TEST: A Token-Curated Registry for Consumer Products

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Abstract. Information asymmetry in retail markets puts consumers at risk of fraud through the sale of counterfeit, adulterated, recalled, and expired goods. Consumers rely on trusted third parties such as regulatory agencies and certificate authorities to control the distribution of these products. However, failures of cost, latency, and trust have limited the success of these centralized authorities, exposing consumers to continued risk. We propose a solution to this information asymmetry problem using a token-curated registry. The TEST Registry will be a curated list of products that meet quality standards. This registry is governed by an application/challenge process. TEST holders can apply for new products to be added to the registry and other TEST holders can challenge these applications. Products that successfully complete their application period without losing a challenge are listed in the TEST Registry. Product challenges are won or lost based on scientific testing performed by TEST-registered laboratories. TEST holders are rewarded for winning challenges, forming the basis for a Self-Regulatory Organization that protects consumers and identifies high-quality products. The TEST Registry aligns incentives between producers, consumers, and validators and offers a public, global, and decentralized alternative to trusted third parties like the FDA.

1. Introduction

1.1. Problem

Fraud in consumer products has persisted for thousands of years despite laws as old as the Code of Hammurabi (1754 BC) making it illegal to cheat buyers with products like diluted beer[1]. Fraudsters continuously update their methods to evade detection by regulators and trick consumers. For example, ancient Roman authorities developed seals to differentiate authentic olive oil and wine; however, there is evidence of counterfeit Roman seals on fraudulent products, defeating this system[2].

[1] D. Keifer, "Brewing: A legacy of ancient times," http://pubs.acs.org/subscribe/archive/tcaw/10/i12/html/12chemchron.html, 2001.
[2] J. Spink, D. Moyer, "Defining the Public Health Threat of Food Fraud," https://onlinelibrary.wiley.com/doi/full/10.1111/j.1750-3841.2011.02417.x, 2011.

Modern fraud in consumer products is regulated by centralized authorities, including FDA and USDA in the US, FSA in the UK, and EFSA in the EU. These organizations are responsible for overseeing consumer health products such as food, cosmetics, and pharmaceuticals. However, failures of cost, latency, and trust have limited the success of these authorities, exposing consumers to continued risk.

An increasingly global supply chain cannot be effectively policed by these domestic authorities. The FDA plans to spend over $5.1 billion in 2018[3]. While this cost is objectively high, it is small compared to the FDA's regulatory scope. FDA-regulated products amount to more than $2.4 trillion in annual consumption[4]. At this scale, the FDA relies on product recalls, a reactive system with high latency, to regulate product safety. Recalls are triggered by adverse events. When enough consumers report negative side effects to the FDA, the FDA initiates an investigation, which may lead to a recall. However, it can take many years and thousands of complaints before a failed product is finally removed from the market[5]. Meanwhile, consumers have low information about product risks and little ability to influence FDA decisions.

Centralized authorities also break our trust in them when they are influenced by the entities they are supposed to be regulating. In 1994, the American Congress passed the Dietary Supplement Health and Education Act (DSHEA), which exempts most dietary supplements from FDA approval[6]. In the past two decades, the dietary supplement industry has collectively spent between $1M and $5M annually on lobbying activities[7]. Meanwhile, US supplement sales have increased under DSHEA from under $6B to over $35B annually[8]. These concentrated benefits provide a large incentive for supplement companies to influence regulatory action and reduce buyer information in these markets. Consumers as a whole would benefit from organizing against these company actions, but the total cost is too expensive for any one individual to undertake, meaning that the collective action will only occur if a critical mass of people coordinates their resources and takes action together[9].

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[3] FDA. "HHS FY 2018 Budget in Brief,"
https://www.hhs.gov/about/budget/fy2018/budget-in-brief/fda/index.html, 2017.
[4] S Walker, C. Nardelli, "Consumer expenditure on FDA regulated products: 20 cents of every dollar,"
https://blogs.fda.gov/fdavoice/index.php/2016/11/consumer-expenditure-on-fda-regulated-products-20-cents-of-every-dollar/, 2016.
[5] M. Kwa, L. Welty, S. Xu, "Adverse Events Reported to the US Food and Drug Administration for Cosmetics and Personal Care Products,"
https://jamanetwork.com/journals/jamainternalmedicine/article-abstract/2633256, 2017.
[6] V. Franks, D. Street, R. O'Neill, "FDA Regulation of Dietary Supplements and Requirements Regarding Adverse Event Reporting," https://www.ncbi.nlm.nih.gov/pubmed/20032973, 2010.
[7] OpenSecrets.org, "Nutritional & Dietary Supplements: Lobbying, 2017,"
https://www.opensecrets.org/industries/lobbying.php?ind=H4600, 2018.
[8] S. Ostroff, "Making Progress in Protecting Consumers from Unsafe Supplements,"
https://blogs.fda.gov/fdavoice/index.php/tag/dietary-supplement-health-and-education-act-dshea/, 2016.
[9] P. Oliver, G. Marwell, "A Theory of the Critical Mass,"
https://www.ssc.wisc.edu/~oliver/PROTESTS/ArticleCopies/OliverMarwellCritMassI.pdf, 1985.

The rise of online marketplaces dramatically increases the scale of this problem. Overall, 30 times more new consumer packaged goods are released each year than were launched annually just 50 years ago[10]. Given high price competition and low product differentiation, especially online, there is a large incentive for sellers of lemons to defraud consumers. On the supply-side, these bad actors lower costs by utilizing poor quality products and raw materials. On the demand-side, consumers' reliance on user reviews as a proxy for product quality has led dishonest sellers to buy fake, positive reviews, further diluting market knowledge[11].

1.2. Current Solutions

Everyone desires and benefits from transparent independent testing, but the total cost is too expensive for any one individual to undertake, meaning that the collective action will only occur if a critical mass of people coordinates their resources and takes action together. There are also concentrated incentives for fraudulent product sellers to fight the production of this information through lobbying and litigation. Thus, it is hard for diffuse groups to engage in private costs to pursue public benefits, with economic logic incentivizing the majority to inaction and the minority to counteraction[12]. When centralized authorities fail to effectively curate fraudulent products out of the market, all consumers are put at greater risk, exposing a classic tragedy of the commons problem[13].

Organizations like Consumer Reports and Labdoor aim to solve this problem by testing products publicly. This work increases market information and aligns incentives between most buyers and sellers. The popularity of these services shows the high consumer demand for transparent independent testing. However, since this information is a non-excludable public good, it is challenging to effectively charge each beneficiary for this service[14]. There is also a high cost for these organizations to defend their work. Consumer Reports has been sued at least 13 times by the subjects of their reviews, and risks triggering additional complaints with every new review[15]. These market failures limit the potential scale of information providers and discourage new providers from entering the market.

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[10] C. Mims, "Why There Are More Consumer Goods Than Ever,"
https://www.wsj.com/articles/why-there-are-more-consumer-goods-than-ever-1461556860, 2016.
[11] J Stempel, "Amazon sues to block alleged fake reviews on its website,"
https://www.reuters.com/article/us-amazon-com-lawsuit-fake-reviews/amazon-sues-to-block-alleged-fake-reviews-on-its-website-idUSKBN0N02LP20150410, 2015.
[12] M. Olson, "The Logic of Collective Action,"
http://www.sscnet.ucla.edu/polisci/faculty/chwe/ps171a/olson.pdf, 1971.
[13] E. Ostrom, "Tragedy of the Commons," http://dlc.dlib.indiana.edu/dlc/handle/10535/5887, 2008.
[14] T. Cowen, "Public Goods and Externalities,"
http://www.econlib.org/library/Enc1/PublicGoodsandExternalities.html, 1993.
[15] R. Finn, "Still Top Dog, Consumers' Pit Bull to Retire,"
http://www.nytimes.com/2000/10/05/nyregion/public-lives-still-top-dog-consumers-pit-bull-to-retire.html, 2000.

1.3. TEST

TEST is a decentralized solution to the problem of fraud in retail markets. The core utility of TEST is to maintain a series of registries that give consumers more transparency into product quality. The first is the TEST Product Registry, a token-curated registry (TCR) that regulates the quality of consumer products. The second is the TEST Lab Registry, which is a curated list of laboratories that meet key accreditations and qualify to provide data and resolve challenges for the product registry. TEST registries will be smart contracts on the public Ethereum blockchain that list the products and laboratories that have been accredited by TEST.

Producers and other applicants submit products to the TEST Product Registry, where they will undergo the standard TCR process, where they may be challenged during an open challenge period before they are added to the registry. Additionally, qualified labs from the TEST Lab Registry serve as validators for the TEST Product Registry during challenges. TEST-registered labs perform the testing required and provide public data to determine whether a product wins or loses its challenge. This application/challenge process ensures that products in the TEST Registry maintain a consistently high-quality over time.

The TEST protocol and registries aim to solve two key problems in retail markets, information asymmetry and regulatory compliance. Consumers can look for the TEST Registered mark on product labels or use TEST-based applications to research and buy products. Listings in the product may include other important information, including instructions for use, ingredient lists, user reviews, and other certifications. TEST enables a shared public data layer, tracking the quality of consumer products over time. Applications will be built on top of this data, the simplest of which will show consumers which products are currently in the registry.

Producers could also use the TEST protocol to comply with government regulations. California's Proposition 65 regulations for purity have long been one of the world's strictest testing standards for consumer products[16]. The TEST Product Registry will require applicants to its product registry to comply with these testing standards. TEST can also help companies comply with new data accessibility requirements. The EMA will require that pharmaceutical companies connect their internal product tracking systems to a central data repository by 2019 and the FDA has mandated that full electronic track & trace capability will be required by 2023 for all members in the pharmaceutical supply chain[17,18]. These capabilities will be built into the TEST protocol, streamlining regulatory compliance across borders.

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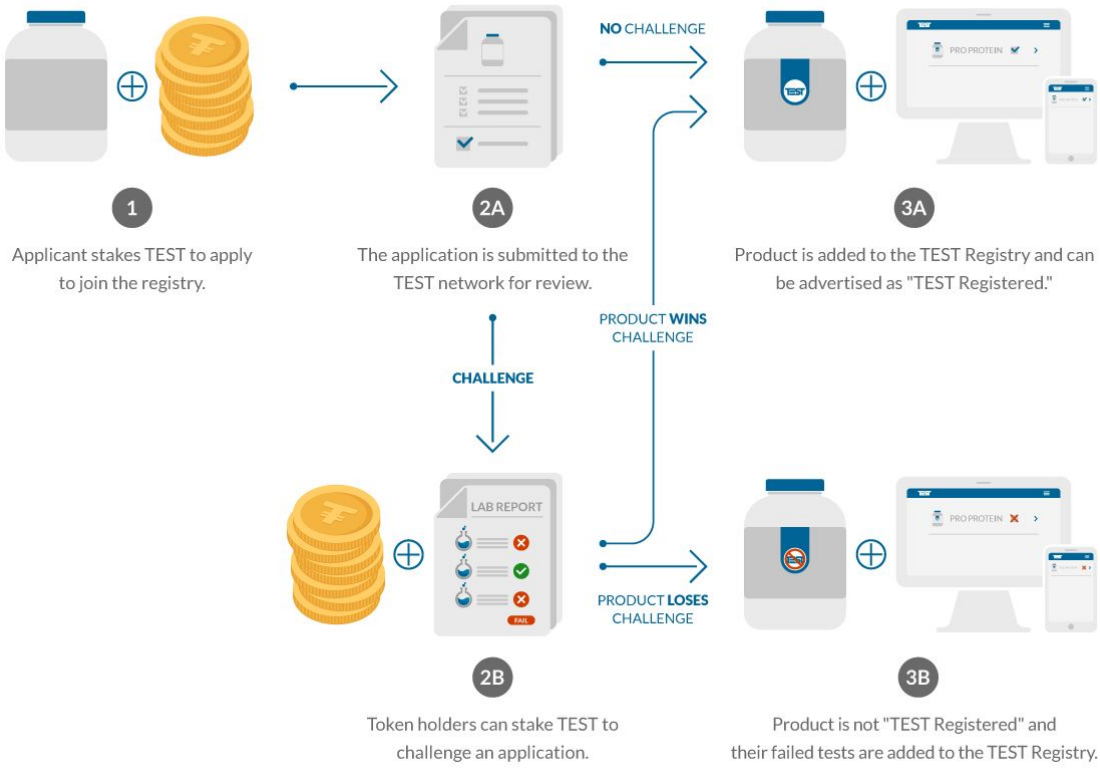
[16] B. Borrell, "Are Proposition 65 warnings healthful or hurtful?," http://www.latimes.com/health/la-he-pro-con2-2009nov02-story.html, 2009.
[17] "COMMISSION DELEGATED REGULATION (EU) 2016/161," http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0161&from=EN, 2016.
[18] "Drug Supply Chain Security Act (DSCSA)," https://www.fda.gov/Drugs/DrugSafety/DrugIntegrityandSupplyChainSecurity/DrugSupplyChainSecurityAct/, 2013.

2. TEST Registries

2.1. TEST Product Registry

The TEST Product Registry is a token-curated registry (TCR) for testing and transparency in consumer health products. This registry is regulated by an application/challenge process inspired by the TCR model in the AdChain Registry white paper[19]. TEST holders can propose new products to be added to the registry and other TEST holders can challenge these applications. Applicants that complete their application period without losing a challenge are listed in the TEST Product Registry. Registrants must maintain a minimum deposit in TEST to remain in the registry, which serves as collateral against future challenges.

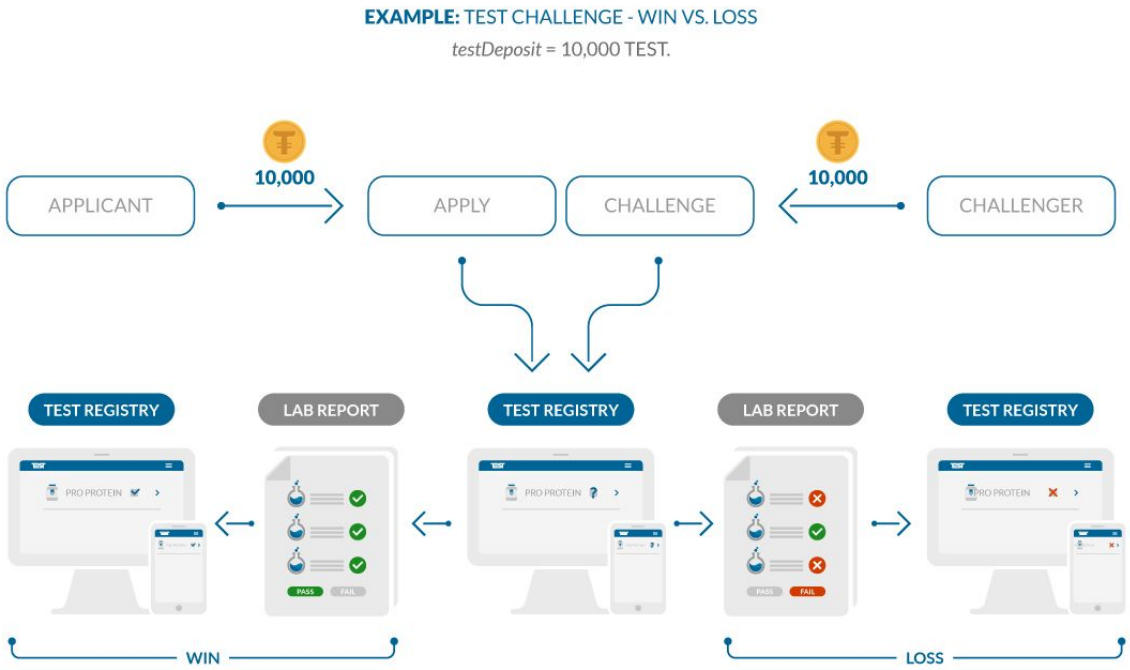
Applications to the TEST network require applicants to attest to their compliance with specific TEST standards. For example, products will be required to comply with California's Proposition 65 regulations for purity in order to be listed in the TEST Registry. A challenger could win a challenge against a product by submitting testing data from a TEST-registered lab that shows that the product fails to meet these standards. These registry standards will also be parameters in the TEST protocol and can be changed by a vote by TEST holders.



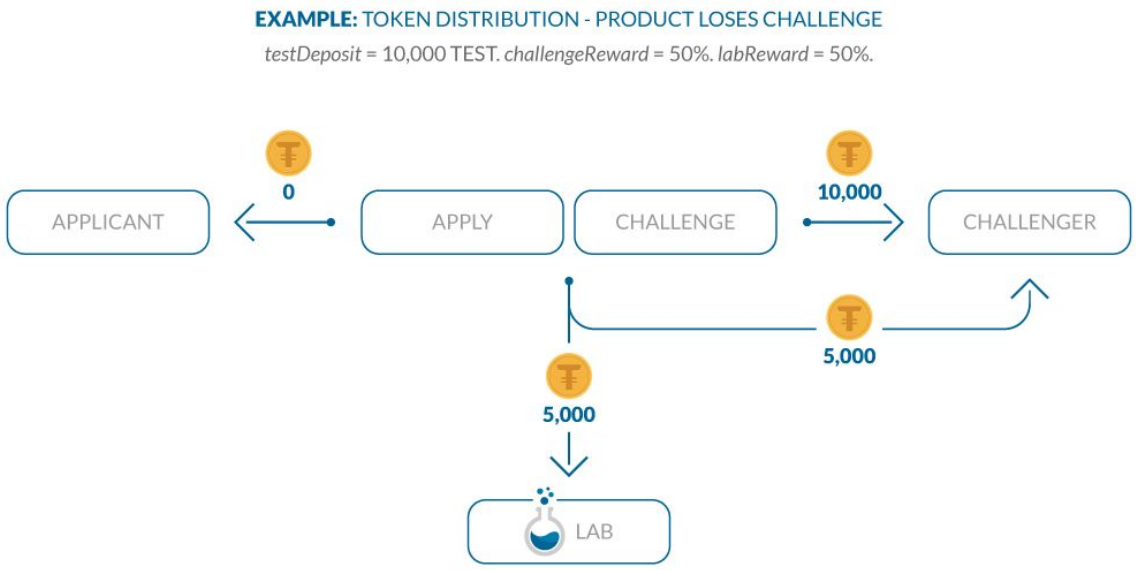
[19] M. Goldin, A. Soleimani, J. Young, "The AdChain Registry," https://adtoken.com/uploads/white-paper.pdf, 2017.

TEST holders stake a deposit of TEST token to apply a product to the TEST Registry. Staking a deposit begins the application period, where other TEST holders can challenge an applicant that they believe are not up to the standards of the registry or fraudulent. Product challenges are won or lost based on scientific testing performed by a TEST-registered laboratory. The product registry aggregates demand for lab testing, which drives demand for laboratories to join the lab registry. In order to stay in the TEST Product Registry, listings must be renewed at least once per year to ensure consistent quality. TEST Foundation can charge a non-refundable fee for every new application. This fee will initially be set to 0 to encourage adoption while the foundation is funded through token sales.

If a TEST holder believes that a product doesn't meet the standards of the registry, they can challenge that product using TEST tokens. To challenge an open application, the challenger must deposit an equivalent amount of TEST tokens to start the challenge. When an application is challenged, this opens a challenge period during which the challengers must submit a case with evidence from a TEST-registered lab that an application fails one or more registry standards.



When TEST holders win a challenge, they receive their deposit back and also receive a reward for sponsoring a winning challenge. The lab that tested the product also receives a reward that comes from the applicant's deposit if the challenge is successful and from the challenger's deposit if the challenge is unsuccessful.



There must be a binary outcome (pass/fail) for every test. For example, assuming the limit for lead content is 0.5 µg/daily serving (based on California Proposition 65 limits), then a product would pass this test if their lab results showed lead levels below this limit. These testing limits will also be parameters in this protocol and can be changed with a vote by TEST holders. An application may require one or a number of tests. A product must pass every test in a given application to be TEST Registered for that purpose.

Token holders can also challenge a product that is already in the registry by staking a deposit against that registrant. Thus it could be profitable for TEST holders to proactively monitor the quality of registrants to identify promising challenge targets, incentivizing registrants to maintain their quality in order to keep their deposits. Registrants could also be incentivized to challenge each other if they believe their competitors are not meeting TEST standards. This forms the basis for a Self-Regulatory Organization (SRO) governed by TEST that incentivizes honesty and transparency without relying on political or legal arbiters to force action[20].

The TEST Product Registry is designed to connect consumers with high-quality products. Thus producers will be increasingly incentivized to apply to this registry as more consumers use this registry as a factor in their purchasing decisions. Labdoor will help bootstrap this process by contributing its hundreds of product certifications to the TEST network at launch. TEST Foundation will recruit other independent testing organizations to contribute their data to the network with the goal to aggregate the world's largest public dataset for product quality.

[20] R. Selkis, A token to self-regulate tokens. But really." https://medium.com/@twobitidiot/a-token-to-self-regulate-tokens-but-really-a61da77e6a7b, 2018.

2.2. TEST Lab Registry

Laboratories use a similar TCR-based application/challenge process to join the TEST Lab Registry, which earns them the right to work for the product registry. Challenges in the lab registry are won or lost based on whether a laboratory is in good standing with its public accreditations.

This registry will initially rely on accreditations set by established regulatory agencies and independent organizations. The two initial requirements for a laboratory to join the TEST Lab Registry will be for the lab to be FDA registered and ISO 17025 accredited. ISO 17025 is the leading independent standard for technical competence for testing laboratories[21]. Organizations like the FDA and ISO can also serve as Oracles that verify the real-world status of these accreditations. TEST Foundation will work to develop independent standards over time that reflect the global consensus of TEST holders and allow for truly decentralized regulations.

Failures in the lab registry will be easier to detect since organizations like the FDA publicly release information about failed laboratory inspections[22]. Lab applicants are incentivized to retract their own applications if they lose their good standing with an accreditation instead of facing a challenge that they are sure to lose. This will make challenges in the lab registry relatively uncommon. Because accreditation data is publicly available, challenges in the lab registry do not need to compensate validators. This allows the challenge reward in the lab registry to be set at 100% of the original deposit, increasing the incentive to challenge bad laboratories.

The lab registry helps laboratories access a global marketplace for product testing. Centralization in the testing laboratories industry has made it difficult for smaller labs to earn new customers. There are over 16,000 testing laboratories in the world, generating over $78 billion in annual revenues; however, just 10 companies

[21] ISO, "ISO/IEC 17025:2005," https://www.iso.org/standard/39883.html, 2005.
[22] FDA, "Inspections Database," https://www.fda.gov/ICECI/Inspections/ucm222557.htm, 2018.

(average age = 112 years old) control over 40% of the global market share[23]. The results of this testing are also largely hidden from consumers and used by producers only for internal quality control purposes. By incentivizing laboratories to join the lab registry and publicly share their testing data with the product registry, TEST will increase transparency and promote more independent testing.

3. Registry Parameters

3.1 Parameter Set

These registries rely on parameters (*highlighted below in italics*) that set the standards for applications, challenges, testing, and value transfer in this protocol. Parameterized values will first be set by the creators and then will be open to reparameterization through voting by TEST holders. The parameter set is below:

- *testDeposit*: The number of TEST tokens required to submit an application to the registry.
- *applicationPeriod*: The amount of time that an application must wait for challenge before being automatically added to the registry.
- *challengePeriod*: The amount of time that a challenge will remain open for challengers to submit data from a TEST-registered laboratory or Oracle.
- *renewalPeriod*: The amount of time that a registrant can remain in the registry before they need to submit a new application.
- *challengeReward*: The proportion of the losing party's *testDeposit* that is earned by the parties who sponsored the challenge.
- *labReward*: The proportion of the losing party's *testDeposit* that is earned by the labs or Oracles that provide data to resolve the challenge.

3.2 Initial Values

- *testDeposit*: 10,000 TEST. (Applicants risk this stake when they apply to the registry, making it expensive to spam the registry with bad applications.)
- *applicationPeriod*: 30 days. (This provides challengers with time to review new applications and analyze their accreditations before an applicant is added to a TEST registry.)
- *challengePeriod*: 30 days. (Most laboratories can perform testing within 2-4 weeks, which gives challengers enough time to collect needed evidence)
- *renewalPeriod*: 365 days. (Annual renewals are the current standard for product and lab accreditations)
- *challengeReward*: 50% of *testDeposit*. (A challenger needs 66.7% confidence that an applicant will fail to justify a challenge)
- *labReward*: 50% of *testDeposit*. (Labs are incentivized to perform testing for TEST challenges when *labReward* is higher than the market rate for these testing services. Testing for compliance to California Proposition 65

[23] Catalyst. "Global Testing, Inspection and Certification, http://www.catalystcf.co.uk/research-documents/2016/catalyst-corporate-finance-testing-inspection-certification.pdf, 2017.

standards can be performed for under $300 per product. As more labs join the registry, a bidding mechanism could be added to set *labReward* based on the lowest active bid offered by a TEST-registered laboratory.)

3.3. Parameter Settings

As the popularity of the TEST Registries increases, TEST value should appreciate relative to fiat value, increasing the cost to apply to the registry. If the cost to apply to the registry becomes too high, then TEST holders can vote to decrease *testDeposit* to encourage more applications. It's also important to note that *testDeposit* remains in the applicant's account as long as they successfully pass all challenges, further increasing our price competitiveness relative to existing accreditations.

Challenge parameters can also be adjusted to improve incentives. If TEST holders judge that not enough challenges are being performed to properly secure the network, they could vote to increase *challengeReward* to incentivize more challengers to take action. For example, if *challengeReward* is set at 100% of *testDeposit*, then a rational challenger would initiate a challenge if they are at least 50% confident that a product will fail testing. This also incentivizes TEST holders to preferentially challenge products that have a high probability of failing these tests.

4. Financial Incentives

4.1. Centralized Registries

The owners of centralized registries are financially incentivized to accept as many applications as possible since each new certification brings in more revenue. If registry owners lower their standards in order to accept more applicants, this will dilute the quality of the registry over time, causing high-quality applicants to leave the registry. Eventually, a new centralized registry is created that promises to be more exclusive. However each such registry faces the same perverse incentives and will trend to erosion over time.

When trusted third parties (TTPs) break our trust, such as the failure of credit rating agencies to accurately rate subprime assets prior to the 2008 financial crisis, they fundamentally distort markets. Certificate authorities, including credit rating agencies, usually receive most of their funding from the entities that they are rating, misaligning their incentives against consumers. Consumers want certifications to be difficult to earn to ensure high quality, while a profit-maximizing TTP could be driven to lower their standards to broaden their potential customer base. TTPs don't solve the problem of trust, they just change the people we need to trust[24].

[24] N. Szabo, "Trusted Third Parties Are Security Holes," http://nakamotoinstitute.org/trusted-third-parties/, 2001.

4.2. Token-Curated Registries

Token-curated registries (TCRs) based on a native token can solve these incentive problems. TEST economically incentivizes individuals and companies to judiciously curate a registry of high-quality products and laboratories. Since TEST is required to participate in the TEST Registry, the value of TEST is dependent on demand for new applicants to join the registry. This creates a virtuous cycle between participants in the registry. As long as TEST holders continue to curate a high-quality registry, then the value of TEST will appreciate. If TEST holders accept too many applications and dilute the registry, demand for new applications will fall and the value of TEST will decrease. The native TEST token is required for this virtuous incentive structure to work since its value is directly connected to the quality of the registry.

This token model can also solve another classic problem that faces new registries — market penetration. The first applicants to any new registry are often hesitant to pay a set certification fee since the value of the registry has not yet been established. In a token-curated registry, application fees rise or fall based on demand for new applications to the TEST Registry. Thus, applicants to the registry are incentivized to buy into the network early and only accept other high-quality applications to keep the value of the registry high. As long as these applicants successfully pass all challenges, they will see the value of their TEST deposits increase without having to pay more money to stay in the registry, rewarding them for being early adopters. Existing certifications cost $2,000-15,000 per product per year and accreditations like ISO 17025 cost $6,000 per laboratory per year in assessment fees, providing comparables for TEST application fees[25,26].

5. TEST Token

5.1. Initial Allocation

The total token supply will be 1 billion (1,000,000,000) TEST. 60% will be retained by TEST Foundation to fund operations through token sales and to grant rewards for contributors to the network. 40% will be granted to Labdoor for founding the TEST protocol subject to lock-up periods as described in section 5.2. TEST tokens can neither be minted nor destroyed, fixing the token supply at 1,000,000,000 once all tokens have been distributed and unlocked. TEST Foundation intends to fund its initial operations with proceeds from a crowdfunding campaign to pay for protocol development, recruit producers and laboratories to the network, and pay for the legal costs to set up the foundation and governance structure. Contributors to this crowdfunding campaign may receive TEST tokens or cash from TEST Foundation.

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[25] L. Tarkan, “What 'USP Verified' and Other Supplement Seals Mean,” https://www.consumerreports.org/vitamins-supplements/what-usp-verified-and-other-supplement-seals-mean/, 2016.

[26] APHL. “Laboratory Costs of ISO/IEC 17025 Accreditation,” https://www.aphl.org/aboutAPHL/publications/Documents/FS-2018Feb-ISO-IEC-Accreditation-Costs-Survey-Report.pdf, 2018.

5.2. Token Distribution

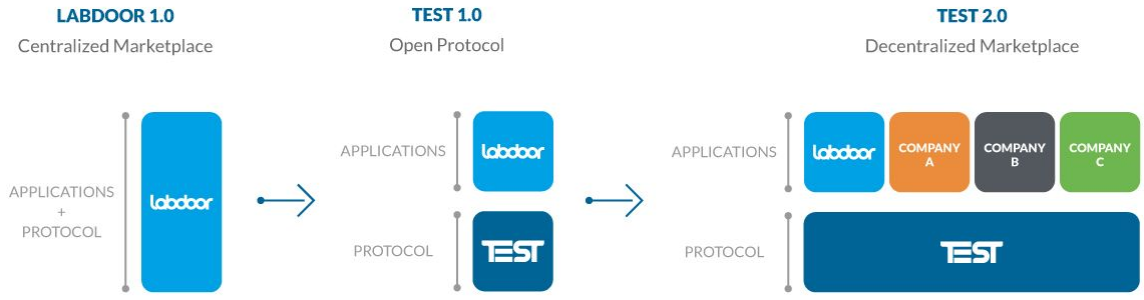
TEST Foundation will control 600 million TEST at formation. This gives it the ability to launch multiple future token sales, ideally at higher prices each time, upon delivery of key protocol milestones. While this protocol is being developed, the TEST team will manage this token reserve and negotiate token sales and partnerships as representatives of TEST Foundation. Once formal decentralized governance is established, tokens retained by TEST Foundation will be held in escrow and TEST holders will vote on whether to approve new token distributions. Labdoor intends to distribute 300 million TEST to company equity holders and 100 million TEST to company employees and advisors, with 50% unlocked at token launch and the remaining tokens unlocked one year following this launch.

6. TEST Foundation

TEST Foundation will manage protocol governance for the TEST protocol and registries, including parameter settings and testing standards. TEST Foundation will also enlist a decentralized network of laboratories to join the lab registry and perform work for the product registry. TEST was initially developed by Labdoor's founders as a way to decentralize product testing and certifications. Labdoor brings its expertise in independent testing, software engineering, and consumer awareness into the design of the TEST protocol and registries. TEST Foundation will initially fund itself through token sales and will work to scale network transaction and API fees to make the organization self-sufficient indefinitely.

7. Labdoor

Since 2012, Labdoor has independently tested and reviewed hundreds of dietary supplements, powering a product review site used by millions of people each year. Labdoor also offers product certifications for Purity (heavy metals and microbiological testing) and Sport (WADA Anti-Doping List testing). This work has been funded through angel and venture capital investments and is monetized through advertising revenue, with retailers paying Labdoor a commission for every sale generated through its website. Labdoor could continue to operate its centralized marketplace indefinitely, but expects to generate more long-term value by building its applications on an open protocol layer.



Labdoor seeks to recruit a broad group of network participants to generate the world's largest public database of product quality data. Labdoor will lead the initial development of the TEST protocol and will contribute its 5+ years of testing data to the blockchain ledger, seeding the product registry. Labdoor's ownership stake in the network incentivizes it to build its applications on the TEST network to serve early network participants. Labdoor will continue to operate its certifications program while the TEST protocol is being developed. These certifications will be added to the product registry when it launches and will help build an early consumer and producer base for the TEST Registry.

Once the token launches, Labdoor will focus on building and scaling new applications and recruiting millions of consumers to research and buy products listed in the registry. One year after the launch of this protocol, Labdoor will no longer hold its initial distribution of TEST tokens and expects to serve as just one of many providers in the network. As creators of the TEST protocol, Labdoor's founders intend to remain involved in TEST governance long-term through official leadership positions and informal community organization.

8. TEST Use Cases

8.1. Supplements

Dietary supplements face no pre-market regulation by the FDA, meaning they can be sold without any safety, purity, or quality testing[27]. The TEST Registry will help consumers identify products that consistently pass quality standards. TEST's challenge process regulates the quality of the registry and provides the incentives for token holders to sponsor testing on products that they expect to fail a challenge. Labdoor has been independently testing supplements since 2012 and will contribute its product data to TEST at its launch, jumpstarting network utility. As the product registry grows, TEST could develop sub-registries that segment different types of products (e.g. supplements vs. food), or even further segment these industries into specific product categories (e.g. fish oil vs. multivitamins). Supplements account for just over 10% of all food recalls in the United States[28].

8.2. Food

There are over 400 food recalls each year in the United States, putting consumers at risk on a daily basis[29]. Food recalls also rely on adverse events (people getting sick) as a reactive signal for regulators to take action. The TEST Registries can more

[27] J. Hamblin, "Why Vitamins and Other 'Dietary Supplements' Can Contain Anything," https://www.theatlantic.com/health/archive/2016/06/supplements-make-tobacco-look-easy/488798/, 2016.
[28] Statista, "FDA food recall share in the United States in Q2 2017, by category," https://www.statista.com/statistics/618177/fda-food-recall-share-us-by-category/, 2017.
[29] T. Maberry, "A Look Back at 2017 Food Recalls," https://www.foodsafetymagazine.com/enewsletter/a-look-back-at-2017-food-recalls/, 2018.

proactively regulate food quality with its challenge process and help producers manage and publicize their quality control work. If consumers got sick from consuming a specific food product, they could organize together to challenge that product in the registry. Regulators and independent auditors could also monitor testing data to identify concentrated points of failure in the global food supply chain. The global Food Traceability market is over $12 billion annually and growing over 5% per year due to quality control issues in the global food supply chain[30].

8.3. Pharmaceuticals

Counterfeit pharmaceuticals are a $200 billion global industry, making them the largest segment of the overall counterfeiting market[31]. This issue is often overlooked in the United States and Europe, where counterfeits are expected to be less than 0.2% of the market[32]. However, the same study estimates counterfeiting rates in Asia and Latin America at over 10%, with anecdotal evidence that up to 60% of pharmaceuticals sold in Africa are counterfeit. All counterfeit products are illegal, but when pharmaceuticals such as antibiotics and AIDs medications are faked, they can lead to serious illnesses and deaths. Listings in the TEST Product Registry can include safety data like product serial numbers and expiration dates, which can help consumers identify authentic pharmaceuticals[33]. TEST Foundation could also develop a barcode system to connect physical units of each product with their listing on the product registry, simplifying the consumer user experience.

8.4. Cannabis

Cannabis is now legal in 29 US states and at least 20 states are requiring laboratory testing on cannabis samples, with each state setting its own testing standards[34]. Cannabis producers and dispensaries will desire a simple way to comply with testing regulations and highlight high-quality products. TEST Foundation will initially focus on cannabis testing and certifications in California. California is the largest cannabis market in the world, and will be phasing-in laboratory testing requirements for different cannabis products throughout 2018[35]. All testing data generated on California cannabis samples by the TEST network will be entered into the Bureau of Cannabis Control track and trace system to simplify compliance. As

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[30] BTS Research, "Global Food Traceability Market," https://bisresearch.com/industry-report/global-food-traceability-market-2022.html, 2017.
[31] P. Behner, M. Hecht, F. Wahl, "Fighting counterfeit pharmaceuticals," https://www.strategyand.pwc.com/reports/counterfeit-pharmaceuticals, 2017.
[32] H. Bale, "Pharmaceutical Counterfeiting," https://www.oecd.org/sti/ind/35650404.pdf, 2005.
[33] J. Swiatek, "Eli Lilly intensifies efforts to stop fake pharmaceuticals," https://www.indystar.com/story/money/2014/04/06/eli-lilly-intensifies-efforts-stop-fake-pharmaceuticals/7327471/, 2014.
[34] L. Rough, "Leafly's State-by-State Guide to Cannabis Testing Regulations," https://www.leafly.com/news/industry/leaflys-state-by-state-guide-to-cannabis-testing-regulations, 2016.
[35] Bureau of Cannabis Control, "Required Testing Chart," http://bcc.ca.gov/about_us/documents/17-261_required_testing_chart.pdf, 2017.

new state and federal regulations regarding cannabis are proposed and released, TEST Foundation will advocate for uniform testing standards while also working to add the testing requirements of different jurisdictions into the product registry.

9. TEST Applications

9.1. Labdoor

Labdoor is the first of many application developers and data providers for the TEST network, offering immediate utility to early adopters of this protocol. Labdoor.com will continue to be a digital hub for product reviews and certifications built on data from the TEST network. Labdoor will also relaunch its iOS and Android applications to make it easier for consumers to access data and rankings on products in retail stores. Labdoor will also be a testing provider for the network and could offer services to help producers improve the quality of their products.

9.2. TEST API

TEST will release an API that will allow any application to access TEST's shared data layer. API usage will be metered using TEST tokens or fiat currency, with proceeds going to TEST Foundation to fund long-term operations. TEST Foundation will maintain ownership over the data in the registry and offer a copyright license to API customers. Non-profit organizations will be offered API access at discounted rates for non-commercial use. TEST data and accreditations would be a valuable addition to applications for consumers (retailers, marketplaces, product review sites), producers (supply chain analytics, competitive analysis), and health care professionals (reference guides).

10. TEST Partnerships

10.1. Government Agencies

Regulatory agencies could broadcast recalls and warnings to listings in the TEST Registry, rapidly alerting consumers of risky products that they have purchased and reducing the risk of additional adverse events. This protocol would serve to decrease information overload in the market by only targeting affected market participants. The current standard for consumer alerts of product recalls is still for regulators to distribute press releases to news organizations; however, these announcements are largely untargeted and can cause recall fatigue in the market[36].

Blockchain-based ID verification could also be used to regulate the distribution and sale of controlled substances such as stimulants, opioids, and cannabis. Smart contracts could be designed to enforce existing laws governing access, frequency, and volume of specific purchases, and a distributed transaction ledger could assist law enforcement in tracking illegal activities such as doctor shopping. This protocol

[36] C. Doering, "Surge in products being recalled may be numbing consumers," https://www.cnbc.com/id/47765935, 2012.

could track product sales across borders, helping regulators coordinate enforcement actions.

10.2. Certificate Authorities

We need to recruit certificate authorities to attach their certifications to products via the blockchain. All testing results would be recorded on the blockchain, continuously updating the product ledger and alerting network participants of successful audits (e.g. certifications) and required actions (e.g. recalls). Consumers could use TEST-based applications to easily access a wide range of certifications and filter purchases based on their required standards. Organizations will receive TEST tokens for contributing certifications and data to the network.

We also need to work with existing communities organized around specific dietary or ideological restrictions. For example, there are over 300 kosher certification agencies in the United States, accounting for over $12 billion in annual retail sales[37]. By integrating this certification data into our network, we can provide a valuable utility to kosher consumers. This model works for any product certification or accreditation and empowers consumers to cross-reference testing results from different organizations. TEST tokens will be offered as an incentive to certificate authorities that publish their results on the blockchain.

10.3. Retailers and Marketplaces

Retailers who are committed to selling only high-quality products could require products to be "TEST Registered" in order to be sold in their stores. They could also simply highlight TEST-registered products in a special section of their stores. Both of these actions would encourage more producers to apply to the TEST Registry, increasing the value of the registry and the token. TEST Foundation will recruit these sellers to adopt TEST into their quality control programs, rewarding early adopters with TEST grants to cover implementation costs.

11. Conclusion

Information asymmetry in retail markets puts consumers at risk of fraud through the sale of counterfeit, adulterated, recalled, and expired goods. Trusted third parties (TTPs) promise to solve the information asymmetry problem, with regulatory agencies such as the FDA blacklisting defective products through a recall system and certificate authorities such as UL whitelisting verified products through a certification system. However, fraudsters continuously exploit vulnerabilities in these centralized systems, allowing bad products to continue to reach consumers. Consumers would benefit from organizing together and sponsoring their own testing program to fight this fraud, but the total cost is too expensive for any one individual to undertake, meaning that the collective action will only occur if a critical

[37] T. Lytton, "Kosher Certification as a Model of Private Regulation," https://object.cato.org/sites/cato.org/files/serials/files/regulation/2013/9/regv36n3-4n.pdf, 2013.

mass of people coordinates their resources and takes action together.

We propose a new decentralized protocol, TEST, which uses its native TEST token to maintain a series of token-curated registries. The TEST Product Registry will require applicants to attest to the quality of their products. This registry will be regulated by an application/challenge process that incentivizes applications from good products and challenges against bad products. Challenges will be judged by laboratories approved by the TEST Lab Registry, which requires labs to provide proof of key accreditations. Labs can also be challenged by the network if challengers have evidence that a lab has not maintained an active accreditation.

TEST Foundation will manage the governance of the TEST protocol and registries. Labdoor will be responsible for the initial development of the TEST protocol and will convert its data and applications to run on the TEST network. This will provide immediate utility to early adopters. This open protocol will power a decentralized network of applications and data providers operating on a shared data layer. At scale, TEST will increasingly become the leading global data source for product quality and TEST certifications will be a common sight in any retail store or online marketplace. Regulatory agencies and certificate authorities could also track TEST blockchain activity to analyze global supply chains and identify concentrated points of failure. Alerts about product recalls and health and safety risks could be rapidly and precisely distributed to retailers and consumers using TEST.

The TEST protocol aligns incentives between all market participants:

1. Producers who consistently deliver high-quality products will be rewarded by the network with increased sales and brand trust.
2. Laboratories work for the network, not the producers. This decentralized network of laboratories ensures that test results are unbiased.
3. TEST holders have the ability to self-regulate the registry via challenges and are rewarded for successful challenges.
4. Consumers benefit from TEST even if they are not token holders, lowering barriers to mainstream adoption.

Following Bitcoin's promise to disintermediate trusted third parties like financial institutions and central banks, this protocol can solve some of the weaknesses of the current TTP-based regulatory model for product quality control[38]. TEST aligns incentives between producers, consumers, and validators and offers a public, global, and decentralized alternative to trusted third parties like the FDA.

[38] S. Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System," https://bitcoin.org/bitcoin.pdf, 2008.