 different inventors, 274 inventors all worked on patent creation for MAKO, though some of them also worked on patent creation of STRYKER. Conversely, 2594 inventors all worked on patent creation for STRYKER, though some of them the also did work on patent creation for MAKO.

What we were actually interested in was to explore how big is the connection between MAKO and STRYKER inventors, thus quantify the exchange of knowledge that goes on between the 2 companies before and after the acquisition. We were able to discover that exactly ***39*** inventors out of the 2829 inventors worked on patent application assigned either to MAKO, STRYKER or both. To actually be able to extract some insight on these ***39*** inventors, we classified each inventor as either MAKO or STRYKER inventor by the following criteria:

- Date of first patent filled, by comapny. For a example: if the date of the first patent filled for MAKO is earlier than for STRYKER, then this obviously tell us that this inventor, first started working on patents for MAKO, thus we can conclude that he started out as a MAKO inventor.
- Number of patents that the inventor worked on for each company. For an example: if the number of patents under assignee STRYKER that this inventor worked on are more than the number of patents that this same investor worked on under assignee MAKO, then this tells us that the probability that this inventor is from STRYKER is higher than being from MAKO.

We decided to divide the inventors on inventors before and after the acquisition, thus we could get an actual insight on what actually happened after MAKO was acquired by STRYKER. We were able to do that again by the date on which the first patent was filled by a certain inventor.

A. Before Acquisition Insights

Inventors that worked for MAKO patents before the acquisition never went on to work for STRYKER patents before and after the acquisition, which tells us that there was no exchange of knowledge from MAKO inventors to STRYKER inventors. However, we found out about an interesting case connected to inventor *"Dr. Dana C. Mears"*. Inventor *"Dr. Dana C. Mears"* worked on a couple of patents assigned to STRYKER in 90s, though later on he moved working on patents for MAKO, thus by the time MAKO was acquired by STRYKER, inventor *"Dr. Dana C. Mears"* already had more patents created with MAKO rather than STRYKER. Since his specialty are knees, this gives us the insight that STRYKER at an earlier point was connected to the ideas of this inventor, but somehow stopped collaborating with him. *"Dr. Dana C. Mears"* developed 6 patents for MAKO, where one of the patents that *"Dr. Dana C. Mears"* worked on happens to be "Patellofemoral implant - USD622854S1" which is the 4th most cited patent of MAKO.

B. After Acquisition Insights

Once the acquisition was finished, we discovered that 34 out of 39 STRYKER inventors went on to work for MAKO's patent creation. This gives us the insight that STRYKER's inventors actually went on to share their knowledge to MAKO's inventors and helped further extend the patent portfolio of MAKO. This must have been helpful for MAKO as fresh and new ideas are always welcome. There were 3 cases where inventors hired to work on MAKO patent's creation later on moved to work for STRYKER patent's creation, thus showing unity and knowledge sharing between both corporations. There were also 2 outlier cases where an inventor started first working on MAKO patent's creation but later on moved working on STRYKER, thus creating more patents for STRYKER rather than MAKO and the other case is the same but is for an inventor that started working first for STRYKER patent's creation.

C. Inventor Relations Conclusion

Overall, the data shows that MAKO uses inventors of STRYKER mostly, while the other way around is quite rare, which actually makes sense as STRYKER is the mother company and is a way older and bigger company then MAKO. The fact that about 13% of inventors of the total invetors that at some point worked on MAKO's patent

creation, first worked for STRYKER's patent creation either before or after acquisition, indicates a substantial amount of knowledge exchange from STRYKER to MAKO. An interesting detail worth mentioning is that none of the inventors that had worked on patents for MAKO before acquision, did not transition working on for STRYKER, but this could be due to the case that MAKO's main product is the Robotic Arm while STRYKER did not have any similar products, thus there were no fields where these inventors could actually do research and continue creating patents. From this we can draw the conclusion that MAKO continued to be alive as a company under the wing of STRYKER, therefore their intellectual property just continued to grow after the acquisition.

VIII. Financial Strategy & Results

In this section we analyze the financial data before the acquisition. At the time of the acquisition MAKO was pioneer in the advancement of the robotic arm assisted surgery in orthopedics. The main 2 areas of MAKO were joint and hip replacement procedures with the Robotic-Arm Assisted surgery system. The 2 most important products used by STRYKER and supported by the intellectual property of MAKO were the:

1) Robotic-Arm Assisted Surgery - their main and most advanced product.
2) Triathlon Total Knee System - a product almost ready after acquisition. It got and FDA approval in 2015, due to the fact there were some initial challenges bringing the two organizations together. The product was launched in 2017.

At the time of the acquisition MAKO was a pretty young company with a bright future, with more than 30,000 operations conducted by MAKO products in the last five years. STRYKER's expectations was for these numbers to continue its growth, due to the fact that surgeries conducted with the Robotic-Arm offered quite a lot of automation, efficiency and accuracy into handling the joint and hip replacement. By 2019 there have been over 300,000 MAKO operations done, exhibiting the higher use of the Robotic-Arm assisted surgery for joint and hip replacement, see Figure 8. Approximately $60,000$ total hip replacements and $82,000$ total knee and partial knee replacements are expected to be performed in 2020. The vice-president of STRYKER, Katherine Owen was quoted as saying: "As we are now six years since the acquisition and nearly five years since the initial launch of the total knee indication, we believe we have validated a strategic rationale and competitive advantage of Mako as witnessed by the roughly 600 basis points of U.S. knee market share that we have gained since 2013. Going forward, we continue to expect to take meaningful market share in knees owing to Mako along with our differentiated portfolio of knee products, including our 3D-printed implants."[12]

STRYKER also saw a growth opportunity for the Robotic-Arm Assisted Surgery in the Pacific-Asia and Japan market. Thus, STRYKER has emphasized clinical evidence, training and education, and media awareness in those areas to support this growth.

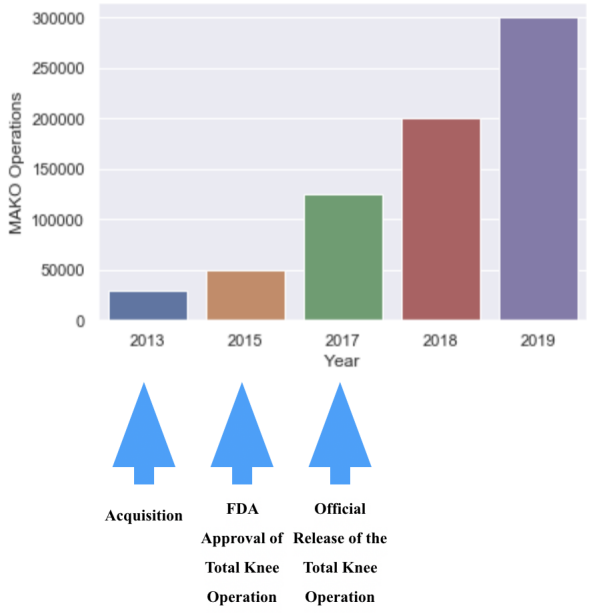

Fig. 8. MAKO Operations Per Year
Source: STRYKER's Annual Reviews

The Robotic-Arm Assisted Surgery product has gained considerable momentum, following about 30% increase of installed systems from 2018 to 2019, see Figure 9. With more than 145 published, peer reviewed studies and more than $1,000$ U.S and foreign patens and patent application, the MAKO System (Robotic-Arm Assisted Surgery) is

the crown jewel of STRYKER-MAKO acquisition [10]. Having installed over 850 systems by 2019 priced at $1M, thus STRYKER has made over $850M just from the Robotic-Arm System, which continues to have more and more use from year to year [11].

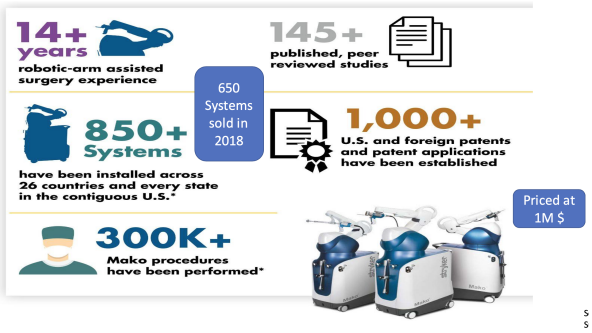

Fig. 9. Robotic-Arm Assistted Surgery Product
Source: STRYKER's Robotic-Arm Product Page

STRYKER has shown a 40 years straight growth including after the acquisition, which comes as no surprise, see Figure 10. The orthopedics sector where MAKO has the most influence, has also showed continuous growth after the acquisition, which shows that with the acquisition of MAKO they were able to actually keep their share of the market and keep up with the pace of innovation going on. In the orthopedics sector more

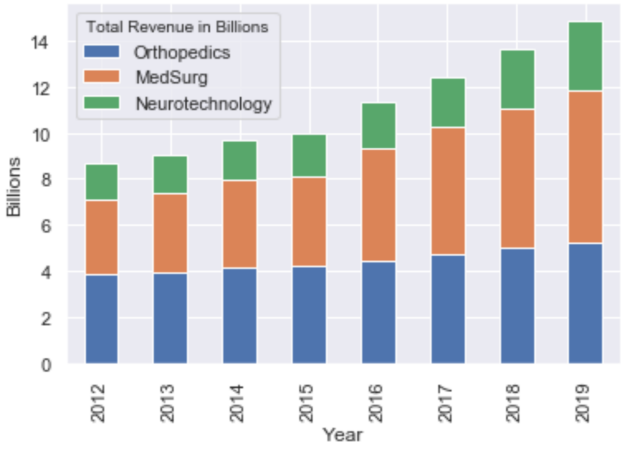

Fig. 10. Total Renevue Per Year
Source: STRYKER's Annual Reviews

than half of the revenue comes from knee and hips area, where MAKO has the most influence, and they have had continuous growth over the

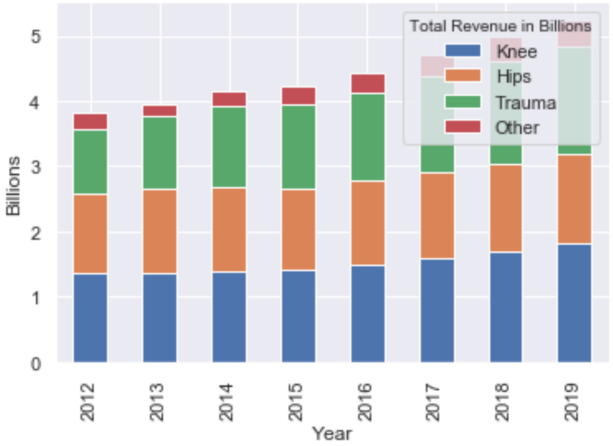

Fig. 11. Renevue Per Year in Orthopedics Sector
Source: STRYKER's Annual Reviews

years, see Figure 11. Overall, financials show that STRYKER has been able to increase their revenue each year, and this is a result of their strategy of good and diversified investments, one of them beging MAKO Surgical Corp. STRYKER ended 2019 with its best quarterly sales of MAKO robotic systems since launching the joint surgery platform in 2017. MAKO's momentum supported STRYKER's 8.1% organic growth to $14.9 billion on the year, thus beating consensus fourth quarter revenue expectations by about $20 million [13]. A lot of financial analysts, including STRYKER's management expect that the benefit of the Robotic-Arm Assisted Surgery will continue to grow in the future, thus make the MAKO acquisition even more advantageous [12].

IX. Conclusion

Our goal in the report was to conclude whether the acquisition was worth, thus by conducting different analysis we were able to extract useful insights and to see the acquisition benefits from different points of view. The analysis of the patents based on their classification sector gave no clear insight, on the knowledge exchange of both companies. However, by exploring STRYKER-MAKO citing patents relations, we were able to identify crucial knowledge exchange between both companies happening before and after the acquisition, see Figure 7. Before the acquisition STRYKER was citing MAKO way more than the other way around. After the acquisition MAKO started citing

STRYKER a lot more, while the other way around slowed down. This clearly indicates that once STRYKER acquired MAKO, they went on the offensive to help MAKO maintain and improve their position on the robotics market. By doing the inventor's relation analysis we were able to identify the same phenomenon as in the patent's citations, and that is that once MAKO was acquired, STRYKER had some of their inventors working on some MAKO patent's creation. The financial-product analysis showed that the Robotic-Arm Assisted Surgery product, took a couple of years to launch however, now the momentum is quite considerable and proves that the acquisition of MAKO was a worthwhile, as numbers are expected to continue their growth. By having all these results, we were able to conclude that by acquiring MAKO, STRYKER was not hoping on improving their already existing products, but was actually going for the entrance of the future market of robotics in orthopedics and thus to slowly to improve their market share in the joint replacement sector. Overall, our opinion is that the acquisition was worthwhile and that the actual financial numbers are still yet to be seen as each year we are moving more towards more robotics, automation and digitalization in our lives.

X. Further Work

For further analysis of the impact of patents on the acquisition of MAKO by Stryker the following points can be explored further:

- The company Stryker filed patents under different names (Stryker France S.A., Stryker Leibinger Gmbh and Co., Kg, Stryker European Holdings Vi); an in-depth analysis of each assignee gives us more insight into the exact structure of Stryker.
- How did the assignment of the acquired patents changes to Stryker. Which acquired companies continue filing patents under their own name.
- A comparison of Stryker's competitors and their patent-filings, especially the IPC classification could be compared in order to see trends and refocusing research. Compare it with the IPC classification of MAKO to see if any new categories appear.
- A more broad analysis could be conducted between all inventors that MAKO had at some point working on its patents, compared to all subsidiaries of STRYKER, thus explore what is the actual connection of inventors between all subsidiaries of STRYKER. Interesting results may come out of subsidiaries that occupy same sectors.
- With respect to financials, it would be interesting to follow the sales of the Robotic-Arm Assisted Surgery product in the next couple of years, since at this point it is having a huge momentum which is expected to last in the years to come.

Some of the point mentioned above were not further explored due to a couple of points:

- All the information that we were able to gather and discover about these 2 companies and this sector throughout the project, gave us more details on what could be interesting to actually do as further work, thus it was quite unlikely that we would have had any thought on these ideas when starting the project.
- Some of the points could be quite time-consuming as they would require quite a lot of research and maybe programming, to be able to actually connect all details.
- We used mainly the "Google Patents Public Datasets on Google's BigQuery" to extract all relevant patents. A historical view (e.g. change of assignee over time) is not exposed. Therefore we have to fall back to other sources (e.g. crawling), which is not in relation with the expected result.

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