Forensics, Elasticities and Benford's Law: Detecting Tax Fraud in International Trade*

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Abstract

By its very nature, tax evasion is difficult to detect as the parties involved have incentive to conceal their activities. This paper offers a setting where tax evasion can be detected because of an exogenous shock to the tax rate. It contributes to the literature by proposing two new methods of detecting tax evasion. The first method is based Benford's law, while the second relies on comparing price and trade cost elasticity of import demand. Both methods produce evidence consistent with an increase in tax evasion after the shock. The paper further shows that evasion induces a bias in the estimation of trade cost elasticity of import demand, leading to miscalculation of gains from trade based on standard welfare formulations. Finally, welfare predictions are derived from a simple Armington trade model which accounts for tax evasion.

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1 Introduction

Wherever taxes are being collected, there is tax evasion. Yet, by its very nature, tax evasion is difficult to detect as the parties involved have every incentive to conceal their lack of compliance with the tax law. Tax evasion matters, as it may alter the distortionary costs of raising tax revenue and affect the distributional consequences of a given tax policy. Resources spent on tax evasion also represent a deadweight loss to the economy. Despite the great importance of tax evasion to public policy choices, relatively little is known about the extent of tax evasion and its responsiveness to tax rates. Finding answers to these questions is often confounded by a lack of large and plausibly exogenous variation in tax rates.

This paper offers a setting where tax evasion can be detected because of a substantial and exogenous shock to the tax rate. It contributes to the literature by proposing two new methods of detecting tax evasion. The first method is based on Benford's law, which describes the distribution of first digits in economic or accounting data. The second relies on comparing demand elasticities with respect to price and trade taxes. Both methods are applied to an unexpected policy change in Turkey and uncover evidence consistent with an increase in tax evasion after the Turkish authorities raised the tax rate applied to external financing of imports. This policy change was of importance, as taxes collected by Turkish Customs amounted to USD 26.8 billion, or about 18% of total tax revenues in Turkey, in 2011.

The paper further argues that incorporating a tax evasion channel is crucial to understanding the true impact of trade policy on economic activity. It demonstrates that evasion induces a bias in the estimation of trade cost elasticity of import demand, leading to miscalculation of gains from trade based on standard welfare formulations. Finally, our study shows theoretically the ambiguous welfare implications of tax evasion in the context of a simple Armington trade model.

The unexpected policy shock exploited in this paper is the increase in the *Resource Utilization Support Fund* (RUSF) tax which took place on 13 October 2011 in response to high and persistent current account deficits. The tax rate was doubled, increasing from 3% to 6% of the transaction value. The RUSF tax, in force since 1988, applies when credit is utilized to finance the cost of imported goods. Whether or not an import transaction is subject to the tax depends on the payment terms. Transactions financed through open account (OA), acceptance credit (AC), and deferred payment letter of credit (DLC) are subject to the tax. Transactions financed in other ways (e.g., through cash in advance) are not.[1] In other words, all imports for which the Turkish importer receives a trade credit are subject to the tax.

Our empirical analysis identifies the effect of the policy change using both cross-sectional and time-series variation. We use very detailed import data, including information on payment terms, to measure the exposure of a given product imported from a given source country to the RUSF tax before the policy change. We then ask whether the post-shock evasion response is systematically related to the pre-shock exposure to the tax. Put differently, our identifying assumption is that import flows which are typically purchased on credit, and thus are subject to the tax prior to the shock, will see a larger increase in evasion in the post-shock period than imports that tended not to utilize external financing.

Before applying our new methods, we show that the "missing trade" approach, proposed by Fisman and Wei (2004), produces evidence consistent with an increase in tax evasion after the policy change. More specifically, we find that the increase in underreporting of imports into Turkey (relative to exports figures reported by partner countries) after the policy change is systematically related to exposure to the RUSF tax before the shock. The estimates imply that import flows that came fully on credit (i.e., tax exposure equal to 100%) saw a 6% larger increase in underreporting relative to flows with no exposure to the tax prior to the shock. This amounts to tripling of underreporting relative to the pre-shock value.

Our proposed detection method based on Benford's law confirms this message. We use

[1] Under the OA terms, foreign credit is utilized as the Turkish importer pays the exporter only after receiving the goods. Under the AC terms, domestic credit may be utilized: a bank sets up a credit facility on behalf of the importer and provides financing for the purchase of goods. Finally, the DLC gives the importer a grace period for payment: the importer receives goods by accepting the documents and agrees to pay the bank after a fixed period of time.

Turkish import data disaggregated by firm, 6 digit Harmonised System (HS) product, source country, month and payment method.[2] For each product-country-year cell, we calculate deviation from Benford's law. Then we show that cells with greater exposure to the RUSF tax prior to the shock have greater deviations from Benford's distribution after the policy change.

Next, we present a simple trade model, which predicts that the elasticity of imports with respect to trade taxes is distorted in the presence of tax evasion. This prediction finds support in the data. We estimate the import demand equation instrumenting for price with the sum of the distance between the province in which the Turkish importer is located and Istanbul (the largest international port of Turkey) and the distance between Istanbul and the exporting country. The tax elasticity before the shock is found to be almost identical to the estimated price elasticity, as predicted by the model in the absence of evasion. This result is in line with our earlier findings that evasion was not prevalent before the increase in the RUSF rate in October 2011. After the shock, however, the esimated tax elasticity becomes substantially smaller, which is consistent with an increase in tax evasion after the shock. This matters, because a biased estimate of trade elasticity will lead to overestimation of welfare losses from the tax increase, as calculated based on the widely used formula proposed by Arkolakis et al. (2012).

We close the paper with a discussion of how evasion affects welfare. We show theoretically that tax evasion affects welfare through two channels. It lowers the actual tax rate and affects the share of expenditure on domestic goods. Tax evasion unambiguously reinforces gains from trade when tariff revenues are wasted because it lowers the domestic expenditure share. However, it has an ambiguous effect when tariff revenues are being redistributed to consumers.

Our paper is related to several literatures. First, it contributes to the fast growing literature drawing attention to the abuse of public trust and regulations (Marion and Muehlegger

[2] One may think of this data set as including transaction-level information aggregated to the monthly level.

(2008), Casaburi and Troiano (2016), Artavanis et al. (2016), Fang and Gong (2017), and Chen et al. (2017)). We extend this literature by showing evidence consistent with such abuse taking place in the context of border taxes. Border taxes matter as they are collected by every country in the world. And according to the World Customs Organization, taxes collected by Customs, such as tariffs, consumption taxes, excise duties, etc., account for, on average, 30 percent of government tax revenues. Not surprisingly, tax evasion is the top issue on the policy agenda of Customs services around the world (Han (2014)).

Second, our work is related to the literature documenting tax evasion in international trade using the "missing trade" approach (Fisman and Wei (2004); Fisman et al. (2008); Javorcik and Narciso (2008); Mishra et al. (2008); Ferrantino et al. (2012); and Javorcik and Narciso (2017)). Our paper contributes to this literature by proposing two alternative methods of detecting tax evasion in international trade.

Third, our paper is related to the literature which studies the response of international trade to changes in trade frictions (e.g. Feenstra (1995); Baier and Bergstrand (2001); Trefler (2004); Yang (2008); Arkolakis et al. (2012); Felbermayr et al. (2015); Sequeira (2016); and Goldberg and Pavcnik (2016)). While the existing literature overwhelmingly focuses on tariffs and quotas, we focus on a non-tariff barrier to international trade: tax on import financing. We contribute to this literature by showing that tax evasion affects gains from trade and the elasticity of trade with respect to tax rates.

Finally, our paper is related to an older literature on "directly-unproductive profit-seeking" (DUP) activities such as tax evasion and lobbying. Bhagwati (1982) argues that such activities limit the consumption possibilities available to consumers by diverting resources from productive activities. Nevertheless, Bhagwati and Srinivasan (1982) show that DUP activities may improve welfare if they arise as a response to a distortionary government policy. Our theoretical setting provides an example of this phenomenon. In particular, we show that, provided that tax revenues are wasted, tax evasion reinforces gains from trade by reducing the effective level of distortionary taxation.

The rest of the paper is structured as follows. Next section describes the institutional context and data. Section 3 presents evidence of tax evasion based on the missing trade approach and Benford's law. Section 4 builds a simple Armington trade model with tax evasion, which yields an empirical specification that we use to detect tax evasion. Finally, section 5 provides the conclusions of our study.

2 Institutional Context and Data

2.1 Institutional Context

Turkey has become increasingly involved in international trade since the early 2000s: the value of exports and imports increased five-fold between 1999 and 2013. While the country trades with more than 200 countries, about 40% of its trade is with the European Union, with whom Turkey has a customs union in manufacturing goods. Turkey's considerably low exports-to-imports ratio (about 65%) has been the main driver of its persistently large current account deficit, which has remained above 5 percent of GDP since 2006 (except in 2009).

In response to this high and persistent current account deficit, on October 13, 2011, Turkish authorities passed a law that increased the cost of import financing. The policy increased the rate of the RUSF tax (discussed in the Introduction) from 3% to 6% of the transaction value.

An import transaction is subject to the RUSF tax if the importer is provided with a credit facility. In particular, the following import payment terms are subject to RUSF: open account (OA), acceptance credit (AC), and deferred payment letter of credit (DLC). Under the OA terms, foreign credit is utilized as the Turkish importer pays the exporter only after receiving the goods (usually 30 to 90 days). Under the AC terms, domestic credit is utilized: a bank sets up a credit facility on behalf of the importer and provides financing for the purchase of goods. Finally, the DLC gives the importer a grace period for payment: the importer receives goods by accepting the documents and agrees to pay the bank after a fixed period of time.[3] The RUSF applies to ordinary imports as processing imports have always been exempted from import duties and other taxation.

2.2 Data

The main dataset used in our empirical analysis is the Trade Transactions Database (TTD), a confidential dataset provided by the Turkish Statistics Institute (TUIK), which contains detailed information on Turkish firms' transactions with the rest of the world over the 2010-2012 period. The data, collected by the Ministry of Customs and Trade of the Republic of Turkey, are based on the customs declarations filled in every time an international trade transaction takes place. TTD reports the quantity and the value of firm-level imports in US dollars by product, classified according to the 6-digit Harmonised System (HS), source country, date of the transaction (month and year), payment method (e.g. cash in advance, open account, letter of credit, etc.) and trade regime (ordinary and processing).[4] Import values include cost, insurance and freight (CIF). We restrict the sample to the members of the World Trade Organization.

We aggregate monthly trade flows into annual data to cover 24-months before and 12-months after the date of the policy change (October 2011). In particular, we construct three 12-month periods: $t = \{T-2, T-1, T\}$, where $T-2$ covers the October 2009-September 2010 period, $T-1$ covers October 2010-September 2011, and T covers October 2011-September 2012.

We measure the RUSF tax exposure of product h from source country c imported at time

[3]The following payment methods are not subject to the RUSF: cash in advance (importer pre-pays and receives the goods later); standard letter of credit (payment is guaranteed by the importer's bank provided that delivery conditions specified in the contract have been met); and documentary collection (which involves bank intermediation without payment guarantee).

[4]In the data, ordinary imports account for about 85% total imports.

t as:

$$Exposure_{hct} = \frac{\sum_{m \in \{OA, AC, DLC\}} M_{hcmt}}{\sum_m M_{hcmt}}, \tag{1}$$

where M_{hcmt} denotes the value of imports of product h from country c on payment method m at time t. The numerator gives the sum of product-country-level imports on OA, AC, and DLC terms at time t, which are subject to the tax, and the denominator is equal to the value of total imports during the same period. A higher value of $Exposure_{hct}$ implies a greater reliance on external financing, and thus a greater exposure an increase in the RUSF tax rate.

Although, to the best of our knowledge, the RUSF tax rate increase was unexpected, in our analysis we take a conservative approach and focus on exposure 24 months before the shock (October 2009-September 2010), $Exposure_{hc,T-2}$. In this way, we eliminate the possibility that some importers have adjusted their behavior in anticipation of the tax increase.

The tax increase mattered. As illustrated in Figure 1, the distribution of $Exposure_{hc}$ for ordinary imports (in the upper panel) shifted to the left after the increase in the RUSF rate. In particular, the average value of the share of imports with external financing decreased from about 20% to 14% after the shock. As expected, the distribution of $Exposure_{hc}$ for processing imports, which are exempt from any type of tax, remained unchanged after the shock (see the lower panel).

The tax increase also affected the magnitude of trade flows. A difference-in-differences analysis (presented in Table 1) shows that imports of firms with a greater initial reliance on external financing decreased in relative terms after the increase in the RUSF rate. The estimated effect is economically significant: a one standard-deviation increase in the share of imports with external financing before the shock was associated with imports declining by between 4% and 17% after the policy change.

3 Preliminary Evidence on Tax Evasion

3.1 Missing trade approach

To investigate the effect of the policy change on tax evasion, we first rely on the "missing trade" approach developed by Fisman and Wei (2004). Focusing on Turkey's imports of product h from country c at time t, we construct a variable that captures the gap between the value of the flow reported by the source country c and the value reported by Turkey:

$$MissingTrade_{hct} = \ln X^{c}_{hct} - \ln M^{TUR}_{hct},$$

where $\ln X^{c}_{hct}$ is logarithm of country c's exports of product h to Turkey as reported by c, and $\ln M^{TUR}_{hct}$ is the logarithm of imports of h from c as reported by Turkey. As export figures are reported on f.o.b. basis and import statistics include freight and insurance charges (i.e., they are reported on c.i.f. basis), we expect $MissingTrade$ to be negative. However, on average the reported exports exceeded the imports by 1.4% in 2010 and 3.3% in 2011.

Implementing the missing trade approach to detecting evasion requires export data reported by Turkey's partner countries. We obtain them from United Nations COMTRADE database. When we focus on flows that are reported by both Turkey and a partner country, we have information on annual imports for 4,295 6-digit HS products from 98 partner countries over the 2010-2012 period. The database also reports the weight of each flow, which we use to construct unit values (value per kilogram).

In the top panel of Figure 2, we plot local polynomial regressions of $MissingTrade$ in the year prior to the shock and after the shock as a function of $Exposure_{hc,T-2}$. As evident from the figure, $MissingTrade$ increase with the exposure to the tax. More interestingly, the $MissingTrade$ curve shifts up at all level of $Exposure$ in the post-shock period with the upward shift being the largest for flows with the highest exposure to the tax.

The bottom panel plots local polynomial regressions of $\Delta \ln X^{c}_{hct}$ and $\Delta \ln M^{TUR}_{hct}$ as functions of $Exposure_{hc,T-2}$. As expected, regardless of the reporting partner, Turkish imports decreased with the initial share of trade subject to the tax. More importantly, the wedge between $\Delta \ln X^{c}_{hct}$ and $\Delta \ln M^{TUR}_{hct}$ is increasing with the initial exposure, which is consistent with an increase in tax evasion after the hike in the RUSF tax rate in October 2011.

To test whether underreporting of imports after the policy change increases systematically with the initial exposure to the tax, we estimate the following equation:

$$MissingTrade_{hct} \quad = \quad \gamma_0 + \gamma_1 1\{t = T\} * Exposure_{hc,T-2} + \alpha_{ht} + \alpha_{ct} + \alpha_{hc} + \varepsilon_{hct}. \quad (2)$$

The equation controls for unobservable heterogeneity at the product-country level with α_{hc} fixed effects as well as for time-varying product (α_{ht}) and country (α_{ct}) fixed effects. Our coefficient of interest is γ_1 whose positive value would be consistent with an increase in tax evasion after the hike in the RUSF tax rate in October 2011.

The results obtained from estimating equation (2) are presented in the first column in the upper panel of Table 2. Our coefficient of interest γ_1 is positive and statistically significant at the 5% level. It implies that increasing *Exposure* from zero to one triples underreporting of imports (missing trade) after the RUSF hike relative to the mean value of missing trade in 2011. We also investigate the channels through which evasion may take place; importers may underreport quantities and/or prices. The results presented in the second and third columns suggest that evasion takes place through underreporting of prices rather than quantities, though the coefficient in the quantity estimation is relatively large, albeit statistically insignificant.[5]

In the lower panel of Table 2, we include $1\{t = T - 1\} * Exposure_{hc,T-2}$ as an additional control to show that the baseline results reflect the effect of the policy change at $t = T$ and not just a pre-existing trend. This is indeed the case.

One may wonder why the results do not indicate significant tax evasion prior to the

[5]When interpreting these results one should keep in mind the imperfect measurement of prices, which are defined as value per kg.

RUSF rate increasing from 3% to 6%. The pattern presented in the upper panel of Figure 2 is consistent with the presence of some degree of evasion before the increase in the RUSF rate in October 2011. The amount of evasion, however, does not seem to be large enough to be detected in our empirical analysis. The most likely reason is that a 3% tax rate was not high enough to induce a large number of firms to pay the evasion costs and risk being detected and penalized. As the theoretical model in the next section will illustrate, the extent of evasion increases in the tax rate and decreases with the cost of evasion, the probability of being detected and the penalty. It is worth noting that the Turkish law stipulates quite harsh penalties for noncompliance with the RUSF tax.[6]

In Table 3, we report two robustness checks. The upper panel of the table shows the results from a falsification test where we construct $Exposure^{placebo}$ using processing imports which are exempt from any type of tax. As expected, the coefficient of interest γ_1 does not retain its statistical significance in this specification. In the lower panel, we explore whether the response of missing trade to the initial tax exposure (the actual one, not the placebo one) is non-linear. We do so by creating indicators for bins based on quartiles of $Exposure_{hc,T-2}$. The results are consistent with the patterns illustrated by Figure 2. The gap between exports reported by partner countries and imports recorded by Turkey increases little at the bottom quartile of $Exposure_{hc,T-2}$ but increases greatly for higher quartiles.

3.2 Benford's law

Our first alternative approach to detecting evasion relies on Benford's law. Benford's law describes the distribution of first digits in economic or accounting data. It naturally arises when data are generated by an exponential process or independent processes are pooled

[6] Although controversial, RUSF is considered an import duty and thus subject to the customs laws and regulations, particularly with respect to penalties for noncompliance. Customs law no. 4458 provides for extensive penalties, which includes the practice of "threefold of import duties." Accordingly, RUSF that is not collected is subject to penalties of three times the underpayment. Considering that value added tax (VAT) is also assessed on the RUSF payable upon importation, the penalty amount will also include an amount for three times the underpaid VAT. Additionally, delay interest on the total amount will be assessed. As a result, penalty amounts can quickly become significant (EY (2014), p. 32.)

together (see Figure 3 for the predicted distribution of leading digits according to the law). Deviations from Benford's distribution have been used to detect reporting irregularities in macroeconomic data (Michalski and Stoltz (2013)) and in survey data (Judge and Schechter (2009)).

We expect Benford's law to hold in our data for the following reasons. First, "second-generation" distributions, i.e., combinations of other distributions, conform with Benford's law, for instance, quantity×price (Hill (1995) as in our case. Second, distributions where mean is greater than median, and skew is positive have also been shown to comply with Benford's law (Durtschi et al. (2004)). Figure 4 demonstrates that the distribution of import values in our data is positively skewed, with a mean greater than the median value.

Our hypothesis is that while Benford's law should hold in import data, it will not hold if the data have been manipulated for the purposes of tax evasion. It is because, as shown by experimental research, people do a poor job of replicating known data-generating processes, by for instance over-supplying modes or under-supplying long runs (Camerer (2003), pp. 134-138). Moreover, since Benford's law is not widely known, it seems very unlikely that those manipulating numbers would seek to preserve fit to the Benford distribution.

We start by performing a simple χ^2 test to check whether our import data conform with Benford's law. We use the data obtained from TTD aggregated to the level of 6-digit product and source country for the 12-month periods T and $T-1$. We consider ordinary trade only, as processing trade is not subject to any border taxes. We classify each product-country-year flow as not subject to the RUSF tax (if *Exposure* is equal to zero at $T-2$) or subject to the tax (otherwise). Table 4 shows that ordinary imports that are not subject to the RUSF tax conform with the law both at $t = T$ and $t = T-1$. However, when we consider ordinary imports subject to the RUSF tax, their distribution conforms with the law before the tax hike but not afterwards. This finding is consistent with the message from the missing trade exercise, which suggests an increase in tax evasion in flows rising with tax exposure in the aftermath of the policy change.

Next, we use a difference-in-differences approach to test whether the distribution of Turkish imports with external financing deviated significantly from Benford's law after the policy change. To do so, we follow Cho and Gaines (2007) and Judge and Schechter (2009) and use the following distance measure to capture deviations from Benford's law:

$$D \;=\; \sum_{d=1}^{9}(f_d - \hat{f}_d)^2, \tag{3}$$

where $\hat{f}_d$ denotes the observed fraction of leading digit d in the data, and f_d fraction predicted by Benford's law. For each product-country hc pair with at least 30 observations, we calculate respective frequencies, f^d_{hct} to construct D_{hct}. We estimate the following specification:

$$D_{hct} \;=\; \theta_0 + \theta_1 1\{t = T\} * Exposure_{hc,T-2} + \alpha_{ht} + \alpha_{ct} + \alpha_{hc} + e_{hct}, \tag{4}$$

which controls for product-year, country-year and product-country fixed effects. We anticipate a positive estimate of θ_1 which would be consistent with an increase in tax evasion after the hike in the RUSF tax rate in October 2011.

This alternative approach to detecting tax evasion yields results supporting our earlier conclusions. The results in column 1 of Table 6 show that an increase in deviation from Benford's law after the shock is positively correlated with the initial exposure to the tax. The estimates imply that going from no exposure to the tax to a full exposure (i.e., increase from 0 to 1) increases the deviation from Benford's Law by 17% relative to the mean value of D at $t = T - 1$.[7] In the second column of Table 6, we show that allowing for pre-existing trends does not affect the estimate of our coefficient of interest.

In the third column, we conduct a placebo exercise by focusing on processing trade which is not subject to any border taxes and where we would not expect to see an increase in

[7] To put this figure into perspective consider a random sample with characteristics similar to an average product-country cell in our sample before the shock, that is, a collection of numbers with D = 0.0172. Now add "faked" observations which do not follow Benford's law. Instead, assume that a "faked" observation is equally likely to start with digit 1, 2, 3, etc. What is the fraction of "faked" observations required to generate the estimated increase in D due to exposure going from 0 to 1? It is about 40%.

deviation from Benford's law after the policy change. The results confirm our priors. The coefficient of interest is not statistically significant and its magnitude is very close to zero.

Finally, we conduct a robustness test where we test the deviation of the joint distribution of the leading two digits from the predicted distribution by Benford law which is given by:

$$Prob(D_1 = d_1, D_2 = d_2) = log_{10} \left[1 + \left(\sum_{i=1}^{2} d_i * 10^{2-i} \right)^{-1} \right],$$

where $d_1 \in \{1, 2, ..., 9\}$ and $d_2 \in \{0, 1, 2, ..., 9\}$. Similar to the baseline exercise, we construct deviations of the observed distribution from the predicted distribution and re-estimate equation (4). Results, as presented in the last column of Table 6, are in line with the baseline results which point to an increase in evasion after the increase in the RUSF rate in October 2011.

4 A Theoretical Approach to Detecting Tax Evasion

4.1 Setup

In this section, we propose an alternative approach to detecting tax evasion in international trade transactions, which relies on comparing price and tax elasticity of demand for imports. While the approach is not new in public economics (e.g. Marion and Muehlegger (2008)), it has not been used to detect tax evasion in international trade.

Compared to a standard taxation model in public economics, our setting poses an important challenge. Whether or not a transaction is subject to the RUSF tax is an endogenous decision taken by an importer. The reason is that the tax applies only when external financing is used when importing. Therefore, the importer decides whether to evade taxes, conditional on using external financing. Our empirical method takes this initial decision into account.

Consider a simple Armington model of international trade with $n + 1$ countries, indexed by c. We refer to Turkey as the home country ($c = 0$).[8] Goods are differentiated by country of origin. On the demand side, we assume that consumer preferences are represented by a standard CES utility function, with elasticity of substitution given by $\sigma > 1$:

$$Q = \left(\sum_{c=0}^{n} q_c^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} ; \sigma > 1$$

where q_c is the quantity imported from country c to the home country ($c = 0$).

International trade is subject to two types of frictions. First, there are transport costs which take the iceberg form: $t_c > 1$. Second, there are policy-induced costs which take the ad-valorem form and are borne by consumers: $\tau > 1$. Domestic trade is not subject to any frictions.

There is a continuum of consumers, indexed by k, in the home country, who have identical preferences over goods. When they import, consumers choose between paying immediately and delaying payment (i.e., using external financing). By paying immediately, consumer k incurs a liquidity cost, $r_k > 1$ but saves τ. Liquidity costs are drawn from a common and known distribution $g(r)$ with positive support on the interval $(\underline{r}, \infty)$ and a continuous cumulative distribution $G(r)$.

Consumers, who choose to delay payments, may misreport prices to evade taxes.[9] Let p_c denote the true price of the good exported by country c, which is inclusive of transport costs. Assuming perfect competition on the supply side and denoting wages in the source country by w_c, prices inclusive of transport costs are given by $p_c = t_c w_c$.[10] Instead of reporting the true price, a consumer may report a faction it: $(1 - \alpha)p_c$, where $\alpha \in [0, 1)$. Tax evasion is subject to a cost that is proportional to the true price and quadratic in α : $((\gamma/2)\alpha^2)p_c$, $\gamma > 0$.[11] With probability θ, consumers are subject to a more careful inspection at the

[8]We drop destination-country subscript for notational simplicity. Turkey is assumed to be the destination country in all derivations.

[9]This assumption is consistent with the empirical evidence presented earlier using the missing trade approach.

[10]This assumption implies that it requires one unit of labor to produce one unit of output.

[11]Yang (2008) uses a similar specification when modelling smuggling costs.

border, which will reveal the true price. If $\alpha > 0$, they pay a penalty for the undeclared amount, denoted by $f > \tau - 1$.[12]

4.2 Predictions and empirical implications

Each consumer first decides on the method of payment. If consumer k decides to pay immediately, then the cost of importing is equal to $r_k p_c$. If she delays payment by using external financing, the cost becomes τp_c, though the consumer can evade the tax by under-reporting the price of the good. In the case of evasion, the expected cost of importing with external financing becomes:

$$\tau^e p_c = [1 + (1-\alpha)(\tau - 1) + (\gamma/2)\alpha^2 + \theta\alpha f]p_c,$$

where τ^e denotes the evasion-inclusive tax rate. The first term in square brackets represents the cost due to financing tax to be paid on the declared price. The second term is the cost of evading taxes (e.g., bribes, obtaining fake documents, etc.), and the last term is the expected cost of penalties. Consumers choose α to minimize expected tax payments. At an interior solution, it yields:[13]

$$\alpha^* = \frac{\tau - 1 - \theta f}{\gamma}.$$

The expression implies that tax evasion increases with the tax rate (τ), and it decreases with the cost of evasion (γ), probability of being inspected (θ), and the fixed penalty (f).

Let us now consider the choice of payment method. Given the cost minimizing level of evasion derived above, consumers compare the cost of liquidity (r_k) to the cost of external financing with evasion ($\tau^e|_{\alpha=\alpha^*}$) and choose the method that is associated with a lower

[12] This is consistent with the institutional setup in Turkey described earlier.

[13] We consider the parameter values at which the minimization problem has an interior solution. Since $\alpha < 1$, we exclude the parameter values that satisfy $\tau - 1 = \gamma + \theta f$. Tax evasion would not be profitable, implying $\alpha = 0$, if the tax payable is equal to the expected fees at the customs: $\tau - 1 = \theta f$. So, this case is also excluded.

expected cost. Given that consumers are heterogeneous in the cost of liquidity they are facing, we can define a marginal consumer who is indifferent between paying immediately and delaying payment s.t. $r^* = \tau^e|_{\alpha=\alpha^*} = \tau - \frac{(\tau-1-\theta f)^2}{2\gamma}$. Consumers with $r_k \in [\underline{r}, r^*]$ choose to pay immediately, and others use external financing to delay payment.

Now we can establish a link between this simple model and our variable of interest in the empirical analysis, *Exposure*. The model implies the following expression for the share of imports from origin country c with external financing:

$$Exposure_c = \frac{\int_{r^*}^{\infty} p_c q_c(\tau) dG(r)}{\int_{\underline{r}}^{r^*} p_c q_c(r) dG(r) + \int_{r^*}^{\infty} p_c q_c(\tau) dG(r)}, \tag{5}$$

In the expression, $q_c(\tau)$ and $q_c(r)$ denote, respectively, the quantity of imports with and without external financing from country c such that

$$q_c(\tau) = yP^{\sigma-1} p_c^{-\sigma} \tau^{-\sigma} \tag{6a}$$

$$q_c(r) = yP^{\sigma-1} p_c^{-\sigma} r^{-\sigma}, \tag{6b}$$

where y denotes per-capita income in Turkey, and P the standard CES price index. *Exposure* depends on the policy-induced cost τ for two reasons. First, an increase in τ decreases the mass of consumers who import using external financing (extensive margin). Second, it decreases the quantity imported by consumers who continue to use external financing (intensive margin). The following result summarizes this prediction.[14]

Result 1 *The share of imports with external financing, $Exposure_c$, declines as policy-induced trade frictions, τ, increase.*

This result highlights the importance of taking the nature of the policy into account when evaluating its impact. In particular, the extent to which changes in the policy-induced tax

[14] See Appendix A for the proof.

rate τ affect imports is determined by the choices made by individual importers. Therefore, differences in the behavior of importers create a new extensive margin of adjustment, which is captured by *Exposure*.

Next, we consider the elasticity of firm imports with respect to the tax rate. Demand for imports by firms that choose to pay immediately does not depend on the tax rate. So, we focus on equation (6a) describing the behavior of firms that delay payments. Taking the logarithm of both sides of the equation and replacing τ with τ^e yield:

$$\ln q_c(\tau) = \ln\left(yP^{\sigma-1}\right) - \sigma \ln p_c - \sigma \ln \tau^e \tag{7}$$

It is easy to see that the elasticity of imports with respect to the evasion-inclusive tax rate is equal to the price elasticity, which is given by σ. However, since we never observe the evasion-inclusive tax rate, we need to derive the elasticity with respect to the policy rate, τ. Using the expression for τ^e, we can write the following relationship between $\ln \tau^e$ and $\ln \tau$:

$$\ln \tau^e = \ln \tau + \ln\left(1 - \frac{(\tau - 1 - \theta f)^2}{2\gamma\tau}\right)$$

Substituting this into the demand equation in (7) gives:

$$\ln q_c(\tau) = \ln\left(yP^{\sigma-1}\right) - \sigma \ln p_c - \sigma \ln \tau - \sigma \ln\left(1 - \frac{(\tau - 1 - \theta f)^2}{2\gamma\tau}\right)$$

We can use this equation to estimate the tax elasticity of imports as follows:

$$\ln q_{kc} \quad = \quad \beta_0 + \beta_1 \ln p_{kc} + \beta_2 \ln \tau + \delta_c + \delta_k + e_{kc}, \tag{8}$$

where δ_c absorbs the market specific variables $\ln\left(yP^{\sigma-1}\right)$, and δ_k controls for selection into external financing as only importers that face relatively high liquidity costs, such that $r_k > r^*$, rely on external financing and delay payment. Since we cannot observe the evasion-inclusive tax rate, e_{kc} includes the term $\Xi(\tau) = -\sigma \ln\left(1 - \frac{(\tau-1-\theta f)^2}{2\gamma\tau}\right)$, which is positively correlated with the policy tax rate:

$$\frac{d\Xi}{d\tau} = \frac{\sigma}{2\left(1 - \frac{(\tau-1-\theta f)^2}{2\gamma\tau}\right)} \frac{\tau+1+\theta f}{\tau^2}\alpha^* > 0$$

This creates a positive bias in the estimate of β_2 as we expect $\beta_2 < 0$.

Result 2 *The elasticity of imports with respect to the evasion-inclusive tax rate is equal to the price elasticity of demand for imports (ϵ), which is given by σ. Since the evasion-inclusive tax rate is not observed, the elasticity with respect to the actual policy rate is estimated with a positive bias, $\epsilon^\tau > \epsilon = -\sigma$.*

Equation (8) forms the basis of our estimation strategy. We augment this equation by including a time subscript. We focus on ordinary import flows. We estimate the equation using firm-product-country-level import data disaggregated by financing terms. In the estimation, we need to address a number of issues. First, equation (8) is subject to the classical endogeneity bias associated with demand estimation. To address this problem, we use the distance between the importing firm and the source country as an instrument for import prices. More specifically, our instrument $\ln Distance_{ic}$ is the logarithm of the sum of the distance between the province in which the importing firm i is located and Istanbul (the largest international port of Turkey) and the distance between Istanbul and country c. Suppose that there are two firms importing the same product from the same country through Istanbul. Our identification strategy relies on the fact that the one that is located farther away from Istanbul will pay a higher c.i.f. price as it pays a higher domestic transport cost. Second, while the model does not distinguish between different products, one could expect heterogeneity across products within a country in the data. We address this issue by adding fixed effects at the source-country-6-digit-product-time level. Third, we add firm-time fixed effects to control for potential time-varying confounding factors at the firm level, as well as to account for selection into external financing. Therefore, we estimate the following equation:

$$\begin{aligned}\ln q_{ihcmt} &= \beta_0 + \beta_1 \ln p_{ihcmt} + \beta_2 \ln \tau_{ihcmt} + \beta_3 1\big\{t = T\big\} * \ln \tau_{ihcmt} \\ &+ \delta_{hct} + \delta_{it} + e_{ihcmt}, \end{aligned} \tag{9}$$

In the absence of evasion, i.e., $\tau^e = \tau$, the elasticity of import demand with respect to the tax rate is equal to price elasticity, which is given by σ. In the presence of evasion, the tax elasticity is estimated with a positive bias, implying that the elasticities given by by β_2 and $\beta_2 + \beta_3$ would be smaller in size (absolute value) than the estimated price elasticity β_1.

Table 7 presents the results obtained from estimating equation (9). Our preferred specification, presented in column 2, instruments unit price with the distance between the importing firm i and the exporting country. The tax elasticity before the shock is -2.18, which is almost the same as the estimated price elasticity. This result is in line with the theoretical predictions in the absence of evasion and our earlier findings that evasion was not prevalent before the increase in the RUSF rate in October 2011. The estimated coefficient on the interaction $1\big\{t = T\big\} * \ln \tau_{ihcmt}$ implies a tax elasticity of $-0.378 = -2.18 + 1.803$, which is substantially smaller than the corresponding elasticity before the shock and the price elasticity. This result is consistent with increase in tax evasion after the shock. In the last column of Table 7, we include an interaction between $1\big\{t = T\big\}$ and prices to check whether there was a change in the estimated price elasticity after the policy change. While the coefficient on this interaction is statistically significant, our coefficient of interest retains its size and significance.

The result that tax evasion creates a downward bias in trade elasticity estimates has an important implication for welfare gains from trade liberalization. Indeed, trade elasticity is one of the two sufficient statistics required to calculate welfare effects of changes in variable trade costs in a large class of trade models (Arkolakis et al. (2012)). To quantify the change in welfare implied by the estimated trade elasticity, we use their welfare formulation.[15] In the absence of tax evasion, tax elasticity is equal to price elasticity, which is estimated to be $\epsilon^{\tau} = 2.18$. The implied welfare change is -0.6%. The estimated tax elasticity in the presence of tax evasion is $\epsilon^{\tau^e} = 0.378$, and the implied welfare change is -3.2%. In other words, the upward bias in the tax elasticity estimates created by tax evasion leads to overestimation of welfare losses.

4.3 Welfare

We have just shown that identifying trade elasticity from variation in import taxes is challenging in the presence of evasion. Evasion also affects the welfare calculations through two other channels: (i) it changes the actual tax rate paid, and (ii) it affects the domestic expenditure share. Here we illustrate this in the context of our simple Armington trade model. To emphasize the importance of evasion for gains from trade, we assume $\underline{r} > \tau$, i.e., all importers choose to delay payment and thus $Exposure = 1$. Although resources spent on evading taxes are wasted, tariff revenues are assumed to be redistributed to consumers as a lump-sum transfer.

Tax-inclusive expenditures on goods imported by Turkey from country c are given by:

$$x_c = q_c(\tau^e p_c) = Y_0 P_0^{\sigma-1}(p_c\tau^e)^{1-\sigma}, \tag{10}$$

where $Y_0 = y_0 L_0$ is total income in Turkey. Then, we can write total expenditures in the

[15]The formula is given by:

$$\hat{W} = \left(\frac{\text{Share of exp. on domestic goods at } t = T}{\text{Share of exp. on domestic goods at } t = T-1}\right)^{1/\epsilon^{\tau}}$$

$\epsilon^{\tau} = \sigma = -2.18 \implies \hat{W} = (0.728/0.719)^{-1/1.218} = -0.6\%$
$\epsilon^{\tau^e} = -0.378 \implies \hat{W} = (0.728/0.719)^{-1/0.378} = -3.2\%.$

home country as the sum of expenditures on domestically produced goods and imports:

$$X_0 = \sum_{c=0}^{n} x_c = x_0 + \sum_{c=1}^{n} x_c$$

where $x_0 = Y_0 P_0^{\sigma-1} p_0^{1-\sigma}$. Government revenues from taxes on foreign goods are given by:

$$T_0 = (1-\alpha^*)(\tau-1) \sum_{c=1}^{n} \frac{x_c}{\tau^e} = \frac{(1-\alpha^*)(\tau-1)}{\tau^e}(1-\lambda_0)X_0, \tag{11}$$

where $\lambda_0 = x_0/X_0$, i.e. share of consumer expenditures on domestically produced goods in the home country. Since tax revenues are redistributed to consumers in a lump-sum fashion, expenditures are financed by labor income and tax revenues:

$$X_0 = w_0 L_0 + T_0$$

We obtain the following relationship between total expenditures and labor income by replacing tax revenues with the expression in (11) and rearranging:

$$X_0 = \mu_0 w_0 L_0, \tag{12}$$

where $\mu_0 = \left(1 - \frac{(1-\alpha^*)(\tau-1)}{\tau^e}(1-\lambda_0)\right)^{-1}$ is a tax multiplier (Felbermayr et al. (2015)). Tax evasion affects the multiplier for two reasons. First, it lowers the multiplier by reducing the actual tax rate paid: the term $\frac{(1-\alpha^*)(\tau-1)}{\tau^e}$ becomes $\frac{\tau-1}{\tau}$ in the absence of evasion. Second, evasion increases the tax multiplier by lowering the domestic expenditure share, λ_0. This happens because evasion lowers the relative price of foreign goods compared to the case where there is no evasion.

Per capita welfare can be written as:

$$W_0 = \frac{X_0}{P_0 L_0} = \mu_0 \frac{w_0}{P_0} = \mu_0 \lambda_0^{\frac{1}{1-\sigma}} \tag{13}$$

The last equality follows as $\lambda_0 = (w_0/P_0)^{1-\sigma}$.[16]

Evasion affects gains from trade through two channels. First, it unambiguously reinforces gains from trade by lowering the relative price of foreign goods, and thus decreasing domestic expenditure share. Second, evasion has an ambiguous effect on gains from trade through its effect on the tax multiplier. While resources wasted on evasion tend to reduce the multiplier, lower relative price of foreign goods tends to raise it. The overall effect remains ambiguous. It can be seen more easily by re-writing the welfare formula in the presence of evasion as follows:

$$W_0^e = \mu_0 \lambda_0^{\frac{1}{1-\sigma}} \underbrace{\frac{\mu_0^e}{\mu_0}}_{\gtrless 1} \underbrace{\left(\frac{\lambda_0^e}{\lambda_0}\right)^{\frac{1}{1-\sigma}}}_{>1} \tag{14}$$

where (μ_0, λ_0) denote tax multiplier and domestic expenditure share without evasion, and (μ_0^e, λ_0^e) denote the respective quantities with evasion. When there is no evasion and tariff revenues are wasted, the welfare formula in (14) collapses to the one in Arkolakis et al. (2012). The last two terms arise due to evasion.

The expression in (14) implies tax evasion unambiguously reinforces gains from trade when tariff revenues are wasted instead of being redistributed to consumers: $\mu_0^e = \mu_0 = 1$. In this case, tariff evasion affects welfare only through its effect on the domestic expenditure share. Since tax evasion unambiguously lowers the domestic expenditure share, tax evasion reinforces gains from trade.

[16]To see this, note that $x_c/x_0 = (p_c/p_0)^{1-\sigma}(\tau^e)^{1-\sigma}$, where $c \neq 0$. So, we have

$$\begin{aligned} X_0 &= x_0 w_0^{\sigma-1}(w_0^{1-\sigma} + \sum_{c=1}^{n}(p_c\tau^e)^{1-\sigma}) \\ &= x_0 w_0^{\sigma-1} P_0^{1-\sigma} \end{aligned}$$

$$\implies \lambda_0 = \frac{x_0}{X_0} = \left(\frac{w_0}{P_0}\right)^{1-\sigma}$$

5 Conclusions

This paper proposes two novel methods of detecting tax evasion in international trade. The first method uses deviations from Benford's law, while the second method relies on comparing price and trade cost elasticity of import demand. We apply both methods to an unexpected policy change that increased the cost of import financing in Turkey and show that both methods produce evidence consistent with an increase in tax evasion after the shock. A standard approach based on missing trade confirms this conclusion.

Our results also suggest that ignoring tax evasion may lead to miscalculation of gains from changing trade barriers based on standard welfare formulations. Finally, we derive formula to calculate gains from trade in a simple Armington trade model with tax evasion.

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Appendices

A Proof of Result 1

It is easier to derive $\frac{d(1/Exposure)}{d\tau}$, where country subscript is dropped to simplify notation. It is equal to

$$\frac{d(1/Exposure)}{d\tau} = \frac{q(r^*)g(r^*)\frac{dr^*}{d\tau}\int_{r^*}^{\infty} q(\tau)dG(r) - \int_{\underline{r}}^{r^*} q(r)dG(r)\left(\int_{r^*}^{\infty}\frac{dq(\tau)}{d\tau}dG(r) - q(r^*)g(r^*)\frac{dr^*}{d\tau}\right)}{\left(\int_{r^*}^{\infty} q(\tau)dG(r)\right)^2}$$

$$\propto q(r^*)g(r^*)\frac{dr^*}{d\tau}\int_{r^*}^{\infty} q(\tau)dG(r) - \int_{\underline{r}}^{r^*} q(r)dG(r)\left(\int_{r^*}^{\infty} yP^{\sigma-1}p_c^{-\sigma}(-\sigma)(\tau^e)^{-\sigma-1}\frac{d\tau^e}{d\tau}dG(r) - q(r^*)g(r^*)\frac{dr^*}{d\tau}\right)$$
$$= \mathrm{q(r^*)}g(r^*)\frac{dr^*}{d\tau}\int_{r^*}^{\infty} q(\tau)dG(r) - \int_{\underline{r}}^{r^*} q(r)dG(r)\int_{r^*}^{\infty} q(\tau)\frac{-\sigma}{\tau^e}\frac{d\tau^e}{d\tau}dG(r)$$
$$= \mathrm{q(r^*)}g(r^*)\frac{dr^*}{d\tau}\left(\int_{r^*}^{\infty} q(\tau)dG(r) + \int_{\underline{r}}^{r^*} q(r)dG(r)\right) + \frac{\sigma}{\tau^e}\frac{d\tau^e}{d\tau}\int_{\underline{r}}^{r^*} q(r)dG(r)$$

where $\frac{dr^*}{d\tau} = \frac{d\tau^e}{d\tau} = 1 - \frac{\tau-1-\theta f}{\gamma} = 1 - \alpha^* > 0$. The last equality follows from the fact that $q(r^*) = q(\tau^e)$. Therefore, $\frac{d(1/Exposure)}{d\tau} > 0 \implies \frac{d(Exposure)}{d\tau} < 0$.

B Tables and Figures

Table 1: **Firm-level Imports before and after the Shock**

	Baseline	Pre-existing trends	Processing imports
	(1)	(2)	(3)
$1\{t = T\} * Exposure_{i,T-2}$	**-0.119****	**-0.151****	-0.104
	(0.0530)	(0.0665)	(0.0847)
$1\{t = T-1\} * Exposure_{i,T-2}$		-0.0666	
		(0.0640)	
N	45818	45818	8549
R^2	0.888	0.888	0.910
FE	s(i)xt,i	s(i)xt,i	s(i)xt,i

Notes: This table shows the results from estimating the following regression:

$$\ln M_{it} = \delta_0 + \delta_1 1\{t = T\} * Exposure_{i,T-2} + \alpha_{s(i),t} + \alpha_i + e_{it}$$

where the dependent variable is the logarithm of the value of imports by firm i at time $t = \{T-2, T-1, T\}$, and $Exposure_{i,T-2}$ is share of firm-level imports with external financing at time $t = T-2$. $1\{t = T\}$ is a dummy variable that takes on the value one for the October 2011-September 2012 period (after the increase in RUSF rate), and zero otherwise. The specification controls for time-varying factors common to a given 4-digit NACE industry ($\alpha_{s(i),t}$) and firm fixed effects (α_i). *, **, *** represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the the 4-digit NACE industry where firm i operates.

Table 2: **Evidence of Evasion: Missing trade approach**

	(1)	(2)	(3)
$MissingTrade$ in	Value	Quantity	Price
		Panel A: Baseline	
$1\{t = T\} * Exposure_{hc,T-2}$	$\mathbf{0.062}^{**}$	0.022	$\mathbf{0.040}^{*}$
	(0.028)	(0.035)	(0.020)
N	70089	70089	70089
R^2	0.812	0.787	0.711
		Panel B: Pre-existing trends	
$1\{t = T\} * Exposure_{hc,T-2}$	$\mathbf{0.064}^{*}$	0.014	$\mathbf{0.050}^{**}$
	(0.034)	(0.042)	(0.025)
$1\{t = T-1\} * Exposure_{hc,T-2}$	0.005	-0.016	0.021
	(0.030)	(0.038)	(0.024)
N	70089	70089	70089
R^2	0.812	0.788	0.711

Notes: This table shows the results from estimating specification in equation (2). $MissingTrade_{hct}$ in terms of value is defined as the difference in the value of exports of product h by country c to Turkey and Turkey's imports of h from c. $MissingTrade$ in terms of quantity is defined similarly using weights (in kg) and in terms of prices is defined in terms of value per kg. $Exposure_{hc,T-2}$ is share of product-country-level imports with external financing at time $t = T - 2$. $1\{t = T\}$ is a dummy variable that takes on the value one for the October 2011-September 2012 period, and zero otherwise. *, **, *** represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the 4-digit HS product and source country level.

Table 3: **Evidence of Evasion: Robustness checks for missing trade approach**

	(1)	(2)	(3)
$MissingTrade$ in	Value	Quantity	Price
	Panel A: Using placebo exposure based on processing imports		
$1\{t=T\} * Exposure^{placebo}_{hc,T-2}$	0.028	0.000	0.027
	(0.030)	(0.037)	(0.020)
N	23913	23913	23913
R^2	0.858	0.838	0.761
	Panel B: Non-parametric estimates		
$1\{t=T\}$			
$*$Bin 2	**0.0546****	0.040	0.014
	(0.021)	(0.026)	(0.015)
$*$Bin 3	**0.072*****	0.026	**0.047*****
	(0.021)	(0.026)	(0.015)
$*$Bin 4	**0.0683*****	0.020	**0.048*****
	(0.022)	(0.027)	(0.015)
N	70089	70089	70089
R^2	0.812	0.787	0.711
Fixed effects	hxt,cxt,hxc	hxt,cxt,hxc	hxt,cxt,hxc
F-stat. $\beta_{Bin2} = \beta_{Bin3}$	1.003	0.414	**5.723****
F-stat. $\beta_{Bin2} = \beta_{Bin4}$	0.484	0.659	**5.727****
F-stat. $\beta_{Bin3} = \beta_{Bin4}$	1.003	0.414	**5.723****

Notes: This table shows the results from estimating specification in equation (2). $MissingTrade_{hct}$ in terms of value is defined as the difference in the value of exports of product h by country c to Turkey and Turkey's imports of h from c. $MissingTrade$ in terms of quantity is defined similarly using weights (in kg) and in terms of prices is defined in terms of value per kg. $Exposure^{placebo}_{hc,T-2}$ is share of product-country-level *processing* imports with external financing at time $t = T-2$. Bins are constructed based on quartiles of $Exposure_{hc,T-2}$, where Bin 1 is a dummy variable that denotes the first quartile and forms the base group in Panel B. Bin 2, Bin 3, and Bin 4 are defined analogously. $1\{t=T\}$ is a dummy variable that takes on the value one for the October 2011-September 2012 period, and zero otherwise. *, **, *** represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the 4-digit HS product and source country level.

Table 4: **Testing Conformity with Benford's law**

Ordinary imports	Not subject to RUSF		Subject to RUSF	
	Before	After	Before	After
Test statistic	12.718	9.021	9.887	**22.301*****
No. of obs	56168	56168	26431	26431

Notes: Table shows χ^2 goodness-of-fit test statistic values for the observed data. Test statistic is calculated as $N\sum_{d=1}^{9}\frac{(f_d-\hat{f}_d)^2}{f_d}$, where $\hat{f}_d$ is the fraction of digit d in the data and f_d is the fraction predicted by Benford's law. The test statistic converges to a χ^2 distribution with eight degrees of freedom as $N \to \infty$. The corresponding 5% and 1% critical values are 15.5, and 20.1.

Table 5: **Summary Statistics for Deviations from Benford's law**

	$t = T-2$	$t = T-1$	$t = T$
D			
Mean	0.0176	0.0172	0.0178
Median	0.0122	0.0120	0.0123
Std	0.0195	0.0191	0.0200
No. of obs. per hc			
Mean	120.1	131.2	130.9
Median	65	67	67
Std	182.1	219.1	219.5

Notes: Table shows summary statistics for the test statistic constructed for deviations from Benford's law for each product-country pair in the data with at least 30 observations. It is defined as

$$D = \sum_{d=1}^{9}(f_d - \hat{f}_d)^2;$$

Table 6: **Evidence of Evasion: Using Benford's law**

	Baseline	Pre-existing trends	Processing	First two digits
$1\{t=T\} * Exposure_{hc,T-2}$	**0.00286*****	**0.00228***	0.0000811	**0.00069***
	(0.00107)	(0.00137)	(0.000719)	(0.00037)
$1\{t=T-1\} * Exposure_{hc,T-2}$		-0.000970		
		(0.00130)		
N	26369	26369	12468	26369
R^2	0.645	0.766	0.798	0.882
Fixed effects	hxt,cxt,hxc	hxt,cxt,hxc	hxt,cxt,hxc	hxt,cxt,hxc

Notes: This table shows the results from estimating specification in equation (4). In the first three columns, the dependent variable is D_{hct}, which measures for each pc-pair the deviation of observed distribution from Benford's law defined as:

$$D_{hct} = \sum_{d=1}^{9}(f^d_{hct} - \hat{f}^d_{hct})^2.$$

In the last column, the dependent variable measures the deviations of the joint distribution of the leading two digits from the predicted distribution by Benford law which is given by:

$$Prob(D_1 = d_1, D_2 = d_2) = log_{10}\left[1 + \left(\sum_{i=1}^{2} d_i * 10^{2-i}\right)^{-1}\right].$$

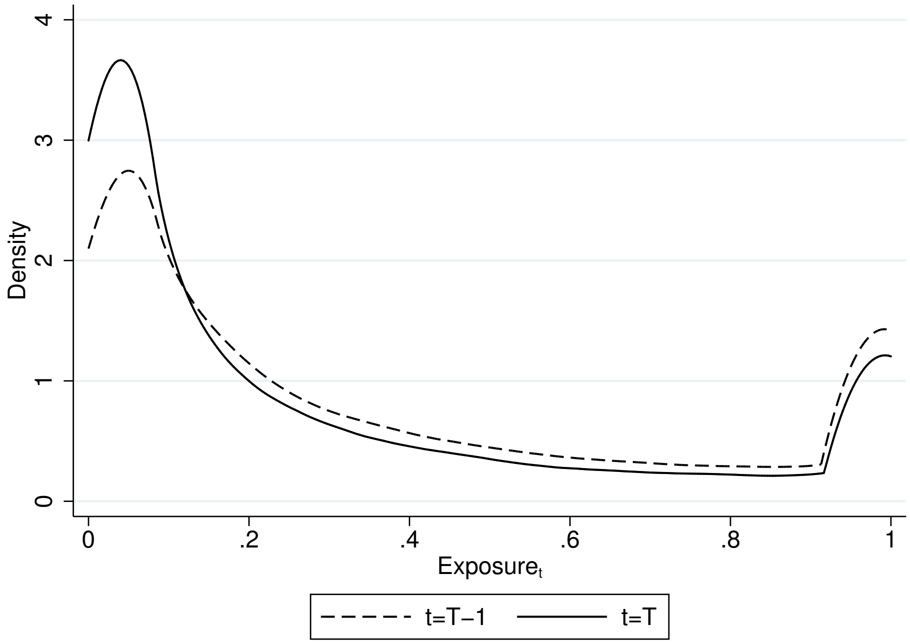
$Exposure_{hc,T-2}$ is share of product-country-level imports with external financing at time $t = T-2$. $1\{t = T\}$ is a dummy variable that takes on the value one for the October 2011-September 2012 period, and zero otherwise. *, **, *** represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the 4-digit HS product and source country level.

Table 7: **Evidence of Evasion: Comparing elasticities**

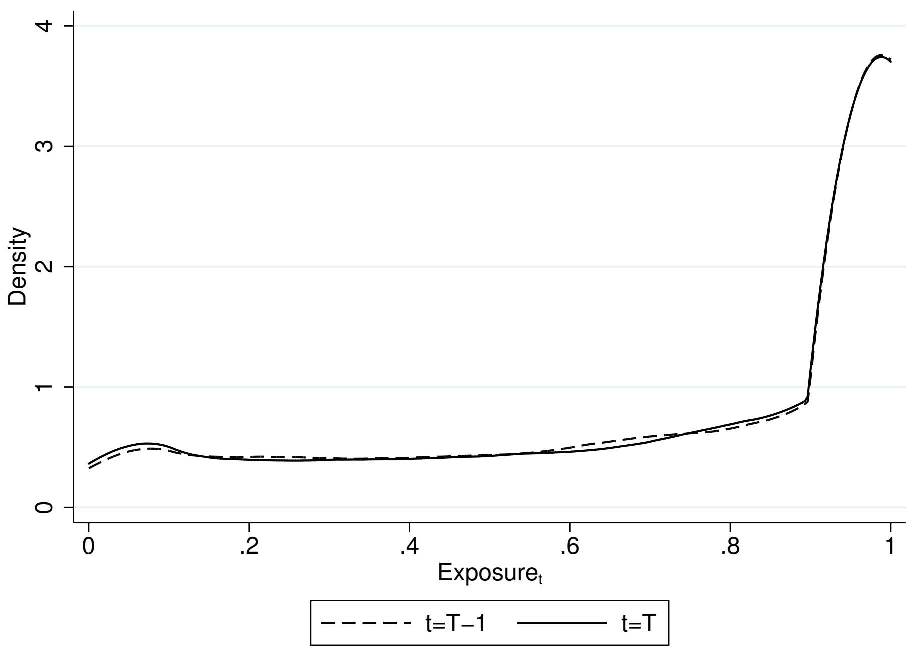
	OLS	IV	IV
	(1)	(2)	(3)
$\ln p_{ihcmt}$	-1.163***	-2.065***	-1.937***
	(0.00729)	(0.412)	(0.389)
$\ln \tau_{mt}$	-2.545***	-2.181***	-2.296***
	(0.464)	(0.691)	(0.655)
$1\{t = T\} * \ln \tau_{mt}$	**2.008***	**1.803***	**2.026***
	(0.456)	(0.640)	(0.720)
$1\{t = T\} * \ln p_{ihcmt}$			-0.325
			(0.599)
N	875034	875034	875034
R^2	0.841		
Fixed effects	hxcxt,ixt	hxcxt,ixt	hxcxt,ixt
F-stat. $\beta_1 = \beta_2$	8.903***	0.0144	0.154
KP test stat		14.08	
CD test stat			11.94

Notes: This table shows the results from estimating specification in equation (9). Dependent variable is the logarithm of the quantity of product h imported by firm i from country c on financing term m at time t. $\ln p_{ihcmt}$ denotes the logarithm of the cif price. $1\{t = T\}$ is a dummy variable that takes on the value one for the October 2011-September 2012 period, and zero otherwise. τ_{mt} denotes the RUSF rate. In columns 2-3, $\ln p_{ihcmt}$ is instrumented with $\ln Distance_{ic}$ which is the logarithm of the sum of distance between the province where i is located and Istanbul (the largest international port of Turkey) and the distance between country c and Istanbul. In the last column, $1\{t = T\} * \ln p_{ihcmt}$ is instrumented with $1\{t = T\} * \ln Distance_{ic}$. KP and CG denote Kleibergen-Paap and Cragg-Donald test statistics, respectively. $^{*}, ^{**}, ^{***}$ represent significance at the 10, 5, and 1 percent levels, respectively. Robust standard errors (in parentheses) are clustered at the 4-digit HS product and source country level.

Figure 1: Distribution of Share of Imports with External Financing ($Exposure_{hc}$)



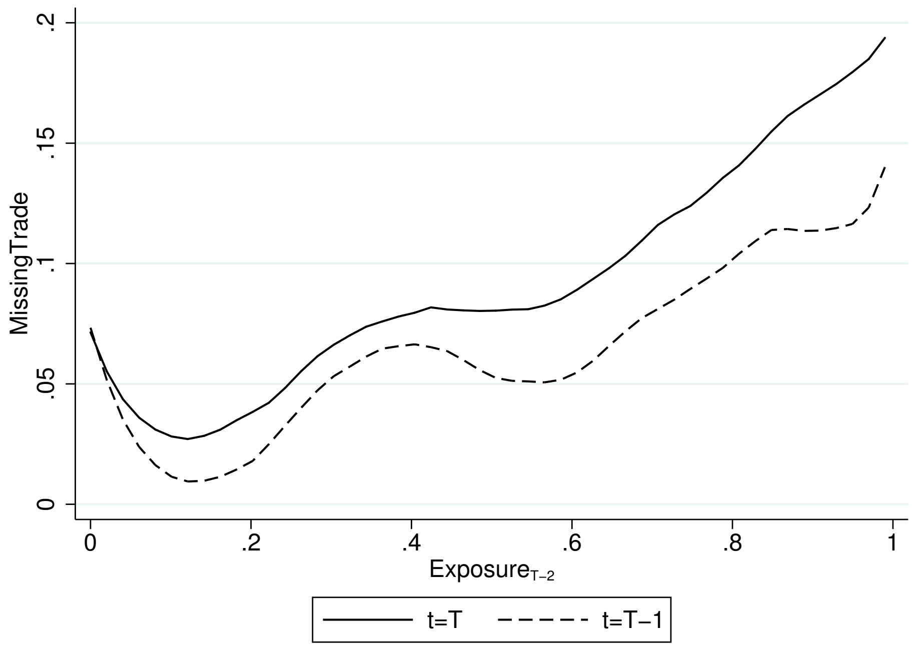
Panel A: Ordinary imports



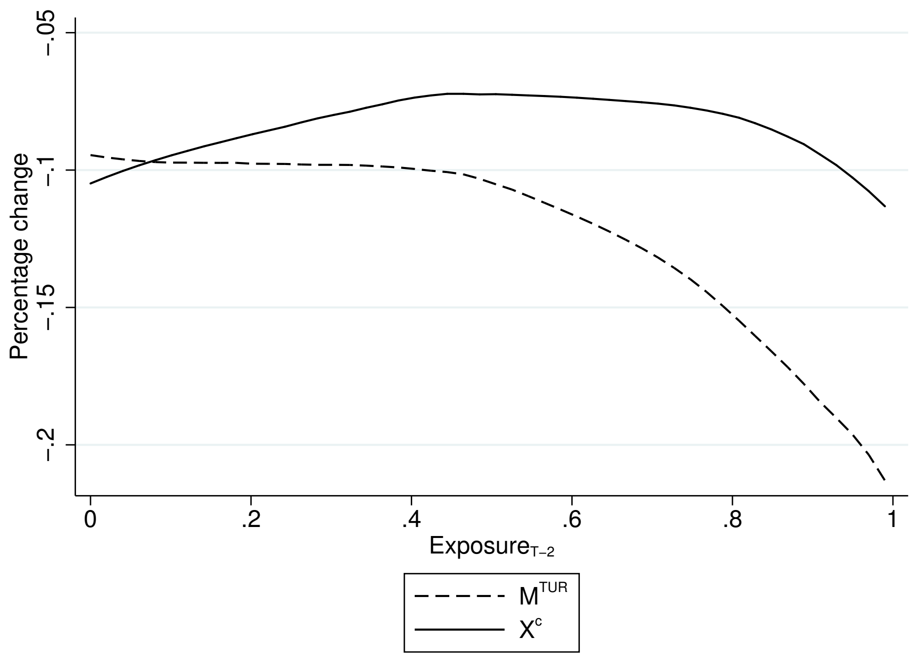
Panel B: Processing imports

Notes: This figure illustrates the distribution of the share of imports with external financing 12-months before and after the increase in the RUSF rate in October 2011. It covers 4,700 6-digit HS products imported from 150 source countries, or 75,000 country-product pairs.

Figure 2: Missing Trade and Exposure to RUSF



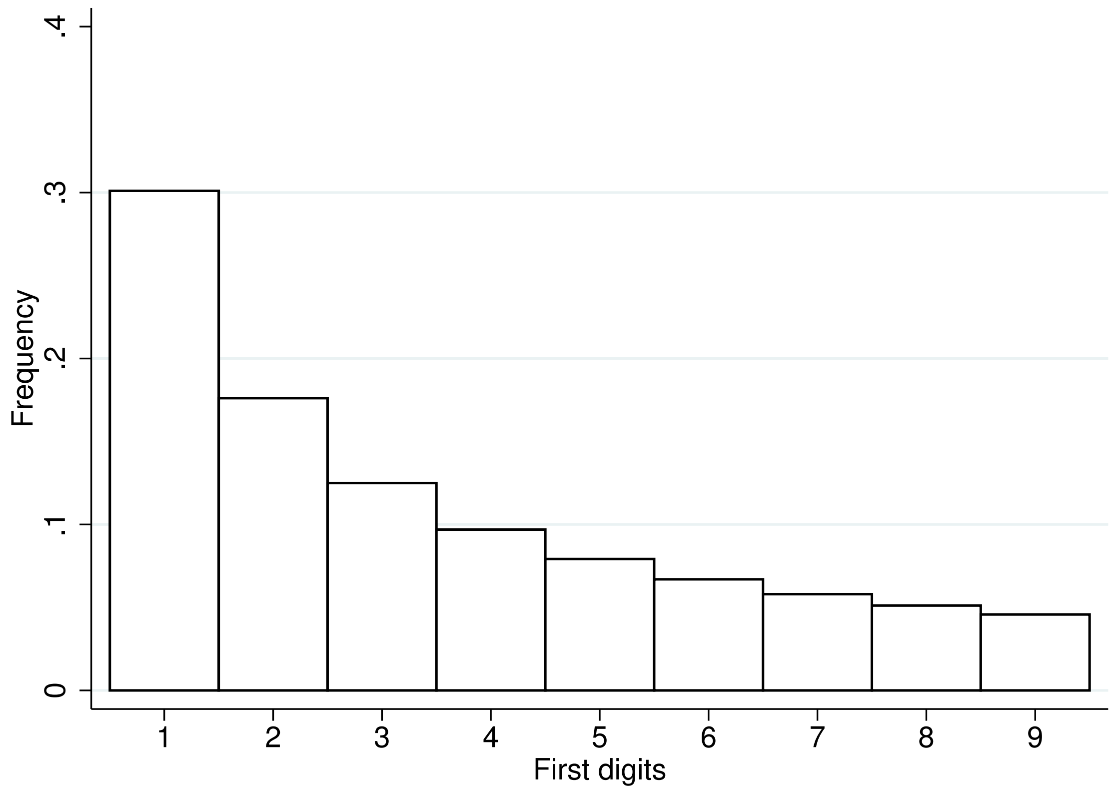
Panel A: Missing trade



Panel B: Change in imports

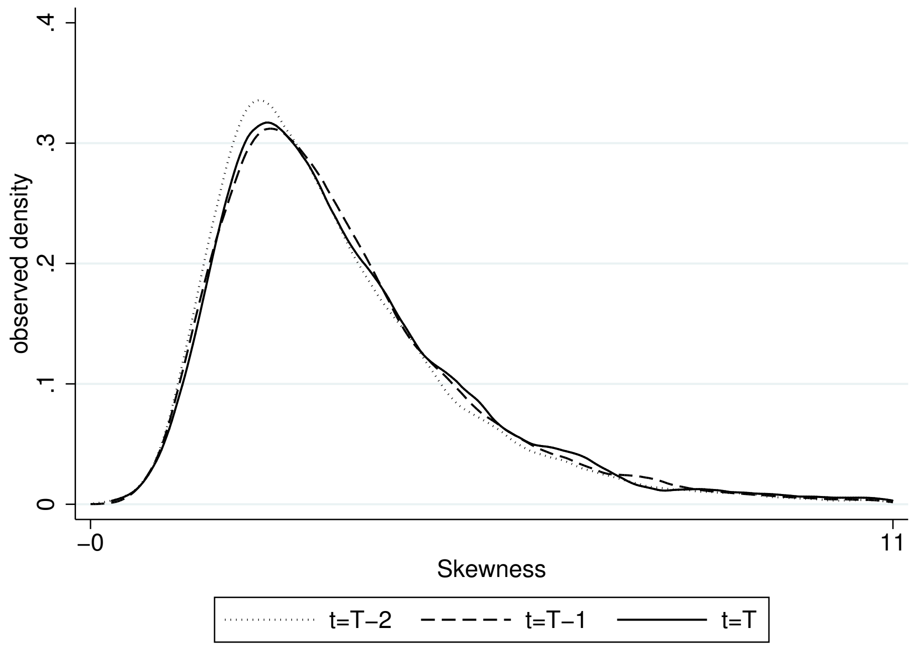
Notes: Panel A (B) shows a local polynomial regression of $MissingTrade$ (change in Turkish imports) as a function of $Exposure$, which is defined as the share of imports with external financing at time $t = T - 2$.

Figure 3: Benford's distribution of first digits

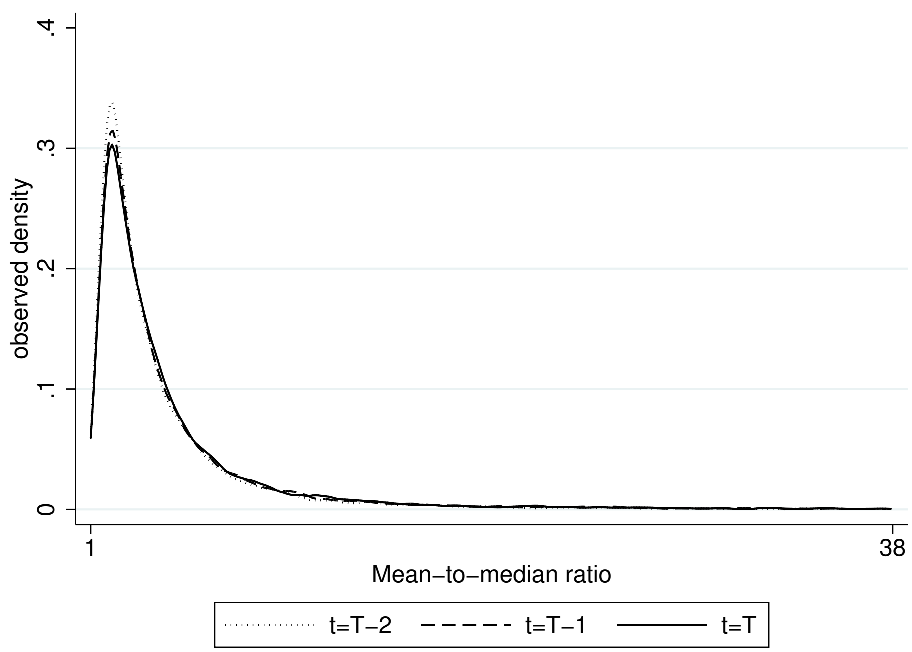


Notes: The figure shows the distribution of the leading first digits as predicted by Benford's law: $P(\text{First digit is d}) = log_{10}(1 + 1/d)$.

Figure 4: Distribution of Skewness and Mean-to-median Ratio in the Data



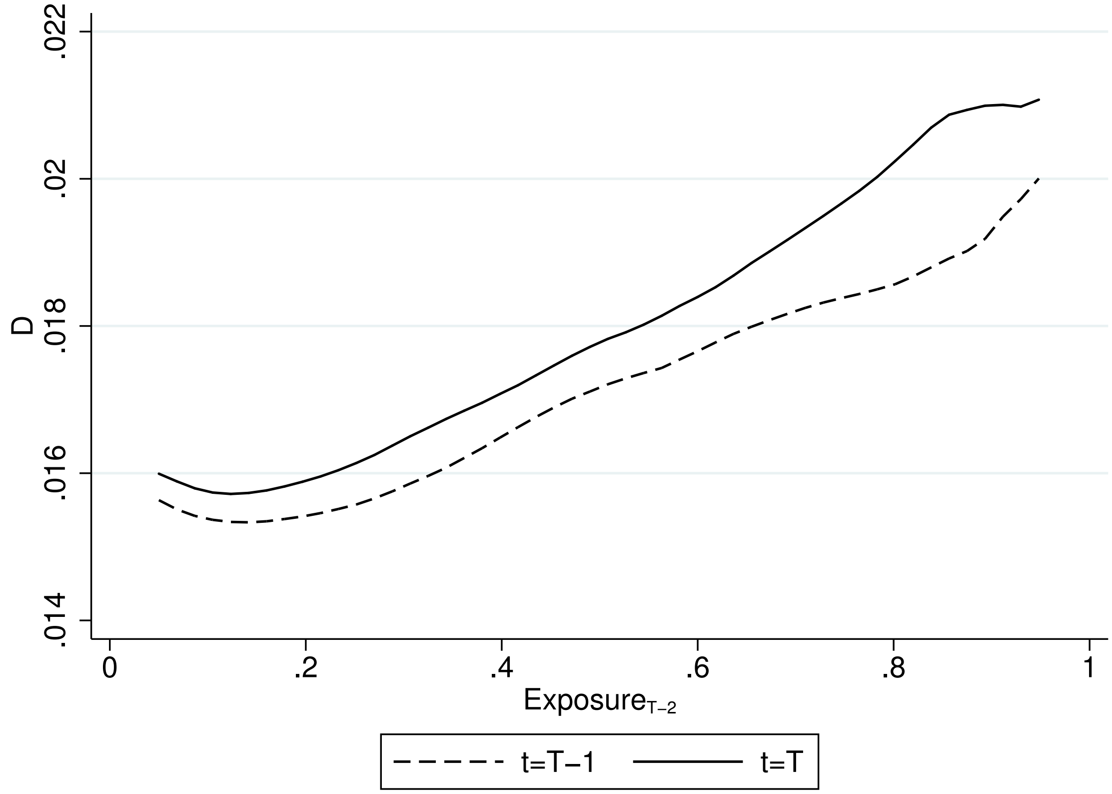
Panel A:Skewness



Panel B: Mean-to-median ratio

Notes: This figures show the distribution of skewness (Panel A) and mean-to-median ratio (Panel B) of Turkey's firm-product-country level imports within 75,000 country-product pairs 12-months before and after the increase in the RUSF rate in October 2011.

Figure 5: Deviations from Benford's law and exposure



Notes: The figures show local polynomial regressions of Turkish imports reported by the source country and Turkey as functions of *Exposure*, which is defined as the share of imports with external financing at time $t = T - 2$.