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Tariff evasion and customs corruption: Does Pre-Shipment Inspection Help?*

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Abstract

This paper provides a new approach to the evaluation of pre-shipment inspection (PSI) programs as ways of improving tariff-revenue collection and reducing fraud when customs administrations are corrupt. We build a model highlighting the contribution of private surveillance firms to the generation of information and describing how incentives for underinvoicing and collusive behaviour between importers and customs are affected by the introduction of PSI. It is shown theoretically that the introduction of PSI has an ambiguous effect on the level of fraud. Empirically, our econometric results suggest that the introduction of PSI services increased underinvoicing in Argentina and Indonesia and reduced it in the Philippines.

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1 Introduction

First introduced in Zaire in 1963 and adopted since then by over fifty countries worldwide, Pre-Shipment Inspection (PSI) consists of requiring imports to be inspected by a private surveillance company[1] at embarkation ports or airports or in the exporter firms' premises, instead of just at the importing country's customs. The idea is for PSI companies to provide a parallel information system enabling client governments to control the tax collection functions of their own bureaucracies. Originally, PSI was intended to fight the use of over-invoiced imports to evade capital controls. As capital controls were progressively phased out, the attention of governments shifted to import-tariff evasion and, starting with Indonesia's program in 1985, the mission assigned to PSI accordingly changed to curbing *under*invoicing.[2]

Whether they look for over- or under-invoiced imports, surveillance companies are entrusted by client governments with the assessment of an important tax base and become, *de facto*, quasi tax collectors, even if tariff collection remains *de jure* under state authority. Although private tax collection is, by itself, an old practice,[3] outsourcing such a key state function to the private sector can nonetheless be perceived by governments as a major delegation of authority, compounded by a sense of loss of sovereignty if those companies are foreign ones. Moreover, it can be expensive. PSI companies charge around one percent of the value of inspected shipments. Given that customs collection is usually below ten percent of import value, fees paid to PSI companies can easily represent more than ten percent of customs revenue. To be politically acceptable, thus, PSI needs to be justified by strong arguments (for a brief review of those arguments, see Ramirez, 1992 or Byrne, 1995; on the difficulties encountered by the WTO Agreement on Customs Valuation in developing countries, see Goorman

[1] The market is dominated by a small number of companies: Geneva-based Société Générale de Surveillance (SGS), Cotecna, Paris-based Bureau Veritas, London-based Inchcape Testing Services International (ITSI), and Houston-based Inspectorate America.

[2] Faced with a lack of domestic political will to implement effective customs reforms, the World Bank and other international institutions have sometimes recommended the outsourcing of some customs operation to the private sector (see Low, 1995).

[3] "Tax farming", consisting of trusting tax collection to private individuals allowed to retain a percentage of tax revenue, was widespread among Europe's monarchies up to the XVIIIth century. On this, see e.g. Stella (1993).

and De Wulf, 2003).

If PSI was never thought of as a permanent substitute for well-functioning customs administrations, it was at least expected that its introduction would prove a powerful expedient in cases of extreme customs inefficiency. However, there has lately been some disillusionment in the policy community about PSI's efficiency even as a short-term fix, prompting a need for methods to assess systematically its impact on collected duties. In a recent paper Yang (2005) assessed the performance of The Philippines' PSI program by taking advantage of its staggered implementation. As a progressively larger number of source countries were included, he showed that imports covered by the program were increasingly diverted to tax-exempt export processing zones, and from there illegally brought onto the domestic market.[4] Yang's results for The Philippines were confirmed by panel estimation of a measure of underdeclaration (discussed below) on tariff rates and a dummy variable equal to one for country/year pairs with PSI programs in force. The PSI dummy was insignificant, suggesting no statistically traceable effect of PSI on collected tariff revenue. Thus, PSI seemed to have affected the form of fraud rather than its extent.

Yang's paper drive home an important lesson –namely, that as long as there are loopholes in the implementation of PSI, it is unlikely to have much effect on collected tax revenue. However, because of the peculiarities of the Philippine's program, his results do not necessarily imply that *any* PSI program is bound to run into difficulties, or why, and under what general conditions, it may set perverse incentives.[5] This is what we set out to do in this paper.

We set up a simple game-theoretic model of under-invoicing based on Aghion-Tirole's information-production framework (Aghion and Tirole, 1997) to explore the effect of PSI on

[4] Yang explains why such trade deflection did not take place before the program's introduction by arguing that if PSI raises the *variable* cost of fraud while deflection to the EPZ involves a *fixed* cost, PSI can make deflection attractive when it was not before.

[5] Johnson (2001) looked at this normative question using a game-theoretic model where the decision to reconcile customs and PSI information (i.e. to make use of PSI information) is endogenous. He shows that PSI information will be used only if the agents having the power to perform the reconciliation have an interest in raising tariff revenue, say because of share pay. Similarly, customs officers' incentives to collude with underinvocing importers are reduced only if penalties are imposed on customs officers when reconciliation shows that they are not taking into account the information provided by PSI. Thus, his work highlights the relationship between the implementation of PSI programs and the structure of incentives for customs officers, a question that is also at the center of our modeling approach.

the equilibrium level of under-invoicing, when customs officers effort is endogenous. Importers strategically under-invoice taking into account bribery costs, penalty taxes if caught, and the probability of being caught. The latter depends on customs' effort, itself determined by incentives (essentially bonuses for uncovered fraud and information-acquisition costs, themselves affected by PSI's presence). The introduction of PSI has two effects: first, it directly generates information; second, it affects customs incentives as information acquisitions are strategic substitutes. In a perfect world, the information generated by the PSI company on shipment values would be used by the client government to control fraud and would therefore directly substitute for customs' own deficient information. However, if government authorities fail to use the information systematically through audits and reconciliation —as is indeed often the case— the strategic effect may come to dominate the direct effect, leading to a *weaker* fraud-control system. Thus, although common sense would suggest at first sight that PSI can only improve the national authorities' information and hence their ability to control fraud, our framework suggests that perverse effects on customs' motivation can be critical when national authorities fail to use the information fully.

We use the model to guide an empirical investigation of the effect of PSI on tariff evasion in three developing countries having used PSI services (Argentina, Indonesia and The Philippines).[6] We estimate the model's first order conditions before and after the introduction of PSI. Strikingly, the results suggest that the introduction of PSI *raised* rather than curbed under-invoicing in Argentina and Indonesia and curbed it only in The Philippines, although the impact was not statistically significant. This is in fact consistent with anecdotal evidence on customs' performance in Argentina, Indonesia and The Philippines. The Tuck School of Business' Emerging Market Access Index, for instance, reports complaints of customs extortion and bribery *after* the introduction of PSI as well as non-transparent appeal processes.

The paper is organized as follows. Section 2 briefly describes PSI procedures. Section 3 provides an analytical model exploring the impact of PSI on under-invoicing and customs

[6] The choice of countries is driven by data availability.

fraud. Section 4 presents the econometric estimation of the model and discusses results. Section 5 concludes.

2 PSI procedures

Import procedures under PSI vary, but the typical one is roughly as follows.[7] The trader operating in the port of shipment must first provide the PSI company's local agent with a detailed description of the shipment, which is then inspected. Upon inspection, the PSI company issues a Report of Findings, which falls into two categories: a Clean Report of Finding (CRF) when the PSI company confirms the trader's declaration, or a Discrepancy Report (DR) when it uplifts the trader's declared value. Either CRF or DR serves as the basis for the determination of applicable import-tax regime (tariff line, special regimes, exemptions etc...) and is sent to the destination port's customs and PSI company agent. In addition, it is also sent for reconciliation purposes to the client government's Ministry of Finance; the extent of reconciliation between customs data and the CRF/DR by the Ministry of Finance varies across countries, but reconciliation rates tend to be low.

At the destination port, the importer or a registered commissioner forwards one copy of the report to the appropriate customs office, together with a set of official customs documents on the basis of which duties payable are assessed. On the basis of these two sets of documents (CRF/DR and customs documents) the PSI company calculates all taxes and duties, which are paid by the importer or commissioner to a designated bank account, from which they are transferred to the Customs' account at the Central Bank and then finally to the Treasury. To these duties, the PSI company adds a fee paid by the importer, typically about 1% with a minimum amount.[8] Shipments landing at the port of destination without having been inspected at the port of embarkation are liable to destination inspection, with penalties for

[7] For a more detailed description, see Low (1995), page 9.

[8] For instance, in a number of countries, SGS charges 1.05% of shipment value over a de minimis threshold of $5,000 with a minimum fee of SFr 450 (around $300). For small shipments, this may add substantially to the burden of import tariffs (a $300 fee on a $5,000 shipment represents an ad-valorem equivalent of 6.15%) and this may have non-negligeable effects in LDCs (least developed countries) where median shipment size is small.

repeat offenses (typically, additional taxes on the second occurrence and seizure thereafter). Customs also sometimes perform independent inspections in addition to PSI.

Disputes between importers and PSI companies are in principle settled by arbitration bodies, but few PSI-using countries have set up such bodies. In their absence, importers have no recourse in case of dispute with the PSI company beyond the right to a second inspection, normally performed within 48 hours of the complaint.

3 Under-invoicing: an analytical setup

We explore the issues described in the introduction through a simple model featuring two components. First, a "positive" (i.e. descriptive) component sets out the strategic interaction between two classes of agents, importers and customs. The environment in which agents make decisions (declared value for importers, inspection intensity for customs) is potentially affected by the presence and efficiency of a PSI company. The PSI company is assumed not to act strategically.[9] Timing and information are specified through an extensive-form game.

Second, a "normative" (policy-choice) component features two types of control variables at the government's disposal: internal-incentive variables (bonuses to customs officers for fraud catches and sanctions for uncovered collusion with importers) and external-incentive ones (intensity of use of PSI-provided information through reconciliation of customs and PSI data). The use of external (PSI-supplied) information acts as an incentive device provided that it is common knowledge, because it affects the effort and collusion decisions of customs through the probability of being caught.[10] Both importers and customs are assumed purely opportunistic, which means that importers minimize tariff payments while customs maximize bribe and bonus income net of expected sanctions and the disutility of effort. Ethical considerations could be

[9] Note that PSI companies may have incentives to "over-correct" under-invoicing as their revenue is often a share of the value they have inspected. However, in countries where an arbitration body has been setup, this strategic behavior by the PSI company could be legally challenged by the importer. In the empirical section we do control for the incentives for the PSI company to "over-correct" under-invoicing.

[10] We abstract from outright smuggling which entirely bypasses customs clearance and for which pre-shipment inspection provides no solution.

added easily to the objective function of customs but would add little to the analysis.[11]

We focus on a single transaction, for which the sequence of events is as follows. An importer chooses the declared value v of a shipment worth V on which a tariff is applicable at ad-valorem rate t. V is known only to the importer.[12] At the embarkation port, a PSI company inspects the shipment and reports its own estimate of shipment value in documentation sent to the destination port's customs, together with the importer's initial declaration. To fix ideas, think of the good being shipped as a piece of machinery whose valuation requires technical knowledge. With probability p, the PSI company possesses or acquires the required technical information and is able to value the shipment correctly at V. With probability $1-p$, it fails and simply reports the importer's declared value v. We will treat p, which can be thought of as the PSI company's reliability, as a parameter.

Note that we do not allow the PSI company to act strategically. In the empirical section, we will see that the inspection company may have incentives for over-invoicing, or rather over-correcting for under-invocing, or goods correctly priced, as its revenue depend on the import value inspected (as discussed in the previous section). If we were to find evidence of this, it would imply that governments are over-paying for the services of PSI companies.

The next stage takes place at the destination port's customs where the shipment and accompanying documentation are inspected.[13] Prior to inspection, shipment value is considered by customs as a random variable $\widetilde{V}$. The (subjective) prior distribution of $\widetilde{V}$ does not need to be specified in what follows. Customs observe two signals on the basis of which they can update their prior: one from the importer and one from the PSI company. The pair of valuations provided in the two documents (importer declaration first, PSI document second) is either (v, V) or (v, v). In the former case, which occurs with probability p,[14] customs obtain the

[11] This also implies that we have very little to say regarding the welfare of customs officers in different equilibrium.

[12] Focusing on a single transactions allows us to ignore shipment size issues, so V can be thought of as either total or unit value.

[13] In principle, shipments subject to PSI are not liable to second inspection by destination customs upon landing. Practices vary widely across countries, with 'second-inspection' rates ranging from 5% for some countries to 100% for others (e.g. Nigeria). There is no overall statistics on the rate of second inspection but a surveillance company estimates it at around 40% of PSI-covered imports.

[14] As a simplification, we assume that p is the PSI company's probability of finding the shipment's true value

correct valuation directly from the PSI company. In the latter, which occurs with probability $1-p$, they infer that the PSI company is simply reporting the importer's declaration which, in an interior equilibrium, they know to be wrong.[15] In that case they undertake inspection.[16] The notion that customs undertake inspection only when PSI documents and importer declaration match comes from the fact that the importer's initial declaration to the PSI company is also sent to customs with the CRF or DR with no possibility for opportunistic revision.[17]

Let inspection intensity (effort) be measured by a continuous variable $e \in [0,1]$ with quadratic effort cost $c(e) = e^2/2$. Quadratic effort cost guarantees a closed-form solution. As in Aghion-Tirole, we will interpret e both as a measure of customs effort and as the (endogenous) probability that the valuation obtained is correct. When the valuation is correct, customs know that it is so (sufficient documentation has been found).

Failing to produce the information, customs can only use v as a signal to update their beliefs about shipment value. Even if they know, because the game's parameters are common knowledge, that importers always under-invoice in equilibrium, customs have in this case no *verifiable* information to support a fraud claim. In order to avoid introducing an element of arbitrariness in the model, we will then suppose that no fraud claim can be made, so that customs' beliefs are, in this particular instance, inconsequential.

Knowing customs' information set, the importer decides on a bribe offer β expressed as a fraction of fraud value, which customs can accept or reject. Finally, the government reconciles through random audits the information provided by PSI and customs. Audit probability is π and is a policy variable.[18] Fraud, whether uncovered through audit or through customs

whether the importer declared truthfully or not. Letting the PSI company update its beliefs using v would complicate the model's description without affecting its results.

[15] As will later become clearer, for some paramater values, it is possible to construct a "no-fraud" equilibrium assessment (set of strategies and beliefs) in which importers never fraud ($v = V$) and customs beliefs are consistent with this. We will henceforth disregard this case, although it may of course occur in reality.

An exogenous fraction h of truthful importers could also be introduced for realism. This would modify customs' behaviour in a way indicated in footnote 22 below.

[16] Instead of being assumed, the situation in which customs do not perform second inspections at the destination port emerges endogenously as the equilibrium outcome when $p = 1$ (see below).

[17] If the importer's initial declaration could be revised, then each time the PSI company issued a CRF, the importer would revise and underdeclare further at destination customs in order to create the illusion that the PSI's higher valuation was the correct one. Customs' beliefs would take account of this strategic behaviour.

[18] Reconciliation between PSI- and customs-provided information is very irregular. A surveillance company

reports, is met with a punitive tariff surcharge at ad-valorem rate T. Customs' "catches" are rewarded with a bonus b expressed as a fraction of tariff revenue recovered,[19] whereas cases of collusion between customs and importers are met with sanctions on customs officers. Those sanctions are assumed to have the form

$$k = k_0 + k_1(V - v)t$$

i.e. to include a constant and an amount proportional to the uncovered fraud. These two components are unlikely to be there simultaneously but their inclusion in the formulation makes it possible to explore two alternative interpretations: when $k_1 = 0$ the penalty is fixed (say, the officer is fired), whereas when $k_0 = 0$ the penalty is a fine or sanction (say, suspension without salary) proportional to the severity of the offense.

3.1 Equilibrium

3.1.1 Rent-sharing in collusive equilibria

The game is solved backwards. In the last stage, customs, faced with a bribe offer β, decide to accept it or not. The information available to customs is a triplet $I = (\nu_I, \nu_P, \nu_C)$ describing, in this order, the importer's declaration ν_I, the PSI's valuation ν_P, and customs' own valuation ν_C. If any one of I's three elements is V, customs know the shipment's true value with certainty and "they know that they know".[20] Let $x \in \{1, 0\}$ be the customs' decision to accept the bribe or not, with the convention that $x = 1$ means acceptance. Three cases must be considered.

Suppose first that the PSI company succeeds in valuing the shipment correctly ($\nu_P = V$). The state of information is $I_P = (v, V, .)$. The triplet's last element needs not be specified

estimates the reconciliation ratio at around one third of all transactions subjected to PSI.

[19] In practice, rewarding customs officers with a percentage of catches is relatively uncommon. Incentive systems are however increasingly introduced as part of customs reform package and often include staff funds rather than individual rewards. There is no database comparing such incentive schemes but a customs analyst interviewed for this paper put the most common bonus rate at around 20% of the value of catches.

[20] In other words, once the true value is revealed to customs, it can be verified without cost.

because, knowing shipment value, customs consider inspection unnecessary and set $e = 0$. Accepting a bribe offer β is risky because it could be uncovered through reconciliation of PSI and customs-provided documents; alternatively, reporting the discrepancy and charging the importer accordingly does not buy customs officers any bonus since the "catch" is really the surveillance firm's.[21] Thus, customs' expected utility given the state of information is:

$$u(x; I_P) = \begin{cases} (\beta - \pi k_1)(V - v)t - \pi k_0 & \text{if } x = 1 \\ 0 & \text{if } x = 0. \end{cases}$$

This defines the customs' participation constraint, i.e. the minimum bribe that they can accept given the risk of detection. The importer sets β so as to satisfy the constraint exactly, i.e. to leave customs just indifferent between accepting and not. The bribe is then always accepted, under the usual assumption that a binding participation constraint makes the contract acceptable. Solving and rearranging gives

$$\beta_P = \pi k_1 + \frac{\pi k_0}{(V - v)t} \tag{1}$$

where the subscript means that β_P is the bribe offered when the shipment's value has been reassessed by the PSI company.

Next, suppose that the PSI company does not uplift the value of the shipment, reporting instead $\nu_P = v$ (i.e., issues a CRF). Then two cases arise, depending on whether customs are successful or not in their own valuation effort. If they are, the state of information is $I_C = (v, v, V)$. The importer offers again a bribe β, although at a different rate. Because PSI documents create no risk of 'hostile' reconciliation by the government, collusion is now risk-free for customs and

$$u(x; I_C) = \begin{cases} \beta(V - v)t & \text{if } x = 1 \\ b(V - v)t & \text{if } x = 0, \end{cases}$$

[21] Adding a bonus when $x = 0$ does not alter the results qualitatively.

so the bribe offer is now $\beta_C = b$.[22]

Finally, if customs are unsuccessful in their own valuation effort, the state of information is $I_I = (v, v, v)$; no credible threat of fraud claim can be made. Thus

$$u(x; I_I) = \begin{cases} \beta(V - v)t & \text{if } x = 1 \\ 0 & \text{if } x = 0, \end{cases}$$

which gives $\beta_I = 0$ (no bribe).

3.1.2 Customs Inspection intensity

In our model, inspection takes place only when documentation provided by the PSI company is deemed uninformative by customs.[23] In that case, ex ante, V is a random variable $\widetilde{V}$ with expectation $E(\widetilde{V})$ and the inspection-intensity problem is:

$$\max_e \; e\beta_C \left[E\left(\widetilde{V}\right) - v\right] t - \frac{e^2}{2} = eb \left[E\left(\widetilde{V}\right) - v\right] t - \frac{e^2}{2} \tag{2}$$

which gives

$$e(v) = b \left[E\left(\widetilde{V}\right) - v\right] t. \tag{3}$$

[22] Thus, increasing the bonus for catching fraud increases the bargaining power of customs officers vis-à-vis bribing importers.

[23] With a fraction h of truthful importers, customs would take a CRF from PSI as informative with probability h and uninformative with probability $1 - h$. Expression (2) below would become

$$\max_e \; (1 - h)\, eb \left[E\left(\widetilde{V}\right) - v\right] t - \frac{e^2}{2}$$

and the first-order condition would yield a lower equilibrium level of effort. The reason is that with probability h, inspection would be redundant and could not produce any bribe opportunity.

All other results remain unchanged qualitatively, and there is in particular no signaling game involved. One could build such a game by taking truthful and opportunistic importers as "good-type" and "bad-type" informed players with single-crossing preferences in some space (say money and clearance time). The separating equilibrium would then be one where truthful importers differentiate themselves from bad ones (in order to expedite clearance) by over-declaring strategically. Over-declaration is, however, hardly a plausible story, because in reality, truthful importers are visibly different from others (typically large formal companies operating as part of international supply chains).

Thus, equilibrium inspection intensity is increasing in the government-provided bonus b, in the tariff rate t, and in the level of fraud. Note that inspection is undertaken by customs only when the PSI's valuation is considered uninformative because identical with the importer's declaration. Thus, average inspection intensity is

$$E[e(v)] = (1-p)b\left[E\left(\widetilde{V}\right) - v\right]t, \tag{4}$$

which decreases with the efficiency of the PSI company. In other words, PSI efficiency and customs effort are strategic substitutes. Thus, the situation in which PSI operates smoothly at the embarkation port and customs never re-inspect at the destination port is the endogenous outcome of the model (rather than assumed) when $p = 1$.

3.1.3 Equilibrium declaration

From now on, we will suppose that customs' (subjective) distribution for $\widetilde{V}$ is centered on the shipment's true value, so $E\left(\widetilde{V}\right) = V$, and that this is known to the importer (but not to customs themselves).[24] The importer's problem is to choose the declared value that minimizes the sum of duty payments and expected penalties given equilibrium play in all sub-games, that is,

$$\begin{aligned}
&\min_{v}\ p\left[\beta_P(V-v)t + (1-\pi)vt + \pi V(t+T)\right] \\
&\qquad +(1-p)\left[vt + e\beta_C(V-v)t\right] \\
&\text{s.t.} \\
&\beta_P = \beta_P = \pi k_1 + \frac{\pi k_0}{(V-v)t}, \\
&\beta_C = b, \\
&e = b\left(V-v\right)t.
\end{aligned}$$

[24] If customs knew what distribution $\widetilde{V}$ was drawn from and that this distribution was centered on V, they could infer V and the information-production problem would disappear.

The maximand has the following interpretation. Either the shipment's value is reassessed by the PSI company (an event occurring with probability p) or not. If yes, upon arrival a bribe β_P is paid to customs no matter what. If collusion with customs is uncovered by reconciliation (an event occurring with probability π), the duty paid is $V(t+T)$ i.e. includes a penalty rate and is applied on the true value V. If not, duty paid is vt. If no reassessment by the PSI company, customs undertake inspection with intensity e. Duty is paid on the declared value v no matter what. If inspection is successful (an event occurring with probability e), in addition a bribe is paid at rate β_C.

Without the constraints, the importer's problem would always yield a corner solution since the cost function to be minimized is linear in v. Thus interior solutions (partial fraud) come from the importer's recognition that a low declared value triggers more careful inspection.[25]

Let $\delta = V - v$ be the degree of fraud. Expressed in terms of δ, the first order condition is:

$$\delta = \frac{1}{2b^2 t}\left[\frac{1-\pi p\,(1+k_1)}{1-p}\right]. \tag{5}$$

It is easily verified that the game without PSI is outcome-equivalent to a game with PSI but with $p = 0$. Letting

$$\alpha \equiv \frac{1-\pi p\,(1+k_1)}{1-p}, \tag{6}$$

we have thus

$$\delta = \begin{cases} \alpha/2b^2 t & \text{with PSI,} \\ 1/2b^2 t & \text{without.} \end{cases} \tag{7}$$

We have refrained from using Kuhn-Tucker conditions for ease of notation but it should be clear that corner solutions can be obtained at $\delta = V$ (total fraud, which can be thought of as smuggling) when α is large enough, or at $\delta = 0$ when $\alpha < 0$. In the latter case fraud is entirely eliminated by the introduction of PSI. A sufficient, although not necessary condition, for the elimination of fraud in the presence of PSI is perfect reconciliation ($\pi = 1$) and perfect efficiency of the PSI company ($p = 1$).

[25] As V is unknown, a lower v triggers more careful inspection not because it is suspect, but because the expected return to inspection is an increasing function of $E\left(\widetilde{V}\right) - v$ no matter what the distribution of $\widetilde{V}$ is.

But the interesting question is probably not whether PSI eliminates under-invoicing and customs fraud associated with it, but whether it helps reduce it. By (7), the introduction of PSI reduces under-invoicing if and only if $\alpha < 1$, i.e. iff $\pi(1 + k_1) > 1$. Thus, even high levels of reconciliation (π close to but smaller than one) may not be sufficient to reduce fraud if the proportional part of the penalty is not sufficiently large.

The intuition of the case in which the introduction of PSI ends up raising fraud is as follows. When fraud is uncovered through PSI (information state I_P) the bargaining position of corrupt customs is weak because reporting the fraud brings no bonus. The informational rent generated by PSI is then entirely captured by importers, which *(i)* reduces the return to inspection for customs and *(ii)* raises the return to fraud for importers. There is then more fraud in equilibrium. The two key elements here are thus rent sharing and the strategic substitutability of PSI and customs' effort, which proxies for the 'de-motivating' effect of PSI's introduction. Introducing bonuses for customs when fraud is uncovered by PSI or letting the rent be shared (say, according to the Nash bargaining solution instead of having customs on their participation constraint) would weaken this mechanism but would not necessarily reverse it.[26] Thus, in general whether PSI reduces tariff evasion is an empirical question, which we address in the next section.

A positive implication of the model derived above is that fraud *declines* with tariffs for a wide range of parameter values. This may seem unexpected, but the theoretical literature on income tax evasion has found that the relationship between tax rates and income tax evasion is generally ambiguous since the work of Allingham and Sandmo (1972).[27] In their paper evasion decreases with taxes because of an income effect: higher tax rates make reporters less wealthy, which under absolute risk aversion (to being caught) tends to reduce evasion.[28] In our

[26] For instance, introducing a bonus at rate b_1 for customs officers using PSI data to report fraud would lead to

$$\alpha = \frac{1 - p[b_1 + \pi(1 + k_1)]}{(1 - p)}$$

Obviously, qualitative results would not change as long as the bonus rate is less than one (which it realistically has to be), but increases in p would have a stronger effect when π is high enough.

[27] For a comprehensive survey of the theoretical literature on tax rates and tax evasion see Slemrod and Yitshaki (2002).

[28] A similar result is found by Lee (2001) who focuses on illegal concealment of income rather than under-

setup a higher tariff raises customs' incentive to find verifiable evidence of fraud, since such evidence improves customs' bargaining position (more exactly their participation constraint). This strategic effect reduces the importer's fraud rent and swamps the direct effect that a higher tariff exerts on the return to fraud, reducing its equilibrium level.[29] Because the inverse relationship between δ and t is somewhat counter-intuitive, it provides a first test of the model's validity as a descriptive tool. We verified this relationship by regressing δ on $1/t$ at the HS 6-digit level for 49 country-year pairs for which we had both tariff and trade data and found a positive (and highly significant) coefficient in 47 out of the 49 regressions.

4 Econometric estimation

This section presents an attempt to estimate structurally first-order condition (7) on panels of imports from the EU, disaggregated at the SITC2 5 digits level for three PSI-using countries. The three countries under consideration (i.e. Argentina, Philippines and Indonesia) are those for which trade and tariff data are available before and after the introduction of PSI. Trade data are from the UN's Comtrade database and tariff data from UNCTAD's Trains.

By its very nature, like all forms of fraud, tariff evasion cannot be measured directly, so roundabout methods must be used. The most common one consists of comparing the records of source and destination customs. Traders attempting to evade import tariffs will underdeclare the value of shipments to destination customs while no such incentive exists at origin ones. In the presence of import-tariff evasion, discrepancies between source and destination trade data reported to Comtrade by national customs will thus reflect not just CIF/FOB differences and measurement errors (on this, see de Wulf, 1981, or Feenstra and Hanson, 2000) but also the extent of deliberate underdeclaration (see Yang, 2005 for similar approaches to measure tariff evasion).[30]

reporting of income.

[29] Note that in this setup it is optimal for the revenue authorities to focus their auditing (or reconciliation) activities on low-tariff products. This has some parallels with the work of Cremer and Gahvari (1995) who found that optimal auditing in the presence of income tax evasion implies focusing on low-income individuals.

[30] There are several well-known problems with this method. One is that for the very reason that they are primarily interested in collecting tariffs and verifying compliance with domestic regulations, customs monitor

4.1 Procedure

The equation to be tested is a stochastic version of equation (7) estimated by country after pooling pre- and post-PSI years respectively. If the coefficient in front of $1/t$ is smaller after the introduction of PSI, then $\alpha < 1$ and the introduction of PSI reduced under-invoicing.

One problem with the estimation of (7) is that the structural model only explains positive values of $\delta = V - v$. Negative values (beyond CIF/FOB differences) are aberrations in the model developed in the previous section, but are however observed in the sample. Negative values of δ correspond to over-invoicing (or misclassification), which needs to be explained by alternative empirical model. It is therefore crucial to distinguish observations driven by under-invoicing from those driven by other forces.

A potential explanation for over-invoicing in our model is that the PSI company may act strategically, contrary to what was assumed in the analytical setup. Indeed, given that most PSI contracts stipulate that the payment to the PSI company is a share of the import value inspected, the PSI agent may have incentives to "over-correct" for under-invoicing. If this were the case, following the logic of the model in the previous section, PSI-induced over-invoicing will be more likely to occur in products with low tariffs, as these will be less likely to be challenged by either the customs officer or the importer.[31] We will be able to test this with our empirical framework.

Because CIF/FOB differences introduce an unobserved negative component in the measured δ, it is impossible to determine *à priori* the cutoff between under-invoicing and the alternative over-invoicing regime (in other words, the regime switch is not necessarily at $\delta = 0$). In order to bypass the problem we estimate (7) using an exogenous switching-regression model with unknown sample separation. We follow Goldfeld and Quandt's D-method (1976), which

imports more carefully than (if at all) exports. Thus, exports may be subject to measurement error. However, exporters are legally liable for their declarations to customs. If, upon audit by their home country's fiscal authorities (say, for corporate profits tax verification), they were shown to have double accounts, they would be in breach of tax laws. One may suppose that they will avoid putting themselves in such a situation without a good reason to do so. Moreover, given that V and v are both on the left-hand-side implies that measurement error will get absorbed by the error term.

[31] Over-invoicing on products will low tariffs will not affect the payment to the PSI company given that it is not proportional to the tariff revenue collected, but the import value.

according to Kiefer (1978) and Maddala (1986) provides consistent estimates in the case of exogenous switching regressions.

Let subscripts i and k refer to periods and commodities, respectively, so t_{ik} is the tariff on good k at time t, and define τ as a dummy variable equal to one for years in which PSI is in force and zero otherwise.[32] Although the model has no constant, we add time dummies d_i to pick up the influence of out-of-model changes in the environment (e.g. non-PSI components of customs reforms such as general changes in tariffs). To determine the regime switch, we use volumes rather than values in order to eliminate the influence of CIF/FOB differences (which affect only values). Let θ be a scale parameter to be estimated, Q_{ik} the export volume declared at the origin customs, q_{ik} the corresponding import volume declared at the destination customs, and $z_{ik} = Q_{ik} - q_{ik}$. The transformed structural equation to be estimated for the different regimes is given by:

$$\delta_{ik} = \begin{cases} \sum_{i=1}^{T} \beta_{10i} d_i + \beta_{11} \frac{\tau_i}{t_{ik}} + \beta_{12} \frac{(1-\tau_i)}{t_{ik}} + \varepsilon_{1ik} \text{ if } \theta z_{ik} \geq 0 \\ \sum_{i=1}^{T} \beta_{20i} d_i + \beta_{21} \frac{\tau_i}{t_{ik}} + \beta_{22} \frac{(1-\tau_i)}{t_{ik}} + \varepsilon_{2ik} \text{ if } \theta z_{ik} < 0 \end{cases} \tag{8}$$

where ε_{1ik} and ε_{2ik}, are normally and independently distributed error terms with zero mean and constant variance. There is a regime switch if the variance in the first regime (σ_1^2) is different from the variance in the second regime (σ_2^2), and if the β_1's are different from the β_2's. The regime switch is modelled through a unit step function $\xi(z_{ik})$ which is continuously approximated using the cumulative normal integral

$$\xi(z_{ik}) = \frac{1}{\sqrt{2\pi}\sigma} \int_{-\infty}^{\theta z_{ik}} \exp\left[-\frac{1}{2}\frac{\xi^2}{\sigma^2}\right] d\xi.$$

Defining $\mathbf{D}$ as the diagonal matrix consisting of $\xi(z_{ik})$, $\mathbf{X}$ as the observations matrix of

[32] PSI years are 1998-2000 for Argentina, 1993-1995 and 1998-2000 for The Philippines, and 1989-90, 1993, and 1995-6 for Indonesia. Note that by doing this we are assuming that inspection applied to all imports. This is a reasonable assumption as exceptions to inspection in these three countries were generally concentrated in arms and fuel. However, we do not have detailed information on which goods were exempted from inspection and therefore we simply assume that they all are.

explanatory variables, $\mathbf{I}$ as the identity matrix, and β_1 and β_2 as the coefficient vectors under regimes 1 and 2 respectively, the system to be estimated is written as

$$\boldsymbol{\delta} = (\mathbf{I} - \mathbf{D})\mathbf{X}\beta_1 + \mathbf{D}\mathbf{X}\beta_2 + \mathbf{W},$$

where $\boldsymbol{\delta} = [\delta_{ik}]$ and $\mathbf{W} = (\mathbf{I} - \mathbf{D})\mathbf{e}_1 + \mathbf{D}\mathbf{e}_2$, $\mathbf{e}_1$ and $\mathbf{e}_2$ being respectively the vectors of error terms under regime 1 and 2. As error terms are heteroskedastic,[33] the system is estimated by maximum likelihood and the log-likelihood function is

$$\begin{aligned} \log \mathbf{L} &= -\frac{n}{2}\log 2\pi - \frac{1}{2}\log|\boldsymbol{\Omega}| - \\ &\quad \frac{1}{2}\left[[\boldsymbol{\delta} - (\mathbf{I} - \mathbf{D})\mathbf{X}\beta_1 - \mathbf{D}\mathbf{X}\beta_2]' \boldsymbol{\Omega}^{-1} [\boldsymbol{\delta} - (\mathbf{I} - \mathbf{D})\mathbf{X}\beta_1 - \mathbf{D}\mathbf{X}\beta_2]\right] \end{aligned}$$

where the covariance matrix is given by the expression $\boldsymbol{\Omega} = (\mathbf{I} - \mathbf{D})^2\sigma_1^2 + \mathbf{D}^2\sigma_2^2$.

Under regime one, the theoretical model's predictions are $\beta_{11} = \alpha/2b^2 < 0$, and $\beta_{12} = 1/2b^2 < 0$. Some of the theoretical model's structural parameters can be retrieved from the estimates. For instance, $b = \sqrt{1/2\beta_{12}}$ and $\alpha = \beta_{11}/\beta_{12}$. Under regime two, we use the same set of explanatory variables, for symmetry across regimes, but also because if the explanation for "over-invoicing" is due to the PSI agent behaving strategically to maximize its revenue, one would expect to observe stronger (PSI-induced) over-invoicing on products with low tariffs. More formally, $\beta_{21} > 0$ and and $\beta_{21} > \beta_{22}$.

In order to test for the results' robustness, we also provide "unconstrained" estimates where V is moved to the right-hand-side to account for CIF/FOB differences between source and destination trade statistics. We could alternatively move v_{iK} to the right hand side, but it is more likely to be subject to measurement error (one can expect European Union trade statistics to be more reliable than those of the three importing countries in the sample). Finally, we provide estimates where the standard deviation of tariffs within a 5-digit SITC category is introduced as an explanatory variable in order to control —imperfectly— for

[33] No clustering is necessary since the variance of our dependent variable is not significantly different from the one of each of our explanatory variables.

potential mis-classification as in Gatti (1999). The idea is that if tariffs within a 5 digit category show a lot of variation at the tariff-line level, it may be easier for importers to get away with misclassification.

4.2 Results

Switching-regime regression results are shown for Argentina, Indonesia and The Philippines in Tables 1 to 3 respectively. We first focus on results obtained under regime one which fit the under-invoicing model developed in section three. In each table, the first two columns present the results of the estimation of (8). Columns 3 and 4 present results for the unconstrained estimation when V is on the right hand side. Finally Columns 5 and 6 present estimation results including the standard deviation of tariffs as a regressor to control for incentives to mis-classify shipments.

In the presence of PSI, the coefficient on $1/t_{ik}$ in regime one always has the expected sign (recall that the dependent variable is v rather than the degree of fraud in columns 3 to 6) and is statistically significant at the 10 percent level. In the absence of PSI, it also has the expected sign but is statistically significant in only three out of six cases.

The existence of two regimes is statistically confirmed. Variances under the first regime (σ_1^2) are different from variances under the second regime (σ_2^2) in all cases and most of the $\widehat{\beta}_1$'s are significantly different from the $\widehat{\beta}_2$'s (Wald tests fail to reject the null hypothesis that they are equal only for Argentina in the first two columns). Estimated scale parameters $\widehat{\theta}$'s are also all significant and positive.

In order to determine whether the introduction of PSI reduced under-invoicing, we need to test whether α is significantly smaller than one. Estimates of α are given by: $\widehat{\alpha} = \widehat{\beta}_{11}/\widehat{\beta}_{12}$ (the ratio of the coefficients in front of $1/t_{ik}$ with and without PSI). Table 4 provides estimates of α for each of the regressions reported in Tables 1-3 under regime one (columns 1, 3 and 5). Point estimates suggest that fraud *increased* with the introduction of PSI services ($\widehat{\alpha} > 1$) in Argentina ($\widehat{\alpha}'$s ranging between 2.6 and 6.8) and Indonesia ($\widehat{\alpha}'$s ranging between 2.3 and

3.7).[34] Wald tests reject the null hypothesis that $\widehat{\alpha} = 1$ for two out of three estimates in Argentina and for one out of three estimates in Indonesia, suggesting that the increases were statistically significant. Fraud *decreased* in The Philippines ($\widehat{\alpha}'$s are in the 0.5-0.9 range), but the null ($\widehat{\alpha} = 1$) cannot be rejected for any of the estimates.[35]

Let us now turn to regime 2 (over-invoicing). Predictions are confirmed for all countries when using the unconstrained estimates. The coefficient on $1/t_i$ in the presence of PSI is always positive and statistically significant, suggesting that in the presence of PSI over-invoicing is larger on products with low tariffs. Moreover, the coefficient on $1/t_i$ in the presence of PSI is always larger than in its absence. This is consistent with the idea that PSI agents may act strategically to "over-correct" for under-invoicing in order to maximize their revenue, while minimizing the likelihood of being challenged by the importer.

5 Concluding Remarks

The recommendation to use PSI services in some low-income countries grew largely out of frustration in the face of slow and ineffective customs reforms, on the expectation that efficient surveillance companies would do a better job than poorly trained and motivated customs administrations. However, there has been some disillusionment in the policy community about the ability of PSI companies to curb fraud effectively. Moreover, customs administrations have often felt marginalized and demotivated as a result of PSI's introduction (see e.g. Low, 1995 and Goorman and De Wulf, 2003). Our analytical setup was designed to highlight these effects. Whereas one might think that "more inspection" implies less fraud, information theory suggests that as PSI and customs efforts are strategic substitutes, the net information gain

[34] Note that high values of α are consistent with high efficiency of PSI companies but low reconciliation rates. As suggested by a referee, we ran separate regressions using Rauch's classification of goods as homogenous/reference priced vs. differentiated (we used his 'liberal' classification). Results were somewhat sharper for differentiated goods but going in the same direction, suggesting that the inability of PSI to curb underinvoicing is clearer —as one would expect— in the case of differentiated goods. We are grateful to the referee for attracting our attention to this issue.

[35] Note that the estimation does not control for import deflection to duty-free zones, which Yang (2005) emphasized as a vehicle for tariff evasion in The Philippines after the introduction of PSI. Taking this into account weakens further the effectiveness of PSI.

generated by PSI may be less than meets the eye. Moreover, the way in which PSI affects incentives along the import chain is complex, strategic effects being capable of swamping direct effects. As a result, the overall effect of PSI's introduction on fraud turns out to be ambiguous and can actually be perverse, in particular when (as is often the case) PSI data is not systematically reconciled with customs data by national authorities. Interestingly, our setup shows that perverse effects can appear even when the surveillance company itself does a good job (i.e. has a high success rate in shipment valuation). The issue that we raise is thus not about the *performance* of surveillance companies but about the *incentives* that their presence generates for importers and customs officers.

As a by-product, the model highlights that as customs have a sharper eye on high-rate tariff lines, fraud is trickier (if potentially more lucrative) in those lines. This effect being anticipated by importers, on the basis of relatively straightforward strategic interaction, the model actually predicts *less* fraud in tariff lines with high rates, a prediction that can be readily tested and is indeed supported by the data.

On the title's normative question, our empirical results, based on a comparison of import values for three PSI-using countries at a highly disaggregated level, confirm that the effect of PSI was at best unspectacular and at worst perverse. PSI *raised* fraud in Argentina and Indonesia, and reduced it only —and not significantly— in The Philippines. Although based on a different logic, these results are in accordance with those of Yang (2005) and with the policy community's current skepticism about the usefulness of PSI.

Moreover, PSI companies may not only be having a perverse effect on fraud, but they may also be charging too much for their services. In most contracts, PSI companies are paid a share of the import value inspected. This creates incentives for PSI companies to "over-correct" under-invoicing in order to maximize their revenue. In order to avoid being challenged by importers or customs officers, this is more likely to occur on products with low tariffs. Our estimates provide evidence of PSI-induced over-invoicing in the three countries studied.

A caveat is in point, however. PSI was introduced in many cases not just to 'bring in the money' but also to streamline import procedures. When destination customs do not perform

second inspections, it is quite possible (and anecdotal evidence suggests) that PSI involves less harassment and delays than customs inspection at the destination port. If duty collection is of primary concern to the governments of poor countries, the smooth operation of cross-border transactions is also an important issue. Our model and estimation results bear only on the former issue (PSI's effect on tariff evasion). The case for PSI may however rest on the second one (streamlining procedures). Trade data, however, cannot tell much on this second issue, which is probably best analyzed on the basis of firm-level data. Given the importance of the issue for low-income countries, more work in the area is obviously called for.

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Table 1: *Switching regression estimates for Argentina*[a]

End. variable	δ	δ	v	v	v	v
	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2
τ_i/t_i	114.7***	48.7	-111.3***	151.9***	-72.1*	101.1***
with PSI	(36.0)	(30.8)	(41.4)	(34.2)	(42.1)	(32.9)
$(1-\tau_i)/t_i$	16.8	6.8	-43.2***	58.9***	-24.1*	35.3***
without PSI	(12.9)	(13.0)	(11.8)	(11.2)	(12.9)	(12.7)
V_{ik}			0.9***	1.3***	0.9***	1.2***
true value			(0.008)	(0.01)	(0.008)	(0.01)
σ_{ik}					-394.9***	429.7***
tariffs std. dev.					(54.9)	(48.9)
$\hat{\sigma}^2$	4471.9***	4125.7***	4333.4***	3940.9***	4354.9***	3897.1***
error variance	(59.7)	(55.2)	(59.9)	(54.4)	(61.1)	(53.9)
$\hat{\theta}$	0.004***	0.004***	0.005***	0.005***	0.004***	0.004***
scale param.	(0.0003)	(0.0003)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
year dummies	Yes	Yes	Yes	Yes	Yes	Yes
# obs.	5902	5902	5902	5902	5902	5902
Log Likelihood	-32060241	-32060241	-32060066	-32060066	-32060013	-32060013

[a]Figures in parenthesis are standard errors. $\star\star\star$ stands for statistical significance at the 1 percent level; $\star\star$ for significance at the 5 percent level and $\star$ for significance at the 10 percent level. The estimation technique is maximum likelihood. Regime 1 corresponds to the underinvoicing regime under examination here. Results for regime 2 are simply shown for completeness of the estimation of the switching regression. The years with PSI are the years 1998, 1999 and 2000; years without PSI are the years 1995, 1996 and 1997. Number of observations: regime 1 (underinvoicing), 2'987; regime 2 (overinvoicing) 2'913.

Table 2: *Switching regression estimates for Indonesia*[a]

End. variable	δ	δ	v	v	v	v
	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2
τ_i/t_i	154.1***	-197.9***	-24.5*	61.6***	-24.6*	61.0***
with PSI	(18.0)	(19.8)	(14.7)	(16.4)	(12.9)	(14.3)
$(1-\tau_i)/t_i$	67.9***	-85.7***	-6.9	27.0	-6.7	26.3
without PSI	(23.6)	(21.5)	(18.3)	(18.4)	(17.6)	(17.9)
V_{ik}			0.7***	1.5***	0.7***	1.4***
true value			(0.01)	(0.02)	(0.01)	(0.02)
σ_{ik}					-1.9*	4.4***
tariffs std. dev.					(0.9)	(1.5)
$\hat{\sigma}^2$	5029.2***	7786.3***	4326.6***	6747.4***	4331.9***	6743.8***
error variance	(88.2)	(112.3)	(75.1)	(83.1)	(72.4)	(85.8)
$\hat{\theta}$	0.002***	0.002***	0.003***	0.003***	0.003***	0.003***
scale param.	(0.0001)	(0.0001)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
year dummies	Yes	Yes	Yes	Yes	Yes	Yes
# obs.	5799	5799	5799	5799	5799	5799
Log Likelihood	-30954261	-30954261	-30953562	-30953562	-30953557	-30953557

[a]Figures in parenthesis are standard errors. ⋆⋆⋆ stands for statistical significance at the 1 percent level; ⋆⋆ for significance at the 5 percent level and ⋆ for significance at the 10 percent level. The estimation technique is maximum likelihood. Regime 1 corresponds to the underinvoicing regime under examination here. Results for regime 2 are simply shown for completeness of the estimation of the switching regression. The years with PSI are the years 1989, 1990, 1993, 1995 and 1996; the years without PSI are the years 1999 and 2000. Number of observations: regime 1 (underinvoicing) 3'875; regime 2 (overinvoicing) 2'564.

Table 3: *Switching regression estimates for The Philippines*[a]

End. variable	δ	δ	v	v	v	v
	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2
τ_i/t_i	132.1***	-167.8***	-45.8***	71.3***	-44.9***	71.8***
with PSI	(16.7)	(19.9)	(13.2)	(18.3)	(16.9)	(17.1)
$(1-\tau_i)/t_i$	155.9**	-138.0	-84.3**	60.6	-71.4*	41.5
without PSI	(62.2)	(106.9)	(36.1)	(69.7)	(41.6)	(69.2)
V_{ik}			0.7***	1.6***	0.7***	1.6***
true value			(0.01)	(0.04)	(0.01)	(0.04)
σ_{ik}					-49.5	-11.3
tariffs std. dev.					(41.6)	(69.2)
$\hat{\sigma}^2$	2854.1.2***	10183.3***	2565.6***	10005.73***	2568.1***	10012.0***
error variance	(72.5)	(89.6)	(65.7)	(104.3)	(71.8)	(95.3)
$\hat{\theta}$	0.002***	0.002***	0.004***	0.004***	0.004***	0.004***
scale param.	(0.0001)	(0.0001)	(0.0003)	(0.0003)	(0.0005)	(0.0005)
year dummies	Yes	Yes	Yes	Yes	Yes	Yes
# obs.	7019	7019	7019	7019	7019	7019
Log Likelihood	-45336097	-45336097	-45335815	-45335815	-45335812	-45335812

[a]Figures in parenthesis are standard errors. $\star\star\star$ stands for statistical significance at the 1 percent level; $\star\star$ for significance at the 5 percent level and $\star$ for significance at the 10 percent level. The estimation technique is maximum likelihood. Regime 1 corresponds to the underinvoicing regime under examination here. Results for regime 2 are simply shown for completeness of the estimation of the switching regression. The years with PSI are the years 1993-1995 and 1998-2000; the years without PSI are the years 1988-1990 and 1992. Number of observations: regime 1 (underinvoicing) 2'992; regime 2 (overinvoicing) 3'890.

Table 4: *Has PSI reduced tariff evasion?*[a]

	$\widehat{\alpha}$	$\widehat{\alpha}$	$\widehat{\alpha}$
	Column 1	Column 3	Column 5
Argentina	$6.8^{\star\star\star}$	$2.6^{\star}$	3.0
	(1.7)	(1.0)	(1.9)
Indonesia	$2.3^{\star\star\star}$	3.7	3.7
	(0.4)	(2.7)	(2.7)
The Philippines	0.9	0.5	0.6
	(0.1)	(0.5)	(0.7)

[a]PSI reduced tariff evasion if estimates of α are below 1, where $\widehat{\alpha} = \widehat{\beta}_{11}/\widehat{\beta}_{12}$ (the ratio of the coefficient in front of $1/t_{ik}$ with and without PSI). βs are obtained from the regressions in columns 1, 3 and 5 of Tables 1-3. Figures in parenthesis are standard errors. $\star\star\star$ stands for statistical significance at the 1 percent level for the rejection of the null hypothesis $\widehat{\alpha} = 1$; $\star\star$ for significance at the 5 percent level for the rejection of the null hypothesis $\alpha = 1$; and $\star$ for significance at the 10 percent level.