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## Latent Dirichlet allocation (LDA) for topic modeling of the CFPB consumer complaints



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### ABSTRACT

The Consumer Financial Protection Bureau (CFPB), created by congress in 2011, receives and processes consumer complaints pertaining to various financial services. Every complaint narrative provides insight into problems that consumers are experiencing. With increasing number of the CFPB complaint narratives, manual review of these documents by human experts is not feasible. This requires an intelligent system to analyze narratives automatically and provide insightful knowledge to the experts. In this paper, we propose an intelligent approach based on latent Dirichlet allocation (LDA) to analyze the CFPB consumer complaints. **The proposed approach aims to extract latent topics in the CFPB complaint narratives, and explores their associated trends over time.** The time trends will then be used to evaluate the effectiveness of the CFPB regulations and expectations on financial institutions in creating a consumer oriented culture. The technology-human partnership between the proposed approach and the CFPB experts could certainly improve consumer experience by providing more efficient and effective investigations of consumer complaint narratives.

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## 1. Introduction

In 2011 the CFPB was created by congress to ensure the protection of consumer interests in many financial markets. The CFPB receives and processes consumer complaints pertaining to various financial services including credit cards, mortgages, bank accounts, student loans, consumer loans, credit reports, payday loans, and debt collection. The raw consumer complaints data is updated every night and publicly available to download from the CFPB's website.<sup>1</sup> This database, known as the largest public collection of consumer financial complaints, includes basic information about the complaints such as submission date, consumer's zip code, the company, the product type, the relevant issue, the consumer narratives, and how the company has addressed the complaint. Making the data publicly available not only allows the financial institutions and their consumers to view the overall quality of their financial products and services, but also encourages public users such as analysts, data scientists and academicians to explore this information, and build on valuable insights accordingly. Nonetheless, there

have been very few published works documenting formal analysis of CFPB database. In the following, a review of these studies is provided.

Ayres, Lingwall, and Steinway (2013) investigate an early analysis of the CFPB consumer complaints at company-specific level as well as zip code demographics level. Their company-specific results demonstrate that companies such as Bank of America, Citibank, and PNC Bank were significantly (at 10% significance level) less timely in responding to complaints than the average of financial institutions. Additionally, their results provide a list of companies including Wells Fargo, American Express, and Bank of America whose consumers are significantly more likely than the average consumers to dispute the company's response. Using the zip code information associated with the consumer complaints and the census zip code tabulation areas (ZCTA), they were able to approximate the demographics information with complaints. Subsequently, their regression analysis on the zip code demographics information indicates that the mortgage complaints significantly increased in zip codes with larger proportions of certain populations such as senior citizens, and high school and college graduates.

Littwin (2015) takes a different perspective from Ayres et al. (2013) in analyzing the CFPB database at the government agencies level, i.e., the author explores the reasons why government agencies should process the CFPB consumer

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<sup>1</sup> <http://www.consumerfinance.gov/data-research/consumer-complaints/>.

**Table 1**

Comparison of various text corpora modeling techniques in terms of their advantages and disadvantages in the CFPB consumer complaint narratives.

	Dimensionality reduction	Semantic annotation	Mixture modeling	Generalization ability
tf-idf	✓	✗	✗	✗
LSA	✓	✓	✗	✗
pLSA	✓	✓	✓	✗
LDA	✓	✓	✓	✓

complaints and whether these reasons justify the resources that complaint processing requires. She investigates three reasons to process the CFPB consumer complaints, namely to settle consumer disputes, to inform the government agency's regulatory activities, and to generate good will for the government agency. Her regression based analysis demonstrates that (1) the CFPB has been successful in providing a dispute resolution forum for the consumers, (2) the CFPB is strong on regulatory activities and displays a significant commitment in ensuring the consumers' complaints are handled by the relevant companies, and (3) there is good will associated with the CFPB activities.

Although Ayres et al. (2013) and Littwin (2015) obtain interesting results from consumer complaints data that should be of interest to the CFPB, financial companies, and their consumers, as yet, there has been no examination of consumer complaint narratives in the literature. These narratives provide context to complaints upon which more interesting insights could be built, potentially delivering valuable informational resources to the financial community. This requires scholars to review the CFPB complaint narratives in order to extract insights from the documents. The amount of narratives received by the CFPB has been increasing over time. With an increasing rate of the CFPB complaint narratives, there is a need for efficient procedures to review and analyze the narratives. Manual review of such a large volume of documents by humans is not feasible as it is a time-consuming process and often subject to human biases.

One trivial solution to the above challenge is labeling the narratives based upon their context at the time of submission. The CFPB has designed a drop-down menu at the CFPB complaint submission portal which allows consumers to choose what issue (e.g. Bankruptcy, Billing disputes, etc.) their narratives are about. These issues are predetermined labels defined by the CFPB experts which describe the primary reason for the consumer complaints. This is the CFPB convention in labeling the consumer complaints. However, this CFPB convention appears to have two shortcomings. First, the consumer selects the label best describing the complaint issue from the drop-down menu. Due to the consumer's lack of knowledge or understanding of the labels, a wrong label (mislabeling) might be selected, or the actual issue that the complaint concerns might not be described by the labels provided in the drop-down menu. As such, the consumer would be forced to select a label that does not best describe the issue. Second, the consumer complaint might be about multiple issues (labels), but due to the limitation of CFPB labeling convention, only one label can be selected.

To overcome the shortcomings of the CFPB labeling convention, there is a need for an effective expert/intelligent system to analyze the complaint data. Expert systems are computer programs that use domain-specific knowledge to facilitate reasoning process of human experts (Forsyth & Rada, 1986). Incorporation of an intelligent system into analysis of the complaints is required as it allows the CFPB experts to analyze narratives automatically and provide insightful knowledge to the CFPB. The intelligent approach helps the CFPB identify top topics/issues, explores their associated trends over time, and stops these issues before becoming bigger problems. The insights from the intelligent system can then be used by human experts to evaluate the effectiveness of

the CFPB regulations and expectations on financial institutions in creating a consumer oriented culture. To analyze the complaint narratives, the intelligent system can be developed based on text mining approaches. Text mining refers to the process of extracting non-trivial patterns or knowledge from unstructured text documents (Aggarwal & Zhai, 2012). Text mining is a much more complex task than data mining (for example the analyses reported in Ayres et al. (2013) and Littwin (2015)) as it involves handling text data that is inherently unstructured and noisy, especially in the realm of consumer complaints.

This paper aims to demonstrate the utility of text mining approaches in analyzing textual data contained in the CFPB consumer complaint narratives. To the best of authors' knowledge, there has been no published paper analyzing the CFPB complaint narratives by text mining approaches. However, there have been previous research works exploring the use of text mining techniques in decoding consumer complaints related to other fields such as the National Highway Traffic Safety Administration's (NHTSA) (Ghazizadeh, McDonald, & Lee, 2014), virtual travel agencies (Lehto, Park, Park, & Lehto, 2007), low-cost airlines or low-cost carriers (LCCs) (Yee & Pei, 2014), the hotel industry (Berezina, Bilgihan, Cobanoglu, & Okumus, 2016), and e-auction stores (Chen, 2011). These studies utilize semi-automated, or fully automated approaches on the textual narrative data to extract and identify coherent insights/topics in their fields. A review of the above text mining approaches is provided in Table 1, and their advantages and disadvantages for the CFPB complaints analysis are discussed in the following.

The most basic approach is the popular tf-idf scheme (Salton & McGill, 1983), which counts the number of occurrences of each word for each document and applies appropriate normalization on the frequencies of the words. The final result of tf-idf is a term-document matrix whose columns contain the normalized frequency of the words for each of the documents in the corpus.

Although the above approach reduces documents of arbitrary length into a fixed-length of the unique words in the corpus, it is not really helpful where the number of unique words is very large (e.g. millions which is very common in practice). Deerwester, Dumais, Furnas, Landauer, and Harshman (1990) proposed latent semantic analysis (LSA), which is an effective dimensionality reduction method on the term-document matrix using singular value decomposition. This approach can achieve significant compression in large collections while capturing some aspects of basic linguistic notions. However, the main shortcoming of LSA is the lack of fitting a model to data to represent the documents into multiple topics (also known as mixture modeling). Hence, the extracted features with LSA may not represent the context of the narrative effectively. It is very likely that a consumer narrative shares multiple topics, i.e., the consumer might be complaining about multiple subjects (Section 3.2 and Fig. 4 provide an explanatory example on a narrative sharing multiple topics). Therefore, **there is a need for a text mining approach that overcomes this issue by assigning multiple topics to consumer narratives.**

A significant improvement in this regard was initiated from Hofmann (1999) by developing a probabilistic LSA model (pLSA). The pLSA approach assigns a probabilistic mixture model to the

words in a document, where the mixture components are viewed as representation of topics. Although pLSA is capable of assigning multiple topics to a document, it cannot generalize to unseen documents due to lack of a well-defined generative model (Blei, Ng, & Jordan, 2003). Moreover, it has been shown that pLSA is prone to overfitting and, empirically, overfitting is indeed a serious problem (Blei et al., 2003). Hence, pLSA is not an appealing approach for analysis of the consumer complaints.

This paper utilizes a probabilistic topic modeling approach known as latent Dirichlet allocation (LDA) (Blei et al., 2003) for the CFPB consumer complaint narratives. The LDA approach extracts the latent topics from the consumer complaint narratives (dimensionality reduction), and simultaneously assigns a probabilistic mixture of these topics into the consumer complaints (mixture modeling). The LDA approach does not require any prior annotations about the consumer narratives; instead the topics are learned from the analysis of the original texts (semantic annotation). Moreover, the LDA model can be used for assigning topics to the new CFPB consumer narratives that will be received in the future (generalization ability).

LDA based topic modeling has been applied to different kinds of text data including email (Blei, Carin, & Dunson, 2010), scientific abstracts (Griffiths & Steyvers, 2004), and newspaper archives (Wei & Croft, 2006). Interesting applications of LDA have also been reported as a powerful technique to create knowledge and discover useful structure in a stream of literature (Song et al., 2018; Asgari & Bastani, 2017). To our best knowledge, this is the first study exploring the utility of LDA on consumer complaint narratives provided by the CFPB datasets. The LDA approach enables us to classify unstructured consumer complaints into a mixture of topics through which their underlying content would be revealed. This task would not be possible by human annotations as it requires reading the full text of the narratives, and identifying the similarities between them, which is very difficult and time consuming. These topics are learned from the analysis of the complaint narratives with no need for input from the consumers on the issue. Therefore, the existing challenges with the CFPB labeling convention can potentially be addressed effectively.

Furthermore, it would be possible to reveal the trends of these topics over time, and evaluate the effectiveness of the CFPB regulations and financial companies in addressing these topics. For example, if it is observed that a topic trend is decreasing over time it could indicate that the CFPB regulations have taken the relevant topic into account, and the companies have been able to improve their customer service with respect to that topic. In the following, the LDA based approach is proposed for topic modeling of CFPB consumer complaints, and the results of this analysis are presented and discussed subsequently.

## 2. LDA based topic modeling to the CFPB complaint narratives

### 2.1. Preparing consumer complaint narrative data

The CFPB consumer complaint database is publicly available and can be downloaded through the CFPB website.<sup>2</sup> This Database is a collection of 615,273 complaint records including certain information for each complaint such as the date of submission, the product and the issue the complaint is about, the company the complaint was sent to for response, etc. Additionally there is a consumer complaint narrative filed in the database including the consumer descriptions of what happened. However, this field is not populated for all the records as it is available only if the consumer

opts to share. This paper focuses exclusively on consumer complaint narratives. Hence, after removing the records with no consumer complaint narratives; the total of 88,295 records remained. It was also observed that from the remaining records, 1492 narratives were repetition of others, hence the repetitive records were excluded, to provide the total of 86,803 records for our text mining analysis. The distribution of consumer narratives by number of words is shown in Fig. 1. The average number of words among all documents is 193, and the median is 138. More than 95% of the narratives have length of at least 30 words which is large enough to be analyzed by LDA. Consequently, the narratives with total number of words less than 30 were removed from our analysis.

### 2.2. Data preprocessing

The proposed text mining analysis starts with preprocessing the data obtained from Section 2.1. Before presenting the data preprocessing tasks, the terminologies used throughout the paper are introduced. A *document* which is defined as a sequence of words and punctuation, refers to any consumer complaint narrative from the CFPB dataset. In our text mining analysis, there are 86,803 documents consistent with the number of records available in the consumer complaint narrative data. A term is defined as a word, however term and word are interchangeably used throughout this paper. The term-document matrix is a matrix projecting the terms found among all the 86,803 documents into the individual documents. Each row of the term-document matrix corresponds to a term, and each column corresponds to a document. The values in the matrix cells present the frequency of each term in each document.

Our data preprocessing includes five tasks (see Fig. 2 for the summary of these tasks), namely, (1) convert to lowercase, (2) remove special characters and tokenize them into terms, (3) remove stop words, (4) stemming, and (5) construct term-document matrix. The details of each of these tasks is explained in the following. In Step 1 all the documents are converted into lowercase to provide a consistent format for all the documents. Step 2 removes the special characters including punctuation marks (e.g. !%\$&\*?,.;") and numbers, as they never contribute to our text mining analysis, and then tokenizes the document into terms. Step 3 is the major task in our data preprocessing. Stop words are generally a set of commonly used words in any language (here English) that should be removed from the document, in order to make the focus on the important words instead. In this analysis two types of stop words, namely, generic stop words (some common words, such as "a", "an", "is", etc.), and domain specific stop words, are defined.

There is no specific rule in identifying the domain specific words, and it requires a thorough consideration of the objectives of our text mining analysis as well as the domain knowledge. The aim of our analysis is to extract the latent topics from the consumer narratives, hence it would make sense to exclude the companies' names from the documents. This is so, as it is observed that the names of the companies appear so frequently in the full text of the consumer complaints, and that those names essentially do not convey any meaningful message for our topic modeling. Hence, the companies' names (e.g., Bank of America, Wells Fargo, Citibank) were included in the stop words set. Similar to the companies' names, it was found that state names do not contribute to the topic modeling as well and therefore they were also included in the stop words set. More importantly, the CFPB applies masking to the consumer complaint narratives to protect consumers' personal identifiable information or personal sensitive information. As a result, in the text of the consumer narratives, the words "xx" "xxxx" and "xxxxxxxx" appear too frequently for the masking purposes, thus, the stop words set also include these words.

<sup>2</sup> <http://www.consumerfinance.gov/data-research/consumer-complaints/#download-the-data>.

### Distribution of Consumer Narratives by Number of Words

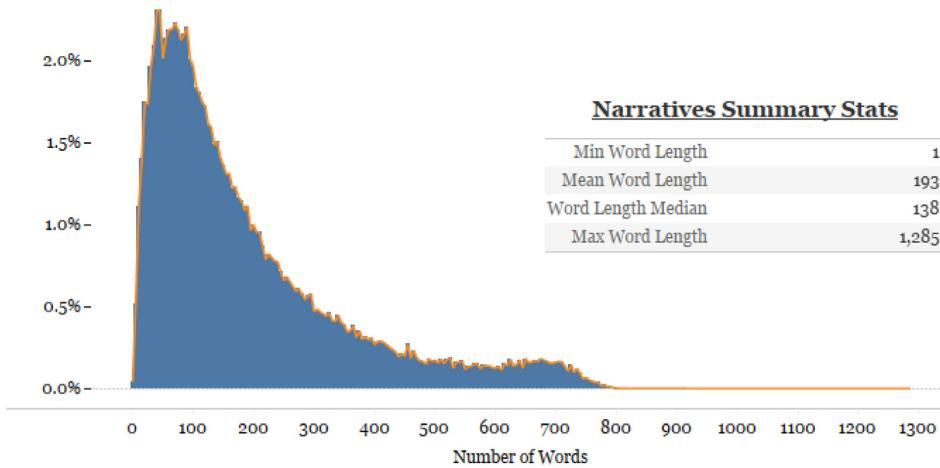


Fig. 1. Distribution of the CFPB consumer narratives by number of words.

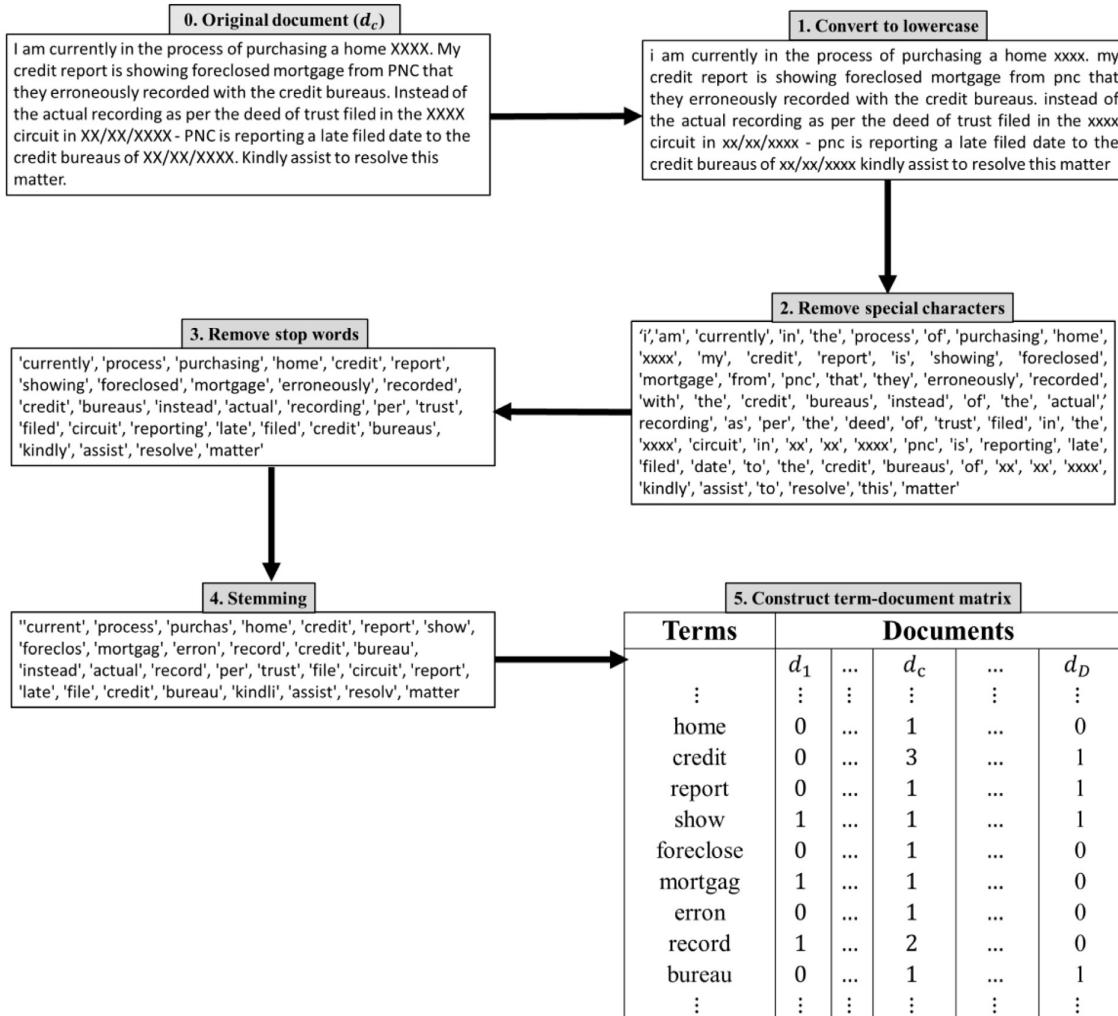


Fig. 2. Data preprocessing tasks for a consumer complaint narrative with complaint ID 1438325 (denoted by document  $d_c$ ). The construct term-document matrix task in this figure is a snapshot from the whole matrix including the frequency of some of the terms in document  $d_c$ .

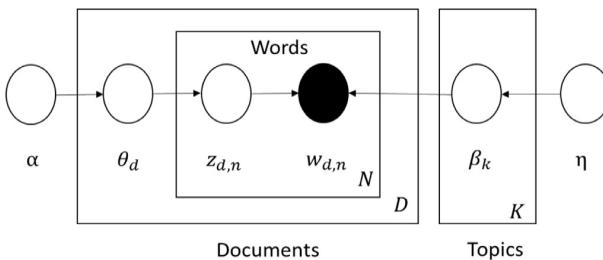
The goal of Step 4, stemming, is to reduce the variation in the text data by converting words to their common base form/word stem. For example, “finance”, “financial”, “finances” and “financing” were converted to “financ”. The stemming step is very common in text mining analysis as it helps concentrate the analysis on the base form of the words, rather than differentiating between variations of the words that might cause confusion to the text mining algorithms. The last task in data preprocessing is Step 5: constructing the term-document matrix. This matrix presents the distribution/frequency of terms (rows) within documents (columns) which is used as the main input to LDA algorithm.

Preprocessing is a very important step in our analysis as it reduces noise from the data that may severely affect the performance of LDA. Apart from noise, there are several redundant words that should also be removed. This is because these words appear so frequently in the full text of the consumer complaints, and essentially do not convey any meaningful message for our topic modeling. Not removing these words will affect the overall semantic of the extracted topics, hence, LDA will not be able to annotate the narratives effectively. A general overview of the LDA approach is presented in the following Section.

### 2.3. Latent Dirichlet allocation (LDA)

LDA was first developed by Blei et al. (2003) as a generative probabilistic modeling approach to reveal hidden semantic structures in a collection of textual documents. The basic idea is that each document exhibits a mixture of latent topics wherein each topic is characterized by a distribution over the words (unique words in the collection of documents), and the relative importance of the topics—captured in the form of different weights—vary from document to document. The underlying generative process of LDA is illustrated in Fig. 3, and the corresponding variables are pictorially explained in Fig. 4.

As shown in Fig. 3, the words within documents  $w_{d,n} \forall n = 1, \dots, N, \forall d = 1, \dots, D$ , are observable variables (any words in the collection of complaint narratives in Fig. 4), while the other components, consisting of the topics  $\beta_k \forall k = 1, \dots, K$  (the distributions over words at top right of Fig. 4), the topic distribution per document  $\theta_d \forall d = 1, \dots, D$  (the histogram at the bottom right of Fig. 4), and the per-word topic assignment  $z_{1:D, 1:N}$  (the colored words in Fig. 4), are not known. These latter items represent unobservable/hidden variables (white circles in Fig. 3), that should be estimated from the analysis of observable variables (shaded circles in Fig. 3). Parameters  $\eta$  and  $\alpha$  are the hyperparameters for prior distributions of  $\beta_k$  and  $\theta_d$ , respectively. As such, the values larger than one for these hyperparameters lead to smooth distributions over topics or words, whereas values below one result in sparse distributions over a few topics or words. The boxes represent the plate notations used to illustrate the replications, i.e., the  $K$  plate denotes the number of topics, the  $N$  plate denotes the total number of unique words within documents, and the  $D$  plate denotes the number of documents.



**Fig. 3.** Latent Dirichlet allocation (LDA) for topic modeling.

The arrows indicate conditional dependencies among the variables in the following fashion: per-word topic assignment  $z_{1:D, 1:N}$  is dependent on the topic distribution per document  $\theta_d$ , and the observed word in each document  $w_{d,n}$  is dependent on  $z_{1:D, 1:N}$  and all the topics  $\beta_k$ 's. The conditional dependencies allow us to define the joint distribution of observed and unobserved variables. Consequently, LDA has the notable benefit of utilizing Bayesian learning to infer unobservable constructs by computing their posterior distribution from the joint distribution. Learning the unobservable variables enables us to elucidate the semantic structure hidden in the documents. More specifically, LDA provides two main outputs, namely, topics  $\beta_k$  and their weights (importance) in each document  $\theta_d$ . Fig. 4 illustrates explanatory outputs of LDA on a collection of complaint narratives in the CFPB dataset. Due to space limitations for this illustration, the outputs include only a single narrative, as presented in Fig. 4. The outputs themselves consist of the three topics exhibiting the largest weights, wherein each topic is represented as a combination of top three words with the highest probability of occurrence. However, to deliver the content of the topics more precisely, it would be helpful to label them. In other words, using human judgments and intervention, the topics can be labeled based on the semantic similarities of their major words (Chang, Gerrish, Wang, Boyd-Graber, & Blei, 2009). In this correspondence, the labels associated to these three topics are also provided in the figure.

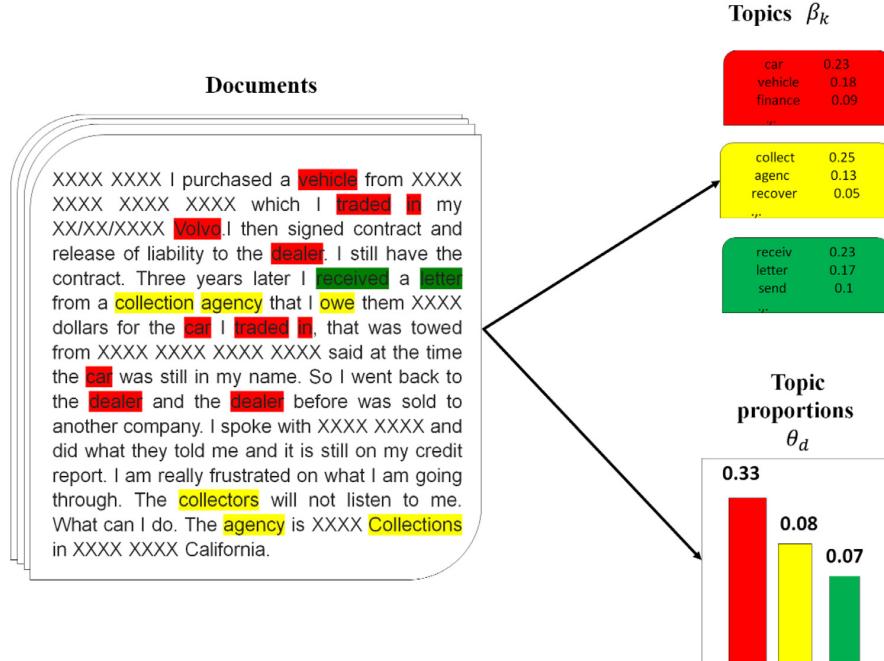
Fig. 4 illustrates the use of LDA in exploring a large volume of documents. Here, instead of dealing with whole texts, which is a time-consuming task, each document is represented as a combination of the topics extracted by LDA. Since the importance of each topic to each document is learned by LDA, it is possible to identify which composition of topics best represents the essence of each document. In other words, each document can be summarized as a combination of topics with the largest weights (e.g. top three topics in Fig. 4). This makes LDA an appealing method to automatically review and explore large volume of complaint narratives received by the CFPB and overcome the burdens associated to the labeling convention of the CFPB.

## 3. Topic modeling for CFPB consumer complaints

### 3.1. Topic modeling implementations

Both data preprocessing tasks and LDA analysis were conducted in Python. The nltk library (Joakim, 2012) was used to preprocess the complaint narratives following the tasks explained in Section 2.2. The term-document matrix is the outcome of these tasks which is imported into the genism Python library (<http://radimrehurek.com/gensim>) for conducting LDA analysis. As shown in Fig. 3, the LDA algorithm requires inputs for two specific hyperparameters,  $\alpha$  and  $\eta$ , and the number of topics  $K$ . The hyperparameters in LDA are both smoothing parameters on the distributions:  $\alpha$  is a topic smoothing parameter, and  $\eta$  is a word/term smoothing parameter. Values larger than one for these parameters lead to more even distributions, whereas values below one result in more concentrated distributions over topics or words. As suggested from most of the topic modeling analyses in the literature (Blei, 2012; Blei et al., 2010; Blei et al., 2003; Kaplan & Vakili, 2015), a value of 0.1 for both hyperparameters results in semantically meaningful topics. This has been verified through our numerical analysis; it was observed that a default value 0.1 for these hyperparameters  $\alpha$  and  $\eta$  lead to more meaningful outcomes.

The LDA algorithm also requires the number of topics  $K$  as input. Many of the topic modeling analyses using LDA in literature (Blei, 2012; Blei et al., 2010; Blei et al., 2003; Kaplan & Vakili, 2015) determine the number of topics by trial and error procedures. They try different values for  $K$ , and select the value pro-



**Fig. 4.** Illustrative example of LDA components and outputs on a complaint narrative with complaint ID 1313544. In this example,  $wd$ ,  $n$  denotes any words in the complaint narrative, e.g. "car", and  $z_{d,n}$  shows per-word topic assignment, e.g. the word "car" is assigned to topic 1 (red color), hence,  $z_{d,n} = 1$ . The complaint narrative is summarized as a mixture of top three topics  $\beta_1$ ,  $\beta_2$ , and  $\beta_3$  with the highest weights (proportions) denoted by  $\theta_d$  and shown in the histogram at the bottom right of the figure. Each topic is a distribution over the words; e.g.  $\beta_1$  is a distribution over "car", "vehicle" and "finance" with the probability of 0.23, 0.18, and 0.09 (only top three words with the highest probabilities are shown due to space limit). Labels of the topics are as follows: Auto loan/dealership, collection agency, and communication.

ducing more meaningful topics as outcome (the typical number selected is 100). Recently a novel nonparametric Bayesian topic modeling algorithm named as hierarchical Dirichlet processes (HDP) has been developed (Teh, Jordan, Beal, & Blei, 2012), which is capable of determining the number of topics on its own during posterior inferences. However, the performance of HDP was not as good as LDA in terms of generating semantically meaningful topics. Hence, the LDA algorithm was preferred for the CFPB topic modeling in this paper. Following trial and error procedures,  $K=40$  was selected as it provided more meaningful topics.

### 3.2. Topic representation and assignments for CFPB consumer complaints

The outcomes of LDA algorithm are topics  $\beta_k$ , per-document topic assignments  $z_{d,n}$ , and topic proportions  $\theta_d$ . The results of LDA analysis on the CFPB consumer complaints are presented in the following. Topic outcomes are shown in Table 2. As discussed earlier, the topics are distributions over words; the top ten words with the highest probability (most frequency) derived from posterior distribution  $\beta_k$  ( $\forall k=1, \dots, K$ ) are provided for each topic in Table 2. However, in order to characterize the underlying content of the topics, it would be easier to label them rather than presenting them as combinations of words. Unfortunately automatic labeling of topics is not possible as discovering the topics is an unsupervised learning process. It rather requires human judgments and intervention to examine the coherence and meaningfulness of the topics, and subsequently label them through their judgment (Chang et al., 2009). As a result, after extracting the topics using LDA, the authors validated and labeled the topics, which can be seen in the third column of Table 2.

The next outcomes from LDA are per-document topic assignments  $z_{d,n}$ , and topic proportions  $\theta_d$ . In the context of

the CFPB, it would be interesting to represent the topics associated with each complaint, along with their proportions (relevance). There were 86,803 consumer complaints analyzed in this paper. Therefore presenting the topic assignments for each of these documents is not practical. Fig. 4 illustrates one example from consumer complaint narratives in the CFPB dataset, and the outcomes of LDA on topic assignment and proportions. The complaint ID related to this narrative is 1313522, which is about a company called Data Line Credit Corp. The top five topics with highest proportions assigned to this narrative are: Auto Loan/Dealership (0.325), Collection Agency (0.082), Communication (0.073), Credit Reporting (0.063), and Customer Service (0.061).

The relevant words for each of the topics in the narrative are colored in correspondence with their associated topics. From these words, it can be verified that LDA has successfully determined the relevant topics, since the words related to the topic of Auto Loan/Dealership (e.g. vehicle, Volvo, trade in, dealer, car) appears more often in the narrative compared to the words related to other topics. Hence, LDA assigned the highest proportion to this topic, and following the same logic, it assigned the other topic proportions based on the frequency of their relevant words appeared in the narrative. A more detailed and informative visualization (viz) is available on Tableau public at the following link:

<https://public.tableau.com/profile/hamed#/vizhome/CFPBTopicModeling/CFPBTopicModeling>.

This viz enables users to explore all the extracted topics from the CFPB, as well as review the topic assignments for each of the consumer complaints. Furthermore as this is an interactive viz, users are able to select the financial companies they are interested in to evaluate the most frequent topics involved with their consumer complaints. Thus it is possible to identify the quality and customer satisfaction issues with these financial companies, and investigate how they have been responsive over time to these

**Table 2**

Extracted topics for the CFPB consumer complaints using LDA.

ID	Topics	Label
0	Payment late made due make appli month past day miss	Payment/late payment
1	Receiv letter sent send mail state request email document notic	Communication
2	Loan student borrow privat navient repay lender default defer forbear	Loan/Student Loan
3	Car vehicil financ dealership dealer ticket book drive trade truck	Auto Loan/Dealership
4	Servic custom repres manag transfer spoke depart supervisor cancel speak	Customer Service
5	Check cash advanc clear return wrote flagstar seiz present payabl	Check
6	File complaint cfpb case complain respond clerk district bsi compliant	CFPB
7	Home hous equiti repair inspect buy door damag sell valu	Home Equity
8	Call phone number person stop time answer messag harass work	Harassment
9	Credit report remov bureau show neg correct inform agenc transunion	Credit Reporting
10	Co program school class colleg signer enrol student region educ	Education
11	Account close open activ statu inaccuraci limit creat past restrict	Account Management
12	Purchas express store buy product order return replac item refund	Store Purchases
13	Consum financi protect practic decept abus institut mislead reposess factor	Consumer Protection
14	Bill insur medi polici hospit cover coverag flood doctor health	Medical Debt/Bill
15	Disput item investig equifax verifi delet inform inaccur valid creditor	Dispute
16	Inquiri author unauthor fraudul tx evict code entitl hard measur	Unauthorized Inquiries
17	Famili mother incom daughter member father live parent employ sister	Family
18	Ident theft fraudul polic victim block fte stolen affidavit inform	Identity Theft
19	Modif mortgag loan foreclosur home document review incom program trial	MLMF <sup>a</sup>
20	Address name number secur social person live verifi inform licens	Address
21	Violat law act feder fair right note legal assign trust	FDCPA <sup>b</sup>
22	Credit score line limit hard maci pull drop impact affect	Credit Score
23	Agreement close contract apprais sign settlement lender cost agre valu	Settlement
24	Bankruptci file judgment court discharg chapter judgement record public includ	Bankruptcy
25	Interest rate princip refin lower high higher increas principl reduc	Interest Rate
26	Card credit use discov debit reward cancel activ visa declin	Credit and Debit Card
27	Mortgag tax escrow properti insur increas refin sold home ir	Escrow Account
28	Debt collect valid owe collector creditor origin alleg ceas settl	Debt Collector/Issue
29	Attorney court legal employ law firm serv garnish lawyer threaten	Attorney/Legal Actions
30	Husband wife ex divor heloc name primari child certif spous	Divorce and Ex-spouse
31	Fraud claim investig fraudul alert depart crimin commit activ suspect	Fraud alert
32	Charg fee overdraft refund transact revers merchant waiv assess post	Charged/Overdraft fees
33	Sale properti short liem titl releas buyer sell sold seller	Property Sale
34	Fund money deposit transact branch debit withdraw bank transfer hold	Fund and Deposit
35	Collect agenc recoveri portfolio reinsert invocio enhanc solut central erc	Collection Agency
36	Offer promot point requir bonu term benefit mile condit receiv	Rewards and Promotions
37	System onlin error websit access free site comput log correct	Online Service
38	Paid amount balanc statement owe full show total due payoff	Payoff
39	Applc approv paperwork process appli deni fill delay discrimin denial	Application

<sup>a</sup> Mortgage/Loan Modification and Foreclosure (MLMF).<sup>b</sup> Fair Debt Collection Practices Act (FDCPA) is a federal law that controls and restricts the activities of third-party debt collectors.

issues. For illustration purpose, an overview of the created viz on topic assignments is presented in Fig. 5.

On the left of the Fig. 5, the complaint ID, company, and the relevant issues of the CFPB complaints are provided. The user is able to select the complaint ID of interest, and review the corresponding complaint narratives, as well as their topic assignments and proportions (top 6 topics are presented with their proportions in the viz). For example, in this viz the complaint ID 1466606 with company NRA Group is selected (the consumer narrative related to this complaint can be found at the bottom of the viz), and the assigned topics with their proportions are shown in the right hand side of the viz.

### 3.3. The CFPB consumer complaint semantic similarities

Once the topics are extracted from the CFPB, and the topic assignments are carried out using LDA, it would be possible to investigate the semantic similarities of the CFPB consumer complaints through their topic assignments. In other words, the consumer complaints sharing the same topic are supposed to be semantically similar. The authors' Tableau viz also includes the topic similarity analysis. However, since presenting the similarities between all the complaints in the paper is not practical at all, the authors only refer to an example, but strongly suggest the readers to check the Tableau viz.

In this example the topic “Divorce and Ex-spouse” is selected to view the similarities of the CFPB consumer complaints. Note that LDA assigns a mixture of topics with various proportions to a document (consumer narrative), where the “Divorce and Ex-spouse” topic could be the first, second, or even fifth element in that mixture. Therefore, it is expected that the documents contain “Divorce and Ex-spouse” as their first or second topic (i.e., with highest or second highest proportions) should be more similar than the documents contain it as their e.g. fifth topic. Table 3 illustrates two exemplary complaints including “Divorce and Ex-marriage” as their first, third, and fifth topic.<sup>3</sup> The complaint IDs 1856929 and 1872426 both contain “Divorce and Ex-marriage” as their first topic. Reviewing their narratives indicates that the topic relevant words (e.g., ex, divorce, wife, and husband) are very common and frequent in the texts, consequently make these two narratives semantically similar. Indeed both consumers complaint about some financial issues (e.g., debt) owned by their ex-spouse, but instead they have been mistakenly affected.

Table 3 also shows “Divorce and Ex-spouse” appeared as Topic 3 (the third highest proportion) for complaint IDs 1374157 and

<sup>3</sup> The complaint narratives provided in this table might contain some typos and misspellings. The reason is that these narratives are taken exactly “as it is” from the CFPB datasets, and no editing was done in order to present the raw data to the readers.

**Table 3**

Example of the CFPB consumer narrative similarities sharing “Divorce and Ex-spouse” as Topic 1, Topic 3, and Topic 5. The topic relevant words are highlighted in yellow in the narratives.

Topic 1
Complaint ID (1856,929) – I have XXXX joint mortgages (I accumulated with my ex-wife of almost 20 years) my credit report and I only own XXXX home. On XXXX XXXX, 2011 I was amicably divorced without legal representation. My divorce decree clearly list XXXXX of the mortgages as the debt of my ex-wife. Number XXXX was gifted to my ex-wife and there is a quit claim deed on file. I have no ownership and yet I am being held hostage whenever my credit is reviewed.
Complaint ID (1872426) – This a debt that my ex husband has done and am not paying for it .my ex-husband has used my name to get a credit card in my name without my permission and am paying for a debit that is not mine we have been divorced since 2001 and I have no contact with him and I am sick and tired of getting this bills that are not mine I don't even have a credit card because of him.
Topic 3
Complaint ID (1374157) – I have a balance with Paypal Credit. This account is my account alone and not a joint account. Paypal contacted my wife and divulged all the information about the account to her. They have violated my privacy by revealing all of the information to my wife.
Complaint ID (1774899) – The associate said that my husband's credit will also be reported if I don't pay. This is for dental work I had done. My husband was my emergency contact. So I told him this is inaccurate as we both did not have work done and he said that if I don't pay that they will report my husband's credit.
Topic 5
Complaint ID (1302,942) – I have paid all copays and just rec'd a bill from a collection agency. I have never rec'd anything in the mail before on this. I called the Dr office and they say it was because visits that are being billed didn't have a referral but I always had a referral and if they told me that I would have gotten XXXX. I have attached proof that my primary care physician did send referrals. I feel as though this is some sort of way for them to bill people almost 5 years later knowing they will pay or it will kill their credit. I am in the XXXX and will be forced to pay something that is not accurate almost 5 years after the services.
Complaint ID (1291437) – Paypal XXXX XXXX has continued to call my workplace and harass me AFTER I have specifically told them to DO NOT CALL MY EMPLOYEE ever again! Our receptionist is also a witness that they continue to call and this needs to stop. It is very disruptive to my job and against our company policy!

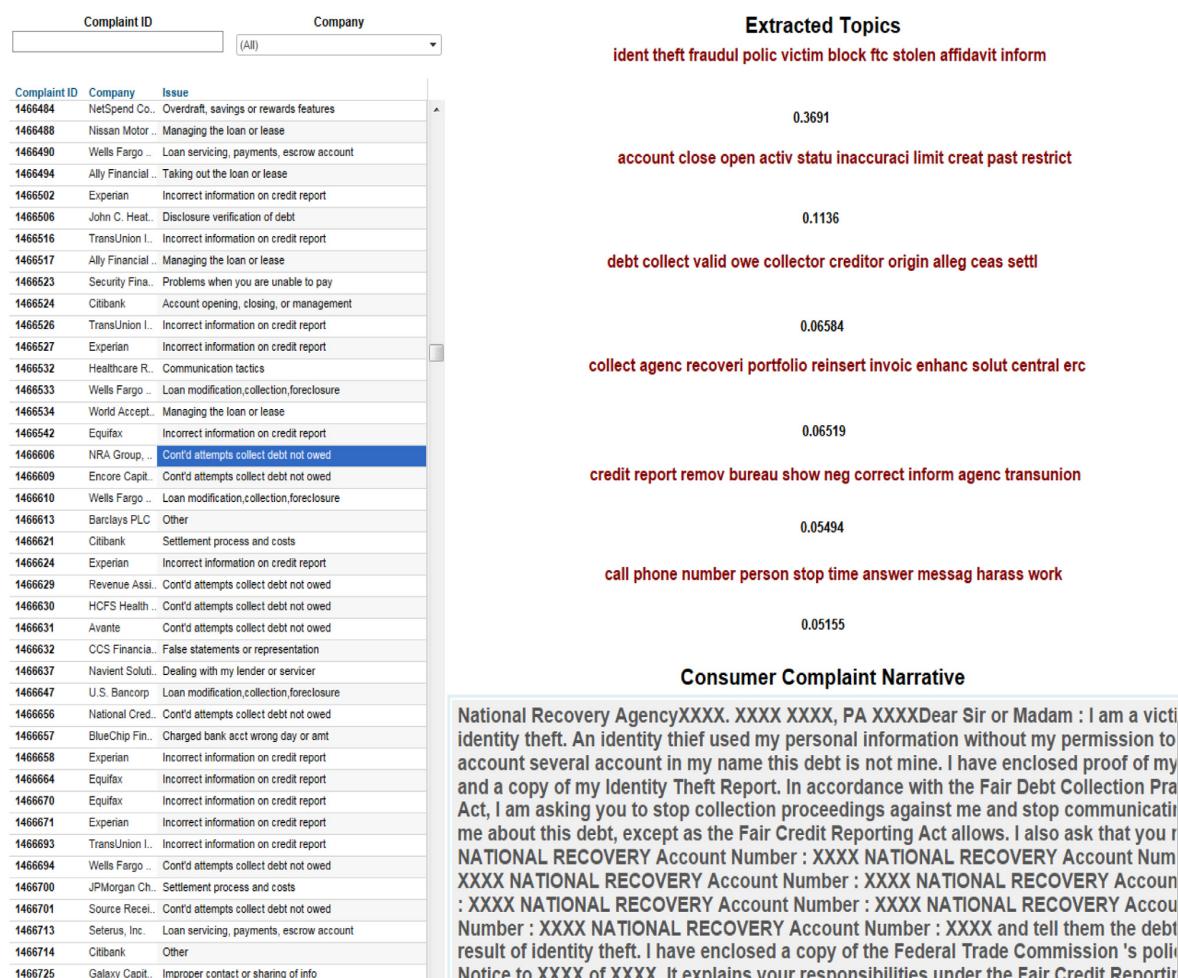


Fig. 5. Overview of the Tableau viz on topic assignments and underlying topic proportions for the CFPB consumer complaints.

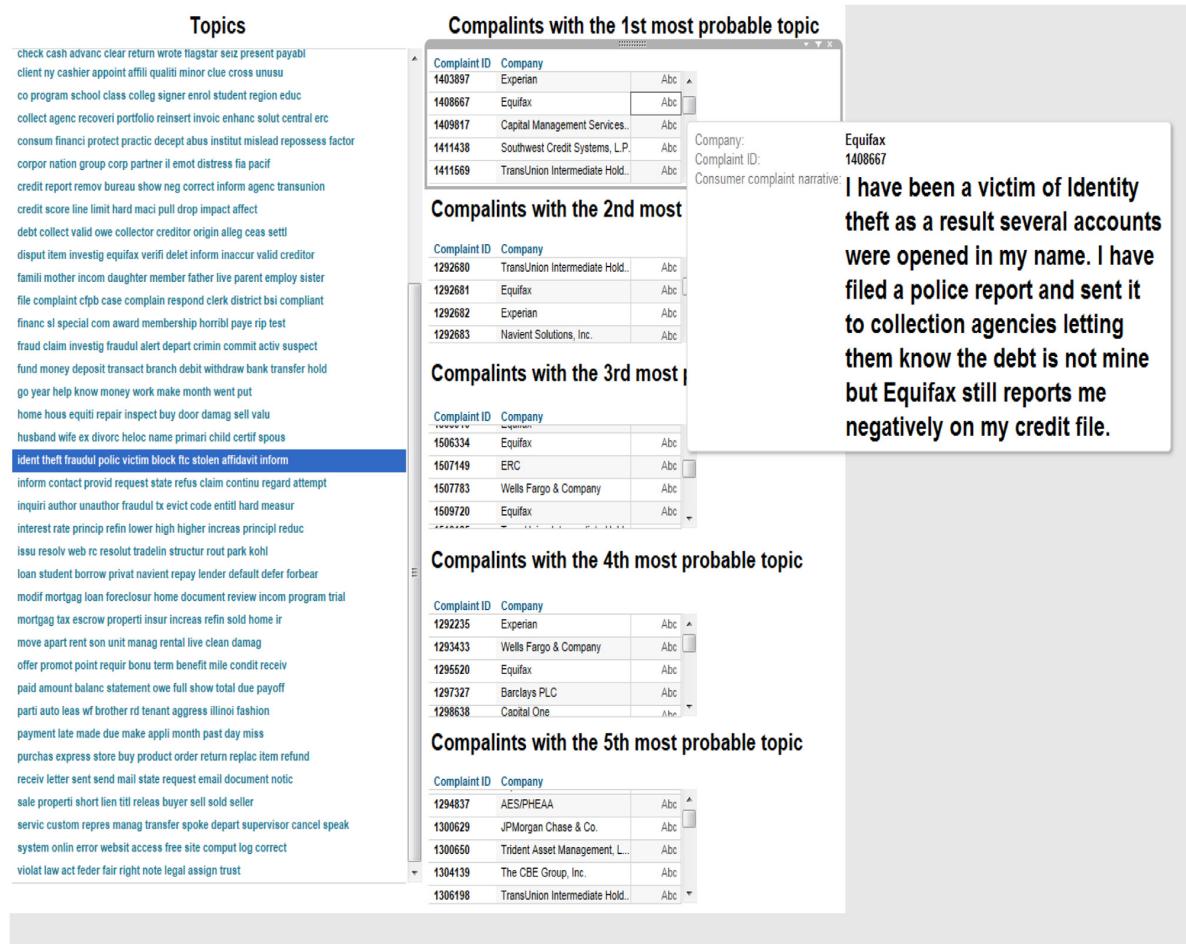


Fig. 6. Overview of the Tableau viz on semantic similarities of the CFPB consumer complaints.

1774899. The topic relevant words such as “husband” and “wife” appear not that frequently (only two appearances) in the texts. From their content it can be understood the semantic similarity between these two complaints in terms of “Divorce and Ex-marriage” is low (lower than the previous complaint IDs). But apparently since “husband” and “wife” appeared twice in both of their narratives, LDA assigns “Divorce and Ex-marriage” as the third element in the mixture of topics derived for these documents. Finally, complaint IDs 1302942 and 1291437 were assigned with Divorce and Ex-marriage as their Topic 5. Obviously it is expected that the semantic similarities in terms of this topic should be very low (the lowest in this example).

In general, this analysis verifies that the documents sharing the topics with higher level of proportions, e.g., Topic 1 or 2 are more semantically similar in terms of that topic rather than the documents holding the same topic as their Topic 4 or 5. As mentioned earlier a more comprehensive interactive analysis of the CFPB complaint similarities are provided in the Tableau viz which is available online. An overview of the created viz on document similarities is provided in Fig. 6. On the left hand side of the viz the topics are shown. By clicking on each topic, the complaint IDs related to the narratives including the selected topic as their Topic 1 (1st most probable topic), Topic 2 (2nd most probable topic), ..., Topic 5 (5th most probable topic) are updated in the viz. For example, in Fig. 6,

the user was interested in viewing the semantic similarities of the CFPB complaints containing “Identity Theft” as one of their top 5 topics. By hovering over the complaint IDs the user is able to read the raw narratives (e.g., here complaint ID 1408667), and evaluate the semantic similarities of the complaints in terms of “Identity Theft” topic.

#### 3.4. Topic popularity over time

Another benefit of LDA analysis on the CFPB consumer complaints is that since each complaint is assigned with a mixture of topics (in our analysis, the top 5 topics with highest proportions are taken into account), this facilitates analysis of the topics with respect to other fields of data in CFPB dataset. One of these fields is “Date Received” which represents the date CFPB received the consumer complaint. This field of data is particularly interesting in the sense that it would be possible to describe the frequency/popularity of the topics over time, and accordingly analyze the responsiveness of the financial companies with respect to these topics. For example, if it is observed that a topic trend is decreasing over time it will indicate that the CFPB regulations have taken into account the relevant topic, as well as the companies have been able to improve their customer service with respect to that topic.

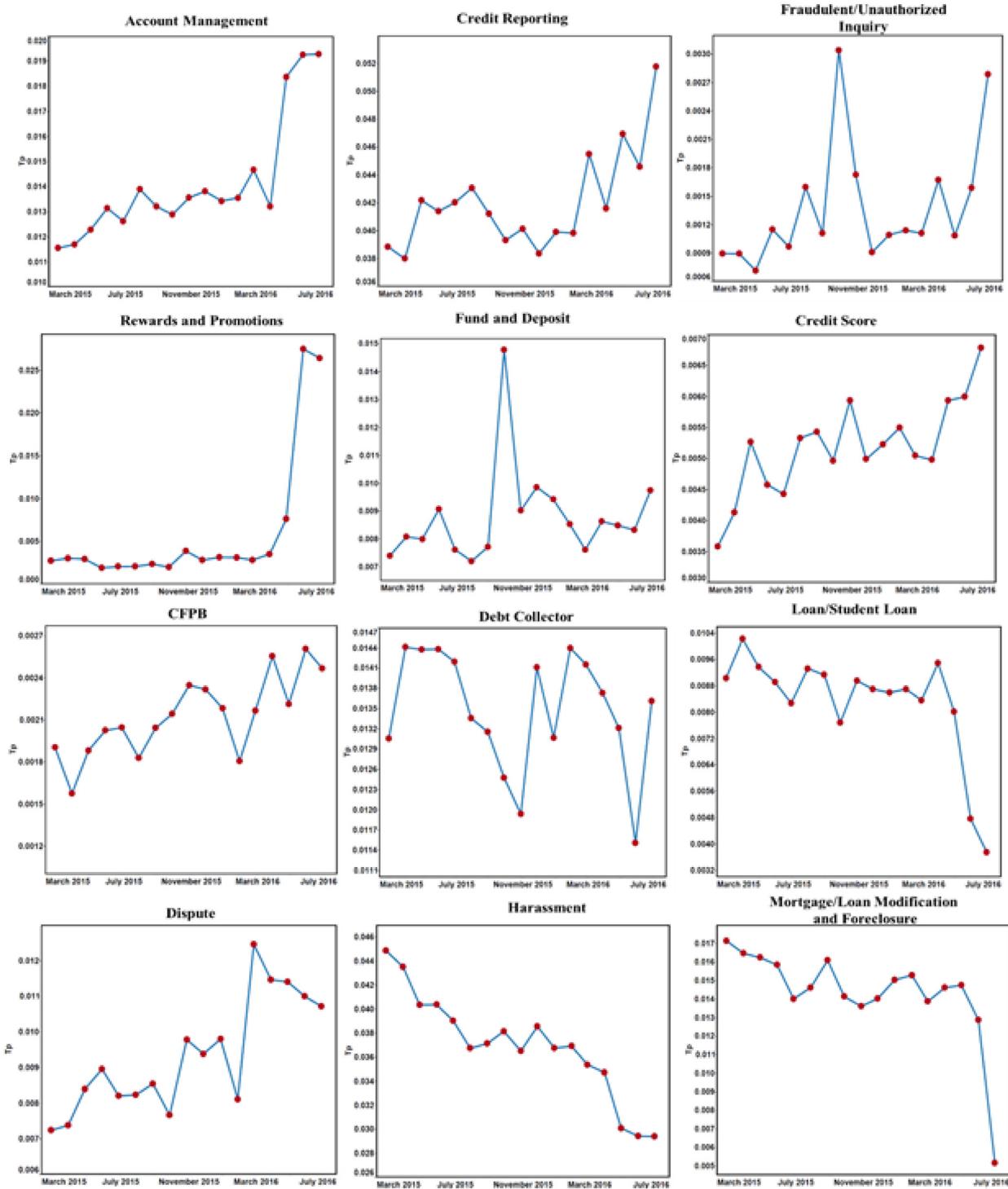


Fig. 7. Time trends of 12 selected topics from March 2015 to July 2016.

First, it is required to define the topic popularity. Topic popularity represents the frequency of the topic appeared in the CFPB consumer complaints over time. However, as each complaint is assigned with a mixture of topics with different proportions, the frequency should be normalized (weighted) by the proportions of the topics in the complaints. For example assume two complaint nar-

ratives received in March 2015 were assigned with a mixture of topics [(3,0.35), (6,0.25), (17,0.2), (25,0.15), (33,0.05)], and [(6,0.45), (17,0.3), (25,0.15), (33,0.08), (3,0.02)} respectively. The first element in (.) is the assigned topic ID, and the second element is its underlying proportion. Then the frequency of all the above topic IDs is two. However, the proportion does really matter instead of

The screenshot shows a web form for filing a consumer complaint. At the top, there is a text area labeled "Describe what happened so we can understand the issue..." with a note: "Do not include sensitive information like your name, contact information, account number, or social security number in this field. We will collect certain personal information at a later step." Below this is a text input field with "3900 characters remaining". A red arrow points from the text "Consumer Complaint Narratives" to the text area. In the middle, there is a section titled "Which of these best describes your issue?" with a dropdown menu labeled "Choose...". A red arrow points from the text "Issue Drop-down Menu" to the dropdown menu. The dropdown menu lists 90 predetermined labels, including: Advertising and marketing, Application processing delay, APR or interest rate, Arbitration, Balance transfer, Balance transfer fee, Banking, Billing disputes, Billing statement, Contacted the Consumer Financial Protection Bureau previously, Contacted another government agency, Hired an attorney, and Filed legal action.

**Fig. 8.** Snapshot from a consumer complaint portal on the CFPB website. The user would be able to select the corresponding issue for his/her complaint through a drop-down menu including 90 predetermined labels.

frequency, as it specifies how much of the complaints are explained by these topics. Hence, the topic proportions should be utilized to define the topic popularity.

Let  $D_t = \{d_t^1, d_t^2, \dots, d_t^{n_t}\}$  be the collection of documents (consumer complaints) received at time index  $t$  (time unit is month in this analysis),  $d_t^j$  be the  $j$ th document in this collection ( $\forall j = 1, \dots, n_t$ ), where  $n_t$  represents the total number of documents in  $D_t$ , then topic popularity for topic ID  $i$  at time index  $t$  is defined

$$Tp_{i,t} = \frac{\sum_{t=1}^{n_t} \theta_{i,d_t^j}}{n_t} \quad (\forall i = 1, \dots, K; \forall t = 1, \dots, T) \quad (1)$$

where  $\theta_{i,d_t^j}$  denotes the proportion of topic ID  $i$  assigned to document  $d_t^j$ ,  $K$  is the total number of topics (here is 40), and  $T$  is the total number of time indices (will be discussed later). From Eq. (1), the nominator represents the frequencies of topic ID  $i$  assigned to the documents received at time index  $t$  (i.e.,  $D_t$ ) normalized by its proportions, and the denominator is used to further normalize the topic frequency metric over the number of documents received at time index  $t$ . The denominator normalization is critical in order to remove the bias effect of the number of documents received over time, and consequently represent the topic popularity metric in range of 0 and 1. Now the topic popularity for the above example in March 2015 (e.g.  $t=1$ ) is computed as  $Tp_{3,1} = 0.185$ ,  $Tp_{6,1} = 0.35$ ,  $Tp_{17,1} = 0.25$ ,  $Tp_{25,1} = 0.15$ , and  $Tp_{33,1} = 0.065$ .

Using Eq. (1) it is possible to explore the CFPB topics popularity over time. Fig. 7 shows the time trends of 12 selected topics from March 2015 to July 2016<sup>4</sup>; the chosen time unit is "month", hence  $T=17$  in Eq. (1) (the readers are referred to Appendix A to view the time trends for other CFPB topics). The time trends in Fig. 7 are generally perceived as the popularity of their corresponding topics characterized with increasing, decreasing, or variable trends. The topics "Account Management", "Credit Reporting", "Rewards and Promotions", "Credit Score", and "CFPB" generally have

increasing trend. Decreasing trend is evident for "Loan/Student Loan", "Harassment", and "Mortgage/Loan Modification and Foreclosure". Other topics including "Fraudulent/Unauthorized Inquiry", "Fund and Deposit", "Debt Collector", and "Dispute" have been highly variable, often accompanied with a high spike.

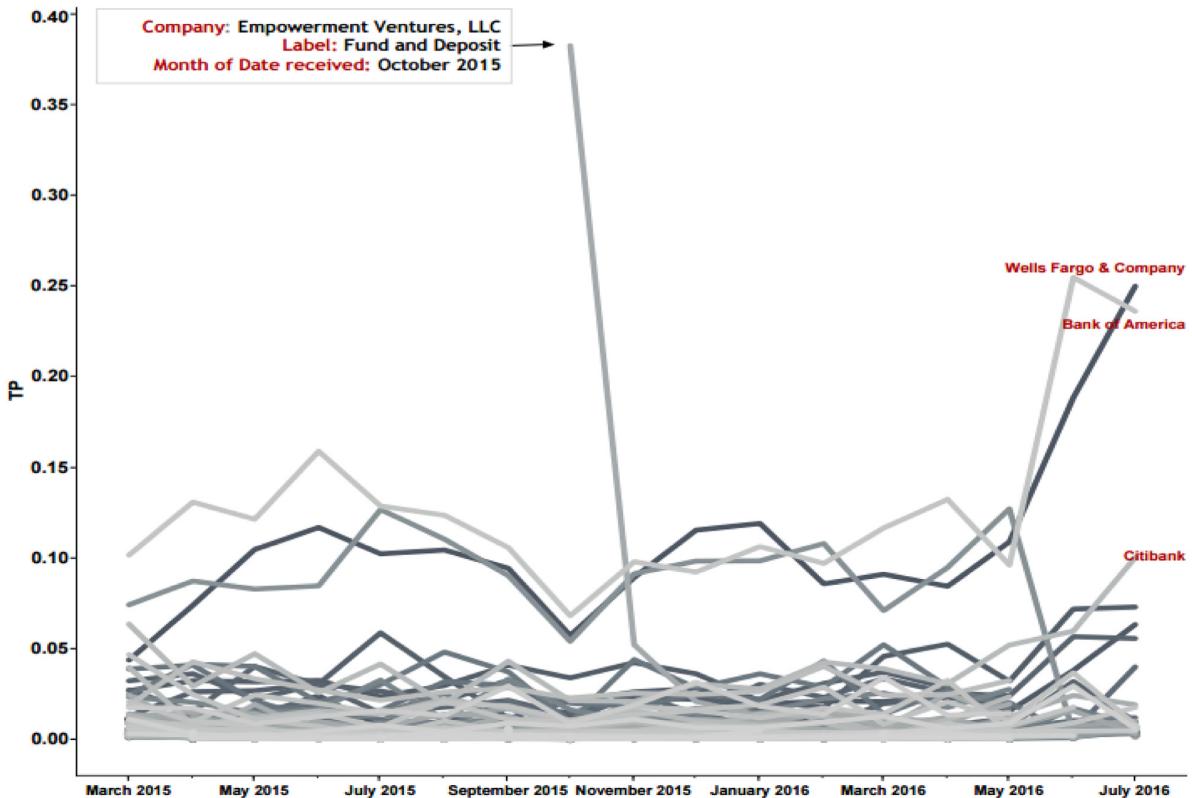
In Fig. 7 "Credit Reporting", "Harassment", "Account Management", and "Debt Collector" have been the most popular topics (largest  $Tp_{i,t}$ 's), respectively. This indicates that the consumer complaints have been mainly associated to these topics over time. Hence, the CFPB examiners might consider more efforts to address these topics as they contain the most proportions of the consumer complaints. Furthermore, some topics have been found with a sudden increase, decrease, or spike in their time trends.

A high spike occurred in October 2015 in "Fraudulent/unauthorized Inquiry" and "Fund and Deposit" (about 100% increase in its computed topic popularity). In the time trend of "Rewards and Promotions", two consecutive high increases occurred in May 2016 (about 100% increase), followed by a much higher increase in June 2016 (about 400% increase). The topic popularity computed for "Mortgage/Loan Modification and Foreclosure" presents a high decrease in July 2016 (about 100% decrease). The sudden changes in the topics above might be relevant to some issues, policies, or new regulations that have caused their occurrences. Hence, a more thorough study is required to reveal the main causes of the sudden changes for these topics. Such discussion is provided in the next Section.

#### 4. Discussion

The results demonstrate the utility of topic modeling for the CFPB consumer complaints. The proposed approach using LDA created coherent and semantically meaningful topics/clusters from consumer complaints. These topics not only summarize a large collection of documents/complaints into human-interpretable decomposition of the texts, but also help practitioners discover new contents that might have been overlooked by the CFPB. In the following it is discussed that the extracted topics are semantically cohesive, argued why and how the proposed approach could

<sup>4</sup> CFPB started publishing online the consumer complaint narratives from March 2015; hence the timeline considered in this analysis is from March 2015 through July 2016.



**Fig. 9.** Topic popularity of Fund and Deposit given all the financial companies in the CFPB dataset.

outperform the CFPB convention in labeling the complaints, and finally, elaborated on the insights gained from topic popularity and time trend analysis using the proposed approach.

#### 4.1. Cohesion of LDA topics with the CFPB issues

One of the fields in the CFPB datasets is "Issue", which describes the primary reason for the consumer complaints. These issues are predetermined labels defined by the CFPB experts, and provided in a drop-down menu for the consumers at the time of complaint submission. Once the consumers want to submit their complaints through the CFPB website, they should select their corresponding issue using this drop-down menu. A snapshot from the CFPB complaint submission portal is presented in Fig. 8. There is a box in the top of this portal where consumer imports complaint narratives, and at the bottom of the portal a drop-down menu exists through which consumer chooses the corresponding issue (e.g., Bankruptcy, Billing disputes, etc.) from the predetermined labels. This is the CFPB convention in labeling the consumer complaints.

In total there are 90 labels in the issue field in the CFPB dataset, however, more than 99% of the consumer complaint categorized by the top 60 labels with highest frequencies. A list of these 60 labels, followed by a plot presenting their normalized frequencies is provided in Appendix B. Reviewing these labels divulges their correspondences with the extracted topics which are also presented in Appendix B. In general there is one-to-one correspondence between the predetermined labels and the extracted topics; there are a few labels correspond to a combination of two or more topics though. Hence, this verifies the extracted topics are semantically cohesive as they can capture the CFPB practitioner's intuitions about the potential consumer complaint issues. There are a few topics that are not corresponded to any labels. For example there

exists no one-to-one correspondence between the topics including "CFPB", "Family", and "Divorce and Ex-spouse", with the predetermined labels. This means there exist some new issues (labels) that might have been neglected by the CFPB, but have been captured using LDA. Hence, LDA would be able to identify new/evolving issues which is not possible by the CFPB labeling conventions.

#### 4.2. Superiority of LDA over the CFPB labeling convention

The proposed LDA-based approach assigns a mixture of topics to a consumer complaint computed by posterior inferences using whole complaint collections (for example please refer to the complaint narrative with complaint ID 1313544 presented in Fig. 4). However, the CFPB conventional labeling approach is based on consumer input selected from the drop-down menu on the CFPB submission portal. There are two shortcomings with the CFPB labeling approach that are addressed by our proposed approach. First, the consumer selects the label best describing the complaint issue from the drop-down menu; hence due to the lack of knowledge or acquaintance of the consumers with the labels, they might select a wrong label (mislabeling), or if the issue they would like to complain about might not be relevant to any of the labels provided in the drop-down menu, then they will be forced to select a label that does not best describe their issue. Second, the consumer complaints may be about multiple issues (labels), but due to the limitation of the CFPB labeling convention they can only select one label.

#### 4.3. Topic popularity insights from consumer narratives

The time trend of topic popularity can be certainly used as a quantitative metric to evaluate the quality and effectiveness of the

CFPB regulations in creating a consumer oriented culture in decision making processes of financial institutions. The decreasing trend of topics over time could indicate that the CFPB regulations have taken the relevant topics into account, and the companies have been able to improve their customer service with respect to those topics. From Fig. 7, "Harassment", "Loan/Student Loan", and "Mortgage/Loan Modification and Foreclosure" generally have decreasing trends (especially within the last 4 months of the data). As opposed to decreasing trend, increasing trend or high variability of topic popularity could indicate that the CFPB regulations have not been adequately effective in addressing the consumer complaints with respect to those topics.

The proposed approach can be certainly useful in monitoring the consumer complaint narratives for emerging topics. It can be easily operationalized (in a number of steps including data pre-processing, LDA based topic modeling, and topic popularity analysis) and run monthly (even daily) to automate the prediction of topic assignments of the new complaint narratives that will be received in the future. Similar to the procedures explained in this paper, monthly (daily) topic popularity analysis of the new complaints can reveal emerging topics (e.g., as "Rewards and Promotions" and "Account Management" were revealed in this paper) based on high increases captured in their very recent time trend.

Other than the CFPB team, financial companies can also adopt the proposed approach to monitor their consumer complaints. The financial corporates will be able to detect abnormal trends in the topics and stop them as early as possible by identifying the root causes of those issues. As an early follow-up investigation, we refer the readers to topic popularity of "Fund and Deposit" which can be seen in Fig. 9. The figure shows the time trend of this topic for all the financial companies reported in the CFPB dataset. Due to the space limit, the captions of only a very few of these companies are illustrated (i.e., Wells Fargo, Bank of America, Citibank, and Empowerment Ventures, LLC). Our analysis discloses a high spike in October 2015, which is primarily associated with Empowerment Ventures, LLC (RushCard). RushCard is a financial company providing prepaid cards for unbanked consumers. In October 2015, thousands of RushCard customers experienced problems as a result of a software conversion. Their consumers were frustrated because they were not able to access their cash, check their balances, or deposit any money into their accounts.<sup>5</sup> As such, they started sending out complaints to the CFPB. An analysis of the complaint narratives, similar to that which is discussed in this document, may have led to detection more quickly.

## 5. Conclusion

An intelligent system based on LDA was proposed in this paper to reveal useful information from the CFPB consumer complaint narratives. LDA generates semantically meaningful topics/clusters to summarize consumer complaints into a mixture of topics that would not be possible by human annotations. The topic popularity/time trend analysis of these topics can be useful in evaluating the effectiveness of the CFPB regulations in addressing the consumer complaint issues. It was demonstrated that the CFPB reg-

ulations have been successfully enforced for "Harassment", "Mortgage/Loan Modification and Foreclosure" and "Loan/Student Loan" as they were the topics with decreasing time trend, and for the topics including "Credit Reporting", "Credit Score", "Account Management", "Fraudulent/Unauthorized Inquiry" and "Dispute" the regulations have not been adequately effective due to their increasing or highly variable trends.

The proposed approach can be useful in monitoring the consumer complaint narratives for emerging topics. It can be operationalized and run monthly (even daily) to automate annotations of new complaint narratives that will be received in the future. Topic popularity analysis of the new complaints can reveal emerging topics. The proposed approach is never intended to replace human experts, instead it is designed as an intelligent tool for the experts to investigate consumer complaints more efficiently and effectively, and eventually improve consumer protections from unfair, deceptive or abusive practices in the financial markets.

Despite all the advantages of the proposed approach, LDA is computationally very expensive on large data sets (e.g. billions of documents). In the future, by increasing the number of complaint narratives, there will be a need for a more efficient approach. A promising solution is to incorporate deep learning approaches in the CFPB complaint analysis. As specific, deep learning models such as Word-to-Vector (Mikolov, Sutskever, Chen, Corrado, & Dean, 2013), and Sentence-to-Vector (Cer et al., 2018) can be utilized for continuous representation of documents and embedding them into much lower dimension while capturing semantic similarities of the documents. In the future, we are exploring the utility of both deep learning and topic modeling algorithms for the CFPB consumer complaint analysis.

LDA modeling assumption does not allow us to include the effect of covariates (e.g., type of financial product, zip code of the consumer, age of the consumer, etc.) in topic modeling of the documents. Roberts et al. (2014) developed an interesting extension of LDA, known as structural topic modeling (STM), to take the effect of covariates of interest in documents modeling. As a future work, the utility of STM can be explored to learn the relationship between the CFPB topics and the covariates of interest from the document meta-data. This will enable the CFPB to leverage other variables in the CFPB database along with the complaint narratives to improve consumer experience with the financial products and services.

Finally, the proposed intelligent system is not specifically limited to the CFPB use case. Similar techniques including topic modeling and deep learning could be utilized to analyze consumer narratives in different applications or industries, e.g., hotel industry, product reviews, movie reviews, etc. These techniques allow scholars to summarize the narratives into lower dimensions, and then apply document-topic representations for different analytic tasks such as classification, clustering, prediction, or sentiment analysis.

## Appendix A

Fig. A.1.

<sup>5</sup> <http://money.cnn.com/2015/10/15/news/companies/rushcard-russell-simmons/>.

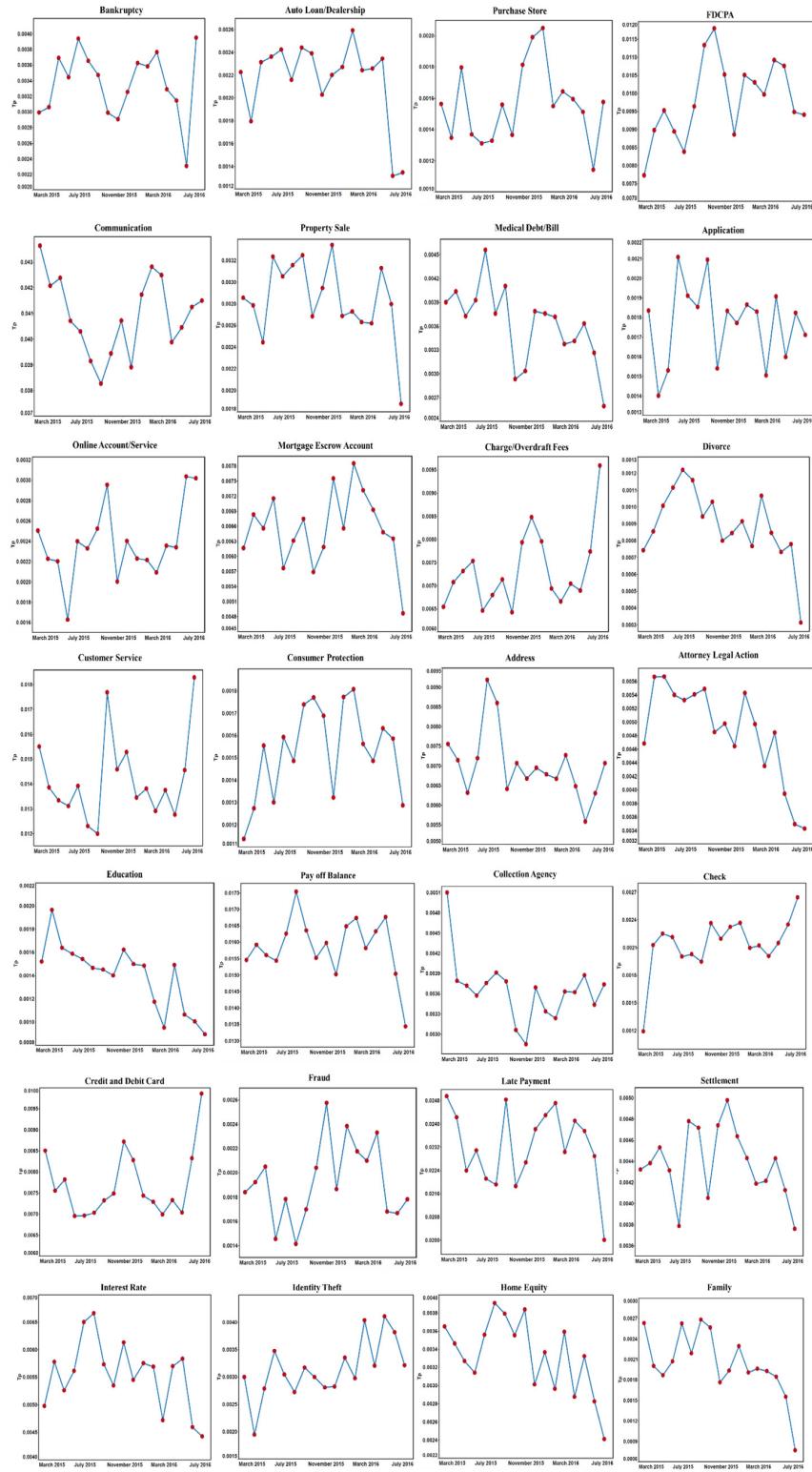


Fig. A.1. Time trend analysis of the rest of topics not included in Fig. 7.

## Appendix B

Fig. B.1. Table B.1.

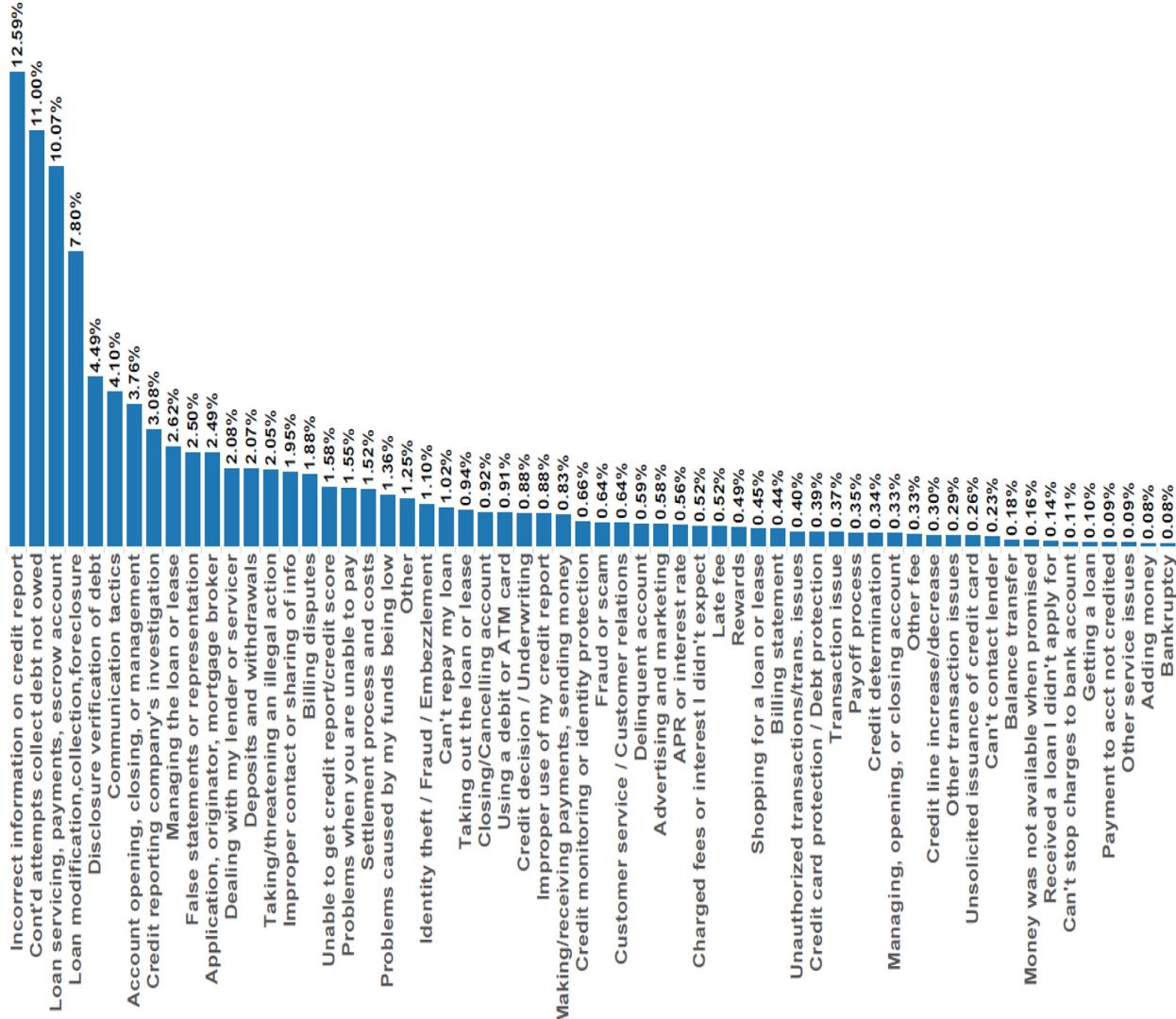


Fig. B.1. Normalized frequency of top 60 issues in the CFPB dataset. These issues cover labeling of more than 99% of the whole consumer complaints in the dataset.

**Table B.1**

Top 60 labels of the issue field in the CFPB dataset, and their correspondence with topics extracted using LDA.

Label	Topic ID	Label	Topic ID
Incorrect information on credit report	1	Fraud or scam	32
Conf'd attempts collect debt not owed	9	Customer service / Customer relations	4
Loan servicing, payments, escrow account	2,28	Delinquent account	0
Loan modification, collection, foreclosure	2,20	Advertising and marketing	36,37
Disclosure verification of debt	6,36	APR or interest rate	26
Communication tactics	9	Charged fees or interest I didn't expect	33
Account opening, closing, or management	12	Late fee	0,33
Credit reporting company's investigation	10	Rewards	36
Managing the loan or lease	2,28	Shopping for a loan or lease	2,3,15,34
False statements or representation	1,23	Billing statement	1,21,47
Application, originator, mortgage broker	39	Unauthorized transactions/trans. issues	17,33
Taking/threatening an illegal action	9	Credit card protection / Debt protection	27
Dealing with my lender or servicer	2,28	Transaction issue	0,13, 16,33
Deposits and withdrawals	35	Payoff process	38
Improper contact or sharing of info	1,23	Credit determination	27
Billing disputes	16	Managing, opening, or closing account	12
Unable to get credit report/credit score	23,27	Other fee	—
Problems when you are unable to pay	0,38	Credit line increase/decrease	27
Settlement process and costs	24	Other transaction issues	—
Problems caused by my funds being low	35	Unsolicited issuance of credit card	27
Other	—	Can't contact lender	2,20
Identity theft / Fraud / Embezzlement	19	Balance transfer	35,38
Can't repay my loan	2, 20	Money was not available when promised	33,35
Improper use of my credit report	17	Received a loan I didn't apply for	2,20
Taking out the loan or lease	2, 20	Can't stop charges to bank account	33
Closing/Cancelling account	12	Getting a loan	2,20
Using a debit or ATM card	27	Payment to acct not credited	0,38
Credit decision / Underwriting	23,27		
Making/receiving payments, sending money	0,37, 38	Adding money	33, 35
Credit monitoring or identity protection	14,27	Bankruptcy	25

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