Forensic intelligence on illicit markets: the example of watch counterfeiting

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Highlights

- Chemical and physical profiling of counterfeit watches
- Comparison and interpretation of chemical and physical links
- Combination of chemical, physical and circumstantial data
- Knowledge on the structure and organisation of production and distribution channels

Abstract

Counterfeit luxury fashion goods have rarely been the subject of scientific studies. Very little is known about the mechanisms of this illicit market despite the apparent prevalence and their adverse consequences. Counterfeit watches remain one of the preferred targets in the luxury goods segment.

The study of marks or traces in a forensic intelligence perspective can contribute to an improved understanding of the phenomenon. The aim of our research was to highlight different types of links that can be drawn between specimens of counterfeit watches, to carry out a thorough study of the information conveyed by the revealed links, to study their complementarity and to get an understanding of the intelligence that can be produced from these pieces of information.

Thirty-five counterfeit watches of a commonly counterfeit watch brand including seven popular models were studied in this research. Chemical and physical links were found that corroborated existing knowledge and also revealed new connections between different seizures or specimens. The comparison of chemical and physical features combined with spatiotemporal information on the seized watches enabled us to produce intelligence disclosing possible aspects of the structure and the organisation of production and distribution channels.

We were able to reveal or confirm links between watches that were previously unknown or uncertain and demonstrated the interconnection of all watches on a chemical and/or physical level, suggesting an overhead organised network with substructures. Despite the limited set of specimens that was considered, this study illustrates that forensic intelligence on this illicit market can be used to support consistent decision-making from all the key-players involved in the anti-counterfeiting process.

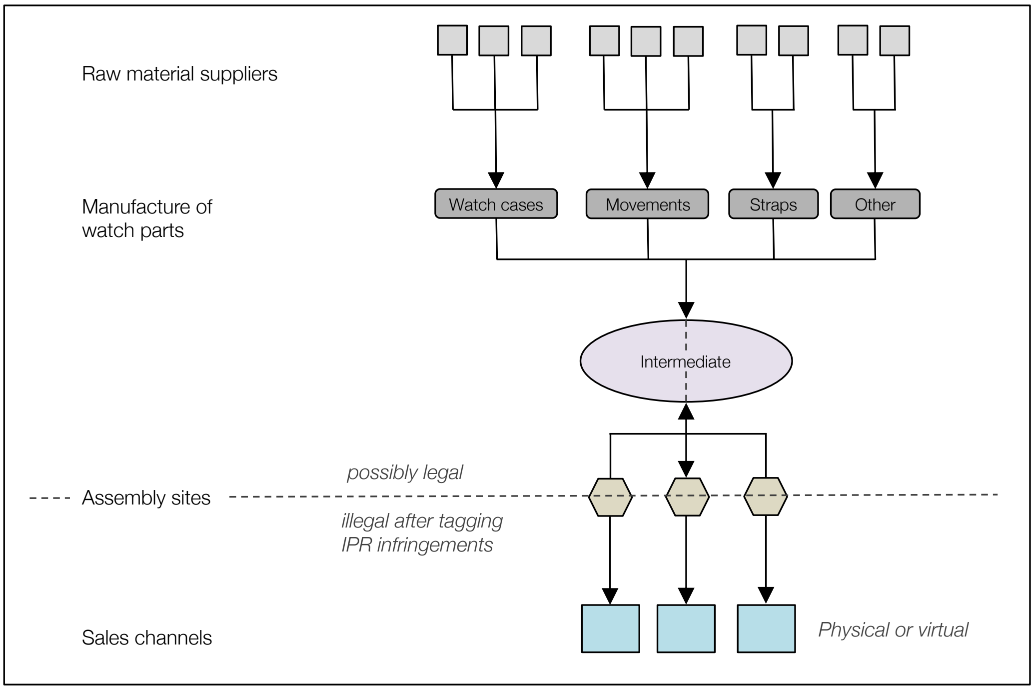
Introduction

Counterfeiting is one of the oldest crimes in history. In 27 BC, a Gaulish wine merchant counterfeited the stopper for wine amphora to sell cheap local wine as expensive Roman wine [1]. Nowadays, counterfeiting has become an estimated USD 460 billion industry where nearly all areas around the globe either serve as a point of origin, transit or destination [2].

With regard to luxury goods, the illicit trade in counterfeit goods has substantially expanded, as a consequence of globalization and free trade agreements, attractiveness and expansion of the Internet as a sales platform, as well as society's insatiable demand for luxury goods [3, 4]. Luxury goods and wearing apparel remain the preferred targets for counterfeiters, linked to both, demand and supply. On the supply side, faking luxury goods is extremely profitable since cheap production costs are associated with tremendous profits. According to estimates on the revenue of illicit markets in Europe, counterfeiting generates 43 billion Euros per year compared to 28 billion Euros for trafficking in illicit drugs (heroin, cocaine, cannabis, and amphetamine drugs) [5]. Another major factor explaining the current interest of this activity is that law enforcement on a national and international level is weak and, in some countries, even non-existent. Penalties are often very low, therefore non-dissuasive and rarely enforced [6]. The negative effects are contrasting and induce confusion in the protection of public or private interests of anti-counterfeiting, but both sectors clearly identified the lack of knowledge about the mechanisms and structure of the illicit traffic [7].

However, we identified three essential steps: 1) the production of the individual watch parts like watchcases, straps, movements and so forth; 2) the distribution of the parts towards various assembly sites where the final product is mounted. It is presumably at this step that tagging of corporate logos and brands, called imprints, takes place; and 3) the diffusion into physical or virtual sales channels. The initial step, i.e. the production phase, may take place in legal businesses. Individual parts can be manufactured for legal watch production with no intention of counterfeiting. Assembly sites may or may not be in the same country as the production of the component parts. In this manner, the watch parts can cross national borders without being confiscated by custom authorities, since there is no violation of the law. The line between legal and illegal business in terms of intellectual property rights is crossed when the watches are tagged with corporate logos and brands. Figure 1 shows a breakdown of the different steps.

Figure 1 : Schema of a counterfeiting network



As stated by Margot, scientists rarely address the problem to contextualize traces and to analyse them with regard to the information they may provide, even if this information is rudimentary and incomplete [8]. Counterfeit watches are the product of an illicit activity and encompass traces on production and/or distribution that could support the understanding on the structure of the traffic. Traces offer a source of information based on objective, measurable and comparable data [9].

Forensic science has an important role, in a security perspective, beyond the general emphasis that is placed on its role for criminal courts. The information content of traces can contribute to models where intelligence and crime analysis tend to support strategic decisions and crime prevention [10]. In this regard, traces are interpreted as 'intelligence' rather than evidence. Hence, all fields facing unlawful activities where traces are generated should consider forensic case data as a valuable source of information [11]. Merging the information provided by the different types of traces and combining them with circumstantial data open the path to the generation of valuable intelligence. This approach grounded on a forensic intelligence perspective and relying on the use of physical, analytical and circumstantial data proved its benefits for deciphering the structure of illicit drug and counterfeit pharmaceuticals organizations [12-14].

In this research we compared links of counterfeit watches assessed by the FHS on the examination of physical characteristics and with the relations resulted from our previous research effort on the chemical profiling of watchcases [15]. We aim to evaluate the potential of physical and chemical characteristics of counterfeit watches combined with the contextualization of seizures' information to bring a better understanding of the phenomenon? Notably, we wanted to investigate the possibility for larger market insights by considering chemical profiling of watchcases from a restricted set of specimens and considering the physical profiling associated to former links between these watches.

Federation of the Swiss Watch Industry

The 'Federation of the Swiss Watch Industry' (FHS) actively fights intellectual property rights infringements [16]. The physical examination and analysis of counterfeit watches is one of their core activities in the anti-counterfeiting department. The approach adopted by the FHS relies on linking counterfeit watches based on precise measurements of physical features, namely the imprints of corporate logos and brands, present on component parts. These established links most often provide information on the assembling site, which is the final step in the completion of a counterfeit watch. However, very little is known on the production of these watches and the relationships among the different steps (supply of raw material, manufacture of watch parts, assembling and diffusion).

Material and methods

Specimens

The specimen set consisted of 35 counterfeit watches, including seven models of one of the top luxury watch brands, seized by customs authorities in 2015[1]. All watches were previously identified as counterfeits and subject to examination by the FHS. We decided to focus our research on one brand, postulating that it would increase chances of gathering intelligence on the relationships between these watches and the underlying structure of the traffic. Studying watches of only one brand and seized during a relatively short period of time (7 months) increases the chances of finding links (on a chemical and physical level) between them. It is more likely that the same raw materials, as well as the same tools to produce the imprints on the watches, were used. Hence more information on acting networks can be gathered.

Data acquisition

This research was conducted in close collaboration with the Legal and Anti-Counterfeiting Department the Federation of the Swiss Watch Industry (FHS) The FHS provided all counterfeit watches with the corresponding examination reports and allowed access to their database of information containing in particular seizure data.

Physical data

All 35 specimens were examined by specialists at the FHS and results of the examination were compiled into reports. The latter contain data about the inventory

[1] Due to confidentiality requirements, no information concerning the brand, specific models or images leading to their identification are disclosed.

and the seizure, the general examination, identification of the clockwork, identification of imprints, connections that were generated within the database with formerly analysed watches and conclusions that were drawn. Links between watches are therefore based on physical relationships.

All imprints present on the different parts of the counterfeit watches were examined independently: strap, watchcase, dial and the crown. To feed the database, features relating to the imprints are translated into numerical codes. These codes contain the information on the position of the imprint (case, dial, crown or strap), manufacturing process (e.g. struck, engraved), category (e.g. symbol, brand), the exact content of the inscription and measurements. The codes can be concatenated to a single code in the form of XXX.XXXX.XXXX, identifying each imprint. Subsequently, the codes are used to query the database and make comparisons in order to detect the links between identical imprints. A link suggests that two imprints were produced by the same source, i.e. the same manufacturing tool.

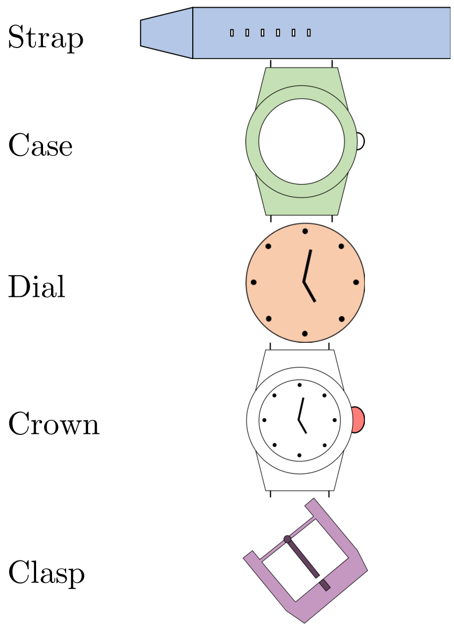
We therefore had access to relevant information to examine the relationships between the 35 watch specimens, hereafter called ‘physical links’. The connections (‘physical links’) highlighted between these 35 counterfeit watches with previously inspected watches stored in the memory of the database were also considered and named ‘physical links on extended level’. Data from the relational database of the FHS was retrieved with an SQL query.

It is important to define specifically what imprints, codes and links represent in order to avoid any confusion amongst them.

- **Imprint**: a physical mark that is left on the watch, that either shows a text or a symbol, representing a brand, a model, a geographical, technical or quality-related indication.
- **Code**: Numerical code identifying each imprint. Imprints with the exact same characteristics in terms of position, manufacturing process, category, content of the inscription and measurement values of width and length share the same code.
- **Link**: Two watches that contain the same codes are linked via this code. Hence, two watches can be linked by several codes on different parts.

Figure 2 shows the watch parts, on which the studied imprints can be found.

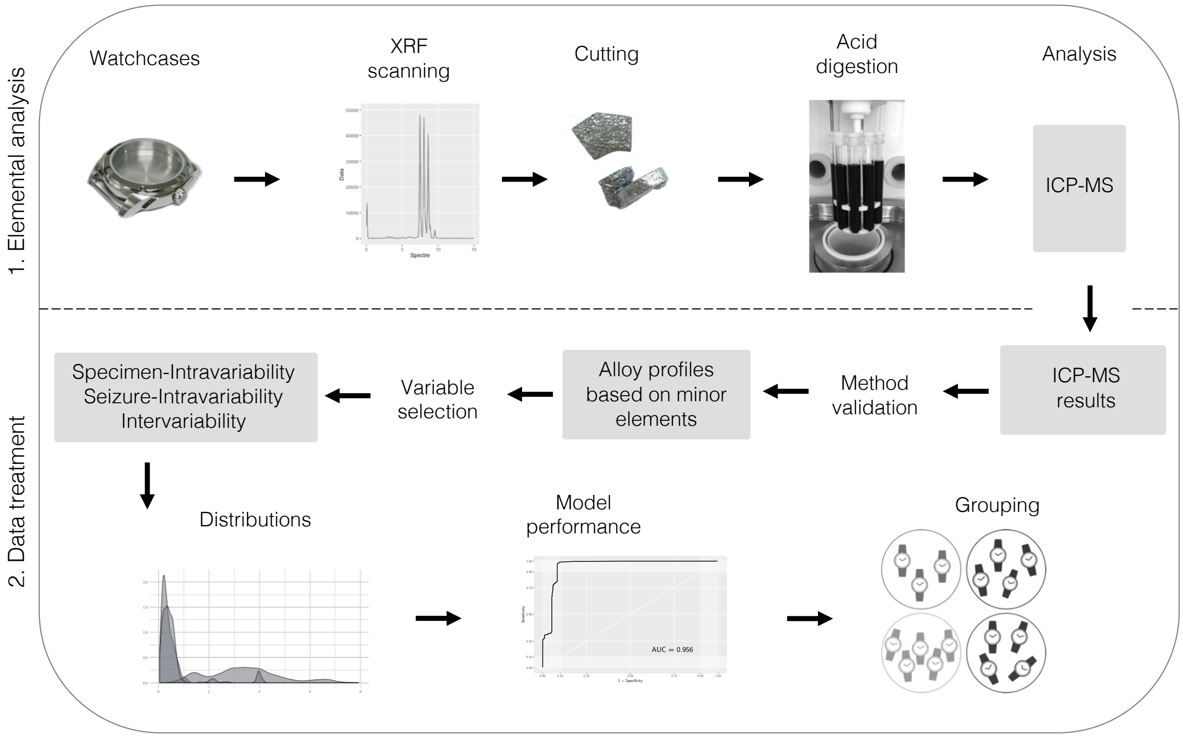
Figure 2: Watch parts, on which the studied imprints can be found



Chemical data

All watches were previously disassembled and only the watchcases were retained for chemical analysis. We developed an analytical strategy to reliably quantify the minor elemental composition of watchcases by inductively coupled mass spectrometry (ICP-MS). We then assessed a strategy for profiling and classifying the watchcases into chemical classes. The comparison algorithm was based on the postulate that similar specimens have similar chemical profiles and can be used to construct chemical classes. Details on the selected specimen set, sample preparation, analytical method, validation procedure as well as multivariate data analysis are presented in our previous paper [15]. An overview of entire process of chemical profiling of counterfeit watches is shown in Figure 3.

Figure 3: Elemental analysis process and data treatment for the chemical profiling



Links and contextualization

It is crucial to identify the level of intelligence that traces, and information provide. We hypothesized that chemical and physical traces convey different information content of possibly unrelated phases of the counterfeiting process. Hence, each category was examined and interpreted separately. Contextualisation was then built up consecutively. As a first step we examined each source of information separately, starting with the chemical links between the specimens, followed by the study of physical links and physical links on extended level.

In our approach, chemical links are easier to apprehend since they are represented by a single variable, namely the chemical class. Hence, watches can either be linked or not. The situation is different with the holistic approach for physical links. Physical links between two watches can occur between the totality of imprints, between some of them or none. This information also had to be interpreted, allowing us to derive information on whether parts were tagged together or separately. Link analysis was then performed and visualized combining both chemical and physical connections in order to decipher specific patterns in the data. This article describes how chemical and physical data of counterfeit watches were analysed, structured and interpreted to extract intelligence.

Data treatment was performed using Excel (2016) and Tableau (2018.1.3.). IBM i2 Analyst's Notebook (9.0.4) was used to visualize the relevant data.

Study of chemical links

The chemical profiling allowed us to classify the 35 specimens into 15 chemical classes. We support the inference that two specimens belonging to a chemical class were produced from a common metallic piece and therefore in the same production facility. The chemical classes including the watches, the number of different models of the brand, as well as the surface plating are shown in Table 1. The classes contain between 1 and 5 watch specimens and at most 3 different models with different surface plating.

Table 1: Watch specimens according to their chemical classes, number of models within a chemical class and types of surface plating

Chemical Class	Watch specimens	# Models	Surface plating
1	M05, M23	2	Steel/Gold
2	M28	1	Gold
3	M04, M16; M20, M26, M27, M29	3	Steel/Gold
4	M17, M32	2	Steel/Gold
5	M13, M14, M15, M25	1	Steel/Gold
6	M08	1	Steel
7	M02, M24	2	Steel/Gold
8	M03	1	Steel
9	M06, M07, M34	2	Steel/Gold
10	M19	1	Steel
11	M33, M35	2	Gold
12	M18	1	Steel
13	M09, M10, M11, M12, M21, M30	2	Steel/Gold
14	M22, M31	2	Steel/Gold
15	M01	1	Steel

Study of physical links

In total, 489 imprints were found on the cases, straps, dials and crowns of the 35 watches. The number of imprints per watch varied between 9 and 18.

The imprints represent 243 individual codes, whereby 145 of them occurred only one time and therefore did not have any connections. This means that 98 codes were shared at least by two of the 35 specimens, corresponding to a total of 344 occurrences[2] within the 35 watches. Yet, these numbers say little on the links that exist between different watches. They were handled through a multidimensional visual analysis environment enabling to reveal connections and patterns (Figure 4). Different colours were used to represent the different watch parts where the imprints were located. Only codes of

[2] One code/imprint can be present on several watches.

imprints that generated links between watches are displayed, hence the 145 codes without any connections were discarded. If several codes on the same component were identified on the same watches, they were aggregated, and the number of codes was added to the figure. Among the 35 watches numerous links were identified. Some watches were only linked through the imprints on the crown or the clasp (device for fastening a chain and part of the strap) but do not share any other physical connection between each other.

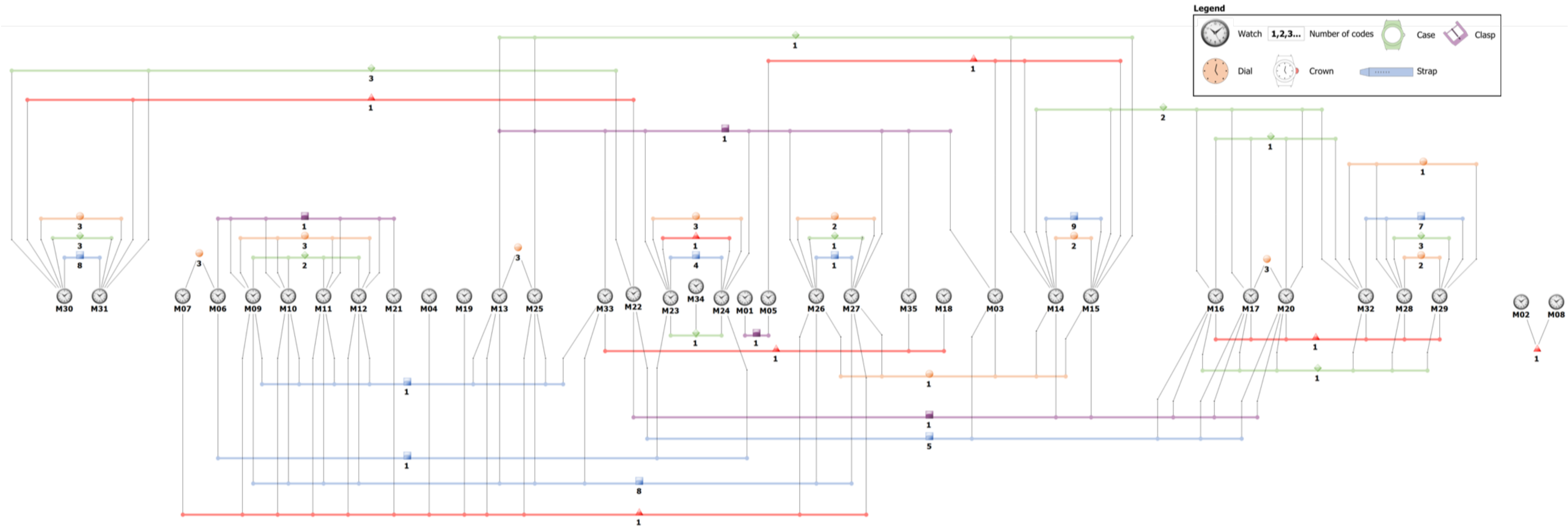


Figure 4: Visualisation of physical links between the 35 watches. Different colours indicate the watch parts, where the imprints were found. The black digits represent the number of codes, which form the same connections between the watches.

Study of physical links on an extended level

We investigated the total number of occurrences from the 489 imprints within the entire database and the number of links with other previously analysed watches. 190 individual codes generated at least one link with another watch. Altogether, links were found with 504 watches that were analysed previous to our 35 specimens set. Several codes generated links with only a limited number of watches in the database. For the purpose of visualisation, we decided to focus on codes that generated 25 or more links. The information about their location can be found in Table 2.

Table 2: Total number of codes, connected to at least one other watch in the database, number of codes connected to 25 or more watches and their distribution within the different watch components

	# codes	# occurrences in DB	# of watches
Total number of codes with links:	190	2124	504
# of codes with more than 25 links:	27	1129	365
• on strap:	23	973	312
• on crown:	3	111	111
• on case:	1	45	45
• on dial:	-	-	-

Hence, considering only the straps and crowns represent already 96% of the total number of occurrences. The analysed imprints can either be brand-specific, e.g. the name or the logo of the brand, model-specific, e.g. the name of the model or model identification number, or non-specific, e.g. technical and geographical indications. It is important to classify them, since they convey different information. Model-specific imprints can only generate links between watches of a same brand and a same model. Two watches of a common brand but different models could not share model-specific imprints although possibly originating from a same production line. Brand-specific imprints can be found on watches of the same brand. Non-specific imprints are very interesting, since they could be used on all watches and even on counterfeit watches of different brands. Brand-specific and non-specific imprints are thus useful to gather information about mass production. They were also found to generate the most links, whereas model-specific imprints were only found three times. Examples of non-specific imprints can be found in Figure 5.

Figure 5 Examples of non-specific imprints and number of observed links

25	32	41	66

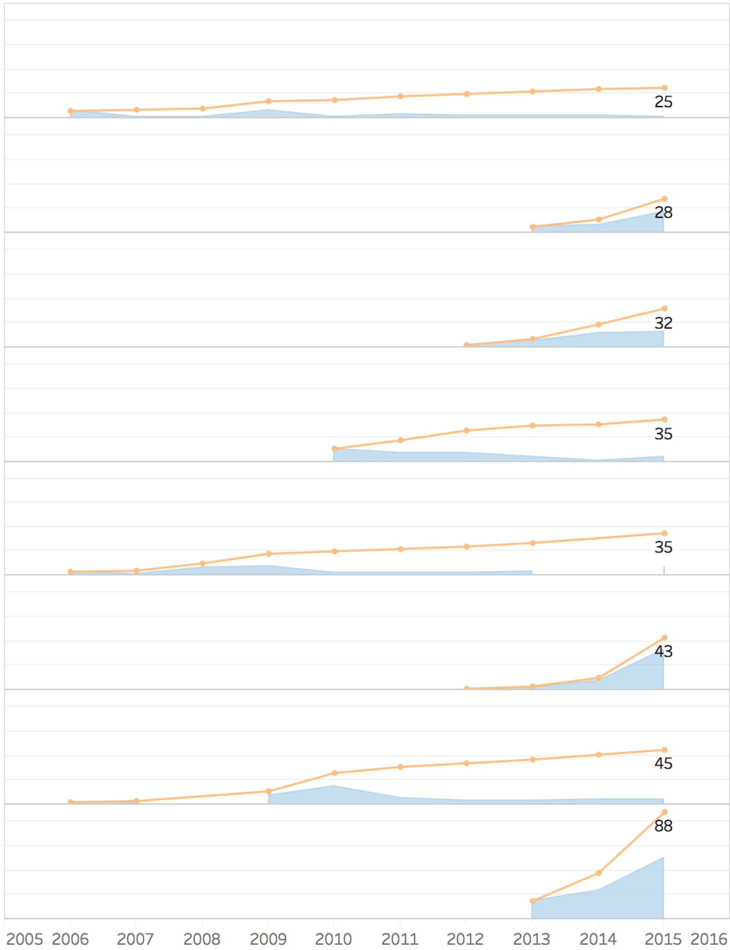
Some imprints were mostly found together, indicating that they are produced at the same time. For instance, three different combinations of 5 codes found on 25 watches, 31 watches and 52 watches, respectively, and a combination of 3 other codes was found on 43 watches. These four groups were composed of imprints that were found on the straps. Interestingly, we observed that there was no mixing between the groups, meaning that two different groups of codes were never found on the same watch.

Temporal analysis of imprints

On a temporal scale we studied the evolution of the imprints that generated the most connections. The dates considered were those of the beginning of the physical examination in the FHS reports. Consequently, no indication of production time is available, but the date is relatively close to the date of seizure. This temporal information is useful, since it can be used to inform on the persistence or appearance of imprints. Figure 6 illustrates the four groups of codes that were generally found together, as stated above. Consequently, we can observe that codes of the same group exhibit a similar temporal trend. In Figure 7 codes with no specific relation to other ones are displayed. Some of the codes generated a lot of links with previously analysed watches and persisted over a long period of time. Some codes persisted over a period of almost 10 years.

Figure 6: Temporal analysis of imprints. The blue area corresponds to the number of links/code/year, whereas the orange line cumulates the number of links and displays the total number of links found for each code. These codes were generally found in groups on the counterfeit watches.

Figure 7: Temporal analysis of imprints that were not found in specific combinations with other codes. The blue area corresponds to the number of links/code/year, whereas the orange line cumulates the number of links and displays the total number of links found for each code.



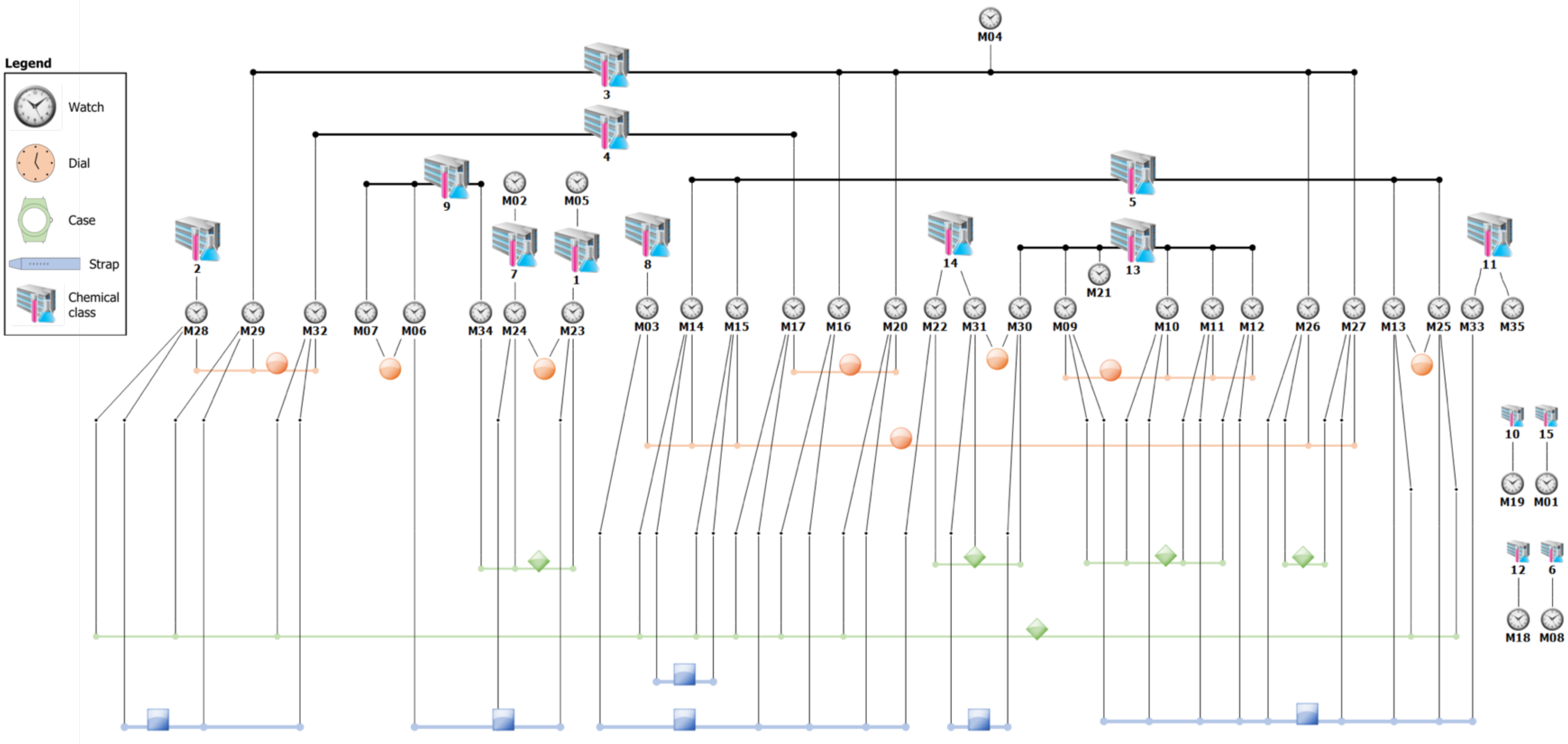
Comparison between chemical and physical links

Physical links between the watches were considered on each watch part separately. The codes that were found in combination were merged into groups to simplify the visualisation. As previously stated, analysis of the physical links showed that the imprints on the crowns and on the clasps have generated links between watches that were not detected on a physical level. Therefore, the codes representing those imprints were also discarded to illustrate a more legible picture of the different connections. Figure 8 shows a representation of chemical and physical links between the 35 counterfeit watches. The watch specimens are displayed in the middle of the figure (watch icons), the chemical connections in the upper part, and the physical links on the lower side.

Among the watches, numerous chemical links were identified. Generally, there is not much correspondence between the chemical and physical links. Although, some chemical links were confirmed by physical links (Figure 8, e.g. M09/M10/M11/M12, M14/M15, M13/M25). 4 out of 35 specimens (Watches M01, M08, M18 and M19) did not share chemical or physical links on the straps (clasps excluded), dial or case with any other watch.

Some chemical links between watches with no physical links can be observed. Also, some watches that share several physical links do not have the same chemical characteristics, e.g. M23/M24 and M30/M31. Nevertheless, relationships between almost all specimens can clearly be seen on a chemical and physical level.

Figure 8: Visualisation of the links produced by combining chemical and physical information



Discussion

Chemical information

Regarding the chemical profiling, we were able to classify our sample into 15 chemical classes. Despite the small number of watches, the number of chemical classes was high. This could either be an indication of several production sites of watchcases, or of a great diversity of the metallic batches that had been used to produce them, depending in their availability. It is important to keep in mind, that the considered brand is one of the most popular in the luxury watch segment and also one of the most targeted in terms of counterfeiting. It is hereafter possible that multiple production sites for watchcases exist and distribute their merchandise to several assembly sites. We found out that a chemical class contained counterfeit watches of at most 2 models, except for one class where 3 models were found. This is consistent with knowledge of the FHS, that counterfeiters generally target two models of a brand [16]. We also found watches with different surface plating, which were chemically linked, suggesting that the same alloys were used for watches with different surface plating. This finding is very interesting, since it confirms the utility of analysing the bulk composition of the alloy rather than surface analysis where simpler techniques, such as X-ray fluorescence spectroscopy (XRF), could be applied.

Physical information within the specimens' set

The network of physical links between the different parts of the watches was complex and the extraction of an understandable structure not obvious. Nevertheless, the structure obtains by visualizing all physical links indicated strong connections between the different watches. Only two of them (M02 and M08), linked between together by the imprints on their crowns, were completely separated from the other 33 watches.

These results suggest that the production of these watches is the result of one main organisation, interacting on several levels. Links between all imprints indicated that the tagging of watches did not take place in a single step but rather the tagging of the different parts individually, that were then assembled to form the entire watch.

Links between imprints on the dial were only found for watches of the same model. This is not surprising, because dials are mostly the watch part where the model is displayed, hence they are model-specific. For these links it is interesting to distinguish between different production lines of counterfeit watches of a same model, but less in terms of identifying imprints used for mass production of different types. In our case we were dealing with a small set of watches including multiple models.

Observations based on the physical links within the 35 watches suggested that these imprints had generated several links between specimens otherwise not related. This indicated that the imprints on the clasps, in our case an application of the brand logo, did not emerge from the same production line as the remaining imprints on the strap.

A total of 243 different codes were found in the entire sample set, whereby 145 codes did not generate any links between the 35 watches. These codes may still be connected to other watches previously analysed. Hence, it is important to analyse imprints on an extended context, which is discussed in the next section.

Physical information on extended level

Considering the physical links and the associated codes generated during the analysis of the 35 watches with the entire memory of the FH database, more than 500 other counterfeiting watches were connected with our research set. These findings demonstrated that the considered brand and models of watches were counterfeited on a large scale within organised networks.

We found out that only a few codes generated most of the links. As a consequence, only codes generating 25 or more database records were retained, which corresponded to 27 codes. These codes are particularly interesting since they indicated an industrial use of the tools used to produce the imprints. Four different groups of codes, generally found in combination on the watches, were identified. The corresponding imprints were all located on the straps and they indicated 4 different production lines of straps. They were composed of non-specific or brand-specific imprints, indicating that they were used at the same time.

It was also found that 3 imprints on crowns linked 111 watches between each other. This also indicated 3 different major production lines of these crowns. Imprints on the clasps and crowns generally generated a considerable number of links. This suggested that they had been produced separately on a large scale and then were distributed towards multiple assembly sites.

Considering the case, one single model-specific code generated links between 45 watches. All other codes from the watchcases generated less than 25 links within the database.

Imprints found on the dials, even though links with other watches existed, did not link to more than 25 watches. Hence, the results of our study suggest that the dial should not be considered as the watch part of interest, if the goal is to look at the imprints with most links, which is indicative of an industrial production. This resulted from the fact that the imprints had mostly been model-specific, and therefore only linked counterfeit watches of the same brand and model, tagged with the same tool. Nevertheless, these imprints could be informative to study the relationships between watches of the same brand and model.

The observations made on the imprints on an extended level also supported the hypothesis that the tagging of the different watch parts was performed separately. This was also underpinned by the groups of imprints on the straps, that were systematically found together, but no links between imprints belonging to different groups were found on a same specimen.

The gathered information on all imprints are also of utmost importance, if an assembly site is dismantled. If tagging tools are found, they could be confronted to the imprints found in the database in order to determine how many watches are linked to them.

Temporal analysis

Time-related information contained in all of the FHS examination reports were the dates of the beginning of the analysis of a counterfeit watch by the FHS. Only codes that were found on at least 25 other counterfeit watches in the database were considered.

The persistence of imprints on a temporal scale clearly revealed that the tools had not only been used temporary. Some of the imprints were found over a period of 10 years. It has to be understood that the complete analysis was based on the initial 35 counterfeit watches. The way the temporal analysis had been performed can therefore only reveal at what time a specific code was found for the first time, and when and how many times it was found until the specimen of the sample set was analysed. As a consequence, it was not possible to detect whether a certain tool, for whatever reason, would not be used anymore. The fact that some codes exhibited the same temporal profile strongly supported the hypothesis that they had been used at the same time and place.

Contextualisation of chemical and physical information

Based on the links from the chemical analysis of the counterfeit watches and the physical characteristics of the different watch components, propositions can be made about their production and distribution.

The watchcases revealed numerous chemical classes. Several watches were not chemically linked to another one and presented a single chemical class. Two propositions could be made according to these findings. It is possible that numerous production sites are specialised in producing the watchcases for the studied brand, which can be explained by the fact that the brand is one of the most commonly counterfeited. Then again it has to be considered that a production site could use metallic feedstock from different sources, which would also lead to different chemical classes, even though the watchcases would originate from the same production site. Chemical links between two watchcases were based on the level of the alloy production itself, and not strictly on the watchcase production. This points to the importance to gather information on how counterfeiters access the raw material. Generally, the more knowledge we acquire, the better we can interpret the analytical results within their context to actively transform the data into intelligence.

For the most part, there was no correspondence between the chemical and physical links. The chemical profiling therefore added knowledge, that was previously unknown. Furthermore, these links informed on the production of the watch cases, which took place prior to the tagging of the different components. This supports the hypothesis that the production of the watchcases and the subsequent tagging with imprints take

place at different stages. Additionally, the watchcases could be produced at several production sites, as supported by the chemical classes, and then distributed towards multiple and independent production sites.
Nevertheless, a number of chemical links were confirmed by the physical ones. This was primarily true if the watches had already been visually indistinguishable with the same seizure context. Chances are high that they were purchased at the same place and originated from a same production and assembly line.
On the other hand, both chemically linked watches without physical links, and physically linked watches without chemical links were found. This again supports the hypothesis of a large-scale organised network. The proposition was made, that several watchcase producers supply multiple assembly sites, that has at disposal the tools for the tagging of the cases and the straps. This is supported by the fact that there has been a general concordance between the physical links of these two components.

Conclusion

This section presents a conclusion of the results, the production of intelligence as well as the limitations, recommendations and perspectives arising from this research.
Although the analytical results were very satisfactory, the methodology based on ICP-MS analysis involved a very laborious sample preparation. It would be beneficial to dispose of a simpler, faster, reliable and non-/less-destructive technique. The capabilities of portable, easy-to-use systems, such as XRF analysis, should be further studied. Even if the inner composition (without surface layer) could not be measured, a preliminary classification due to differences in the chemical composition could be obtained and useful information could be extracted. The developed chemical profiling method also has to be tested on a larger sample and validated with new seizures. The use of a certain batch of an alloy will run out at one point and the metallic composition of a same production source will change. It would be necessary to analyse a large sample from seizures over an extended period to study the lifetime of a chemical profile. Nonetheless, the analytical approach enabled to obtain reliable data on the chemical composition of watchcases. Furthermore, the analytical results allowed us to group samples into classes according to their chemical resemblance.
The methodology focussing on physical features applied by the FHS offers information that can be gathered on each part of the counterfeit watch. Nevertheless, the interpretation of the relationships based on the different components also complicates the understanding of the tagging process of the watch as a whole. This research provided working strategies to optimize the content of information that can be gathered from the physical profiling of imprints. It was useful to separate the clasps and the crowns from the other imprints, since we found out that these particular imprints originated from different, large-scale production lines. Another useful aspect for the interpretation of the results was the classification of the imprints regarding their specificities. Brand-specific imprints only reveal links between counterfeit watches of the same brand, and model-specific imprints only link between watches of the same

model. Model-specific imprints were generally found on the dials. Non-specific imprints could reveal links between counterfeits of different brands. It would be interesting to find out whether links between counterfeit watches of different brands exist. In this sense, a major opportunity of chemical profiling of watchcases is the possibility to reveal brand independent links. It is currently not known whether the production and tagging of counterfeit watches of different brands is the fruit of specialization or rather diversification.

Every source of information (chemical, physical, temporal) resulted in an added-value of knowledge, but on different levels. The contextualization supported the hypothesis that the production of the component parts and the tagging with imprints of the watches took place at different stages. Moreover, results indicated a potentially opportunistic use of the base alloys for the production of the component parts.

The limiting factor of our research was, however, the size of the specimens' set. The number of specimens was kept small, because it is more difficult to test and develop an analytical strategy on a large set of specimens. Furthermore, an additional goal was to demonstrate that a vast quantity of information can be gained from chemical profiling of watchcases from a small set of specimens in combination with the physical profiling associated to former links between these watches. The small sample size did not allow generalized conclusions regarding the production and distribution of counterfeit watches. Nonetheless, the proposed approach, based on the triangulation of information related to the traces of the production of counterfeit watches and to their distribution channels, provided valuable leads and a solid basis for further research. The general approach can be applied by analogy to other illicit market domains, facing similar problems.

Interpretation of the results and the resulting intelligence strongly depends on the circumstantial information that is available. Each player involved in anti-counterfeiting can contribute to actively gather information and hence help others to understand their findings. Forensic intelligence is the process of enabling the comprehension of a criminal phenomenon on the basis of the information conveyed by traces [17]. We demonstrated the use of forensic intelligence in a rather unconventional field and showed that we can add intelligence from the traces examination of counterfeit specimens that enhances the understanding on the production and distribution of counterfeit watches.

Anti-counterfeiting involves several players including right holders, customs officials, law enforcement, legislators, IP agencies and many more. Our research exemplified a general approach, demonstrating that forensic science can actively contribute to gather intelligence on illicit markets and therefore add knowledge to the 'big picture'.

Bibliography

1. Phillips, T., *Knockoff: The Deadly Trade in Counterfeit Goods*. 2005: Kogan Page Business Books.
2. *Trade in Counterfeit and Pirated Goods: Mapping the Economic Impact*. 2016, OECD/EUIPO: Paris.
3. Wall, D.S. and J. Large, *Jailhouse frocks: Locating the public interest in policing counterfeit luxury fashion goods.* The British Journal of Criminology, 2010. **50**(6): p. 1094-1116.
4. *The Economic Impact of Counterfeiting and Piracy*. 2008, OECD: Paris.
5. Savona, E., M. Riccardi, and (Eds.), *From illegal markets to legitimate business: the portfolio of organised crime in Europe. Final Report of Project OCP- Organised Crime Portfolio*. 2015, Trento: Transcrime – Università degli Studi di Trento.
6. Commuri, S., *The Impact of Counterfeiting on Genuine-Item Consumers' Brand Relationships.* Journal of Marketing, 2009. **73**(3): p. 86-98.
7. Staake, T., F. Thiesse, and E. Fleisch, *The emergence of counterfeit trade: a literature review.* European Journal of Marketing, 2009. **43**(3/4): p. 320-349.
8. Margot, P., *Traceology: The trace as the fundamental vector of police science/forensic science.* Revue Internationale de Criminologie et de Police Technique et Scientifique, 2014. **67**(1): p. 72-97.
9. Morelato, M., et al., *Forensic intelligence framework-Part I: Induction of a transversal model by comparing illicit drugs and false identity documents monitoring.* Forensic Science International, 2014. **236**: p. 181-190.
10. Roux, C., F. Crispino, and O. Ribaux, *From forensics to forensic science.* Current Issues Crim. Just., 2012. **24**: p. 7.
11. Ribaux, O., et al., *Forensic Intelligence*, in *Professional Issues in Forensic Science*, M. Houck, Editor. 2015.
12. Esseiva, P., et al., *Forensic drug Intelligence: An important tool in law enforcement.* Forensic Science International, 2007. **167**(2-3): p. 247-254.
13. Dégardin, K., Y. Roggo, and P. Margot, *Understanding and fighting the medicine counterfeit market.* Journal of Pharmaceutical and Biomedical Analysis, 2014. **87**: p. 167-175.
14. Dégardin, K., Y. Roggo, and P. Margot, *Forensic intelligence for medicine anti-counterfeiting.* Forensic science international, 2015. **248**: p. 15-32.
15. Hochholdinger, S., et al., *Elemental analysis for profiling counterfeit watches.* Forensic Science International, 2019. **298**: p. 177-185.
16. *Annual Report*. 2015, Federation of the Swiss Watch Industry.
17. Ribaux, O. and P. Margot, *Case based reasoning in criminal intelligence using forensic case data.* Science and Justice - Journal of the Forensic Science Society, 2003. **43**(3): p. 135-143.