An explorative study into the effectiveness of a customs operation and its impact on trade

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Abstract

There is a lack of overall efficiency in Sub-Saharan Africa's logistics systems, with a large contributor to this problem being inefficient customs processes and unnecessary customs delays. Many comparisons have been drawn between the levels of efficiency of different countries and regions, especially in recent trade facilitation research, and some models have been developed to demonstrate how the efficiency of a customs operation can potentially be improved. The development of effective policies, strategies and operational procedures, supported by business intelligence and predictive models, however, depends on an in-depth understanding of the reasons for long delays in the customs process. There are multiple factors impacting the customs and logistics process; in order to progress towards improved solutions it is essential to identify the areas of worst performance, their common denominators and the underlying causes that contribute to low observed performance. This requires exploratory analysis of a large set of data representative of an overall customs operation. This article describes the first attempt to analyse transaction-level data and derive exploratory statistics representative of customs operations as implemented in South Africa. The most important process outcomes from the perspective of both trade and customs are defined, the key input factors are identified, and performance measures are extracted from data exchanged between the customs authority and cargo consignors during the period September 2014 to September 2016. The time duration per category for the completion of the customs process was measured, as well as the effectiveness of the customs authority in screening consignments for inspection. The study indicates that, for the selected dataset, of all shipments delayed by customs, more than 90 per cent were delayed unnecessarily, indicating inefficient risk identification in the South African customs process. This study highlights the need for improved customs processes in the southern African context to ensure more efficient trade.

1. Introduction and background

Customs authorities aim to balance revenue collection and safeguarding citizens, while facilitating efficient cross-border traffic of people and goods. The increased risk to individuals, and the private and public sectors represented by global goods shipments, has been a driving force behind vigilance by customs and regulatory authorities in different countries.

Historically, many customs administrations have used risk-averse approaches, requiring 100 per cent inspection of all shipments, conveyances, crews and passengers. As this approach today would not be practical, the private sector has applied pressure to minimise government intervention in commercial transactions (Widdowson, 2007, p. 32). Today, a more holistic approach is required to optimise international supply chains. Customs administrations are therefore searching for more efficient risk management processes, including risk identification prior to shipping to ensure compliance while reducing unnecessary time and cost delays. Systematically implementing risk management strategies at strategic, operational and tactical levels ensures that customs administrations better protect their citizens from threats to health, safety and security, while supporting economic growth through efficient transit times (Finger et al., 2010, p. 3).

In the African context, efficient transit times have been a large concern. Many African countries are heavily reliant on the revenue obtained from tax collection, which often results in conflict between customs authorities and the private sector. Delays in the southern African region are especially high, which has a direct financial impact on the private sector (Hoffman et al. 2016, p. 252). Some studies have shown that poor customs procedures are one of the largest contributors to delays in Africa (UNECA, 2013; USAID, 2015).

Customs modernisation in developed countries has also started to shift responsibilities from customs to traders, as per SAFE Pillar II (World Customs Organization, 2015). In the past, customs compliance was checked by customs authorities at the border. Should there be any discrepancy in the documentation, the shipment would remain 'stuck in customs' for as long as it took to resolve the discrepancy (Truel, 2010, p. 65). To alleviate supply chain pressures, traders have demanded a separation between the clearance and the release of goods (Khan & Zsidisin, 2012, p. 56). Customs in many countries have responded by introducing simpler clearances, supported by audit-based controls at the traders' premises (Truel, 2010, p. 45).

Automated risk assessment of transaction-level data can be a useful tool to identify potential risk indicators even before the goods are loaded at the place of origin (Manners-Bell et al., 2014, p. 2; Baldwin, 2016, p. 201). New technologies can also help reduce corruption by eliminating opportunities for tampering with sealable, traceable cargo (Finger et al., 2010, p. 36). Some examples can be found in the literature, as outlined below.

Komarov (2016) studied automated risk assessment by Ukrainian Customs. The system creates risk profiles to enable automated selection of high-risk transactions by dividing transactions into risk categories: high risk or 'red' (representing 4.34% of transactions) are subjected to physical inspections, 'yellow' (15.60%) to documentary checks, 'light green' (6.48%) to 'information massage' while the remaining 'green' transactions (73.58%) are not subjected to further checks. However, Komarov provided little detail about the data used and how the relationships between inputs and risk outcomes are established. Neither the extent to which customs interventions impacted time delays nor the success of the system's ability to find actual infractions were accurately quantified.

In a Senegalese country study, Laporte (2011) applied regression models to calculate a risk outcome that reflects the probability of an infraction on a transaction basis, using six variables: importer, freight agent, HS classification, origin, provenance and customs regime. The study claimed that this model enabled the filtering of high-risk transactions so accurately that more than 96 per cent of all infractions could be found by inspecting only 20 per cent of consignments. In a subsequent study, Davaa and Namsrai (2015) extracted a similar model from Mongolian customs data to predict infraction probability, using the following input variables: HS classification, importer, country of origin, customs terminal code, customs broker and type of transportation means. The level-of-risk prediction accuracy that they achieved was not quite as impressive as those obtained by Laporte; their model could classify consignments so that the incidence of infractions increased from 0.05 per cent in the lowest risk category to 0.22 per cent in the highest risk category.

The existing research demonstrates the value of a non-intrusive data analytics approach to customs risk management. No consistent set of inputs factors have yet been identified to be included in such a customs risk management model. Furthermore, the cited references provided no quantified indication of the relationships between the input factors and the operational customs performance. Such an analysis will indicate which areas of the overall customs operation suffer the most from inefficiencies, and whether specific types of cargo or specific entities seem to be unfairly targeted.

There is little empirical evidence that customs authorities in southern Africa are using well-designed statistical systems to identify possible high-risk transactions. Existing processes combine simple criteria, such as the importer code, the origin of the goods and the applicable tax regime, and do not appear to apply sufficient statistical techniques and data analysis. Laporte (2011, p. 18) highlights the poor application and use of ASYCUDA (Automated System for Customs Data), as well as the use of outdated versions. The authors of this paper have also estimated the impact of long cross-border delays on the southern African region and recommended better data analytics to streamline customs processes (Hoffman et al., 2016, p. 263). This paper aims to continue previous work by investigating input–outcome relationships for customs processes currently applied in South Africa in order to measure the extent and identify the primary reasons for customs delays.

This paper uses transaction-level data that was obtained from South African freight forwarders. The paper aims to quantify the impact on customs delays resulting from stops and inspections, and the efficiency of decisions taken by the current customs system. The paper is structured as follows: in section 2 we describe the data used in the study and in section 3 the methodology used to extract information from this data. Section 4 provides results and findings, and section 5 concludes with recommendations.

2. The data

Data was obtained from several freight forwarders in South Africa, in accordance with an agreement between the North-West University (NWU) and the South African Association of Freight Forwarders (SAAFF). The data represents transaction-level flows exchanged between the South African Customs Authority (SARS) and consignors of goods imported into South Africa between September 2014 and September 2016. The data includes approximately 3.5 million transactions over this time.

For each transaction the following information was obtained:

- times and dates when electronic declarations were submitted by consignors and received by SARS
- name of the customs office where declarations were submitted
- HS code
- customs value
- mode of transport through which goods entered into South Africa
- Customs Procedure Codes (CPC) reflecting the reason why goods were imported into South Africa
- country of origin, export and import (some goods may be in transit via South Africa en route to a final destination elsewhere in southern Africa)
- codified identity of the entity submitting the customs declaration (preserving the anonymity of the declarants)
- detailed set of customs response codes communicated to the declarant for each transaction, together with the time and date for each code.

Table 1 provides a summary of these input factors and the level of detail that was included in the data.

Table 1: Input factors reflecting customs declaration processes

Input factor	Number of categories	Examples
Import /export	7	Imports, Ex-bond, In transit
Customs office	36	Durban, Cape Town
CPC code	31	10, 11, 12
Previous CPC code	23	00, 14, 20
Country of origin	237	GB, CN, GE
Country of export	222	GB, CN, GE
Country of import	197	ZA, ZM, ZW
Transport code	9	Ocean, Road, Rail
Consignors	310	#0, #1, #7
HS code	18	Animal, Chemical

Table 2 provides a summary of the customs response codes that can be received for any given transaction and indicates the actions required by customs for that specific transaction.

Table 2: Customs response codes

Customs response code	Description
1	Release
2	Stop for physical inspection at unpack depot or X-ray scanning
4	Refer to other governmental agency (OGA)
6	Reject declaration
13	Supporting documents required
26	Request adjustment to declaration
27	Accept
31	Request additional supporting documents
33	Supporting documents received
36	Booked for physical inspection

3. Methodology

The approach that was applied to extract meaningful information from the available dataset consisted of the following sequential steps:

1. **Identify the factors impacting customs processes**. Those inputs that could affect the customs process were identified through discussions with SAAFF members and included in the set of data, as reflected in Table 1. The importance of each input factor was also confirmed through correlation analysis.
2. **Define the sequential steps through which consignments are processed.** The customs process is not limited to a fixed number of sequential steps, as described in Table 2. Analysis of the data indicated thousands of different combinations of possible response codes. It was therefore necessary to identify specific combinations of response codes that represent specific types of customs decisions.
3. **Identify the primary customs outcomes.** From the many possibilities the following set of primary outcomes were defined (see Table 3):

Table 3: Description of customs codes and outcomes

Outcome	Condition
1. Not stopped	no code 2, 36, 13, 31, 4
2. Stopped	code 2
a. Not inspected	no code 36
i. Not amended	no code 6 or 26
ii. Amended	code 6 or 26
iii. Accepted	code 27
b. Inspected	code 36
i. Not amended	no code 6 or 26
ii. Amended	code 6 or 26
iii Accepted	code 27
3. Request additional docs	code 13 or 33
i. Not amended	no code 6 or 26
ii. Amended	code 6 or 26
iii. Accepted	code 27
4. Refer other government agency	code 4
i. Not amended	no code 6 or 26
ii. Amended	code 6 or 26
iii. Accepted	code 27

4. **Quantify the time impact for each possible outcome.** After all transactions were categorised according to the above input factors, the following set of statistical parameters were measured for each category:

   i. total time duration per observation measured from the time and date of submission until the final customs outcome (acceptance, rejection, amendment or referred)

   ii. number of observations (each declaration regarded as an observation) per input category and per outcome

   iii. fraction of total observations per input category and per outcome

   iv. average, median and standard deviation of time duration for all observations, per input category and per outcome

   v. fraction of total observations that were found to contain customs infractions[1]

   vi. average, median and standard deviation of time duration for each type of outcome, found to contain infractions

   vii. fraction of all declarations interrupted by customs that contained infractions

   viii. fraction of total time delay represented by each outcome, by different infraction types and by interrupted declarations not containing any infractions

   ix. repeating each measurement (time delays and fractions) for each outcome and for infractions within each input category.

5. **Determine the quantified impact of each input factor on average time delay, probability of an infraction and avoidable time delays**. By comparing the above results between different input factor categories, the following could be determined:

   i. the way in which the customs authority made decisions regarding the consignment

   ii. the time delay to which the consignment of goods was exposed

   iii. the probability of customs finding an infraction within the consignment.

6. **Estimate the saved time through improving customs systems**. An ideal customs system will have the ability to screen all declarations and to identify those containing infractions, allowing customs to stop, inspect and reject or amend only such consignments. The share of consignments that are interrupted by way of either a request for additional documentation or by a stop and/or a physical inspection, and for which no infraction was subsequently discovered (and associated share of total time delay), can be regarded as representing the potential for improvement of the customs systems from the status quo towards the ideal.

7. **Determine the trends of important outcomes.** By calculating all of the above outcomes per time period and plotting the resulting performance levels as a function of time, it is possible to determine if there is a trend over time, and if specific time periods were characterised by specific eventualities (e.g. when Customs may have decided to take special measures at specific offices). In this case we used monthly measurements as the basis for time-dependent behaviour.

8. **Determine correlations between input factors and outcomes**. The most commonly used measure to determine whether there is a significant relationship between an input factor and an outcome is linear correlation. All of the input factors that are considered are, however, categorical in nature.

In order to generate variables associated with the input categories that are continuous in nature to allow the calculation of a correlation coefficient, we implemented the following approach:

- Within each input category (e.g. for Durban customs office) we calculated the accumulated average of each outcome over time (e.g. the average time delay was calculated as from September 2014 until the end of each following month, e.g. November 2015, December 2015, etc.).
- As these accumulated averages represent the behaviour observed within that category up to that point in time, they were used as explanatory variables.
- These explanatory variables were regarded as representing the impact of the respective input factor (e.g. customs office) on a possible outcome (e.g. finding an infraction).
- Each new observation falling into a specific set of categories (e.g. customs office Durban, CPC code 41, Country of Origin CN) was allocated the values of the accumulated averages for each performance parameter calculated for the categories to which it belongs.
- The Pearson correlations were calculated between the explanatory variable values (e.g. the average time delay for Durban up to that point in time) and the specific value for that observation (e.g. its actual time delay).

9. **Compare impact of different input factors**. Repeat the above process within each subcategory (e.g. per customs office), compare the correlations between the different input factors and determine which way of categorisation has the biggest impact on which outcome.

The results of this analysis provide evidence of the basis for customs decisions and of the accuracy of these decisions. It also provides an indication to the private sector of the time delays they could expect for specific consignments that fall within specific categories. The results can be used to improve customs procedures and ensure future systems will reduce unnecessary time and cost delays and improve the predictability of customs operations in South Africa.

4. Results and findings

This section provides an overview of the results extracted from the dataset described in the previous section. First, an overview of the total dataset is given. This is followed by comparisons of results between different categories. This section is concluded by calculating correlation coefficients between the different input factors and the most important outcomes, including the probability of being stopped and inspected, the probability of a request for additional documentation and the probability of an infraction being discovered by Customs. In the process we provide quantified outputs with respect to each of the research questions to be addressed.

4.1 Overview of the dataset

In Figure 1 the number of declarations and average duration (h) the number of declarations available per month and the average duration for processing by customs are displayed. While the number of declarations remain more or less constant over the two-year period, there is a marked increase in average duration over the last six months of the period under consideration.

Figure 1: Time trend over all consignments: Number of declarations and average duration (h)

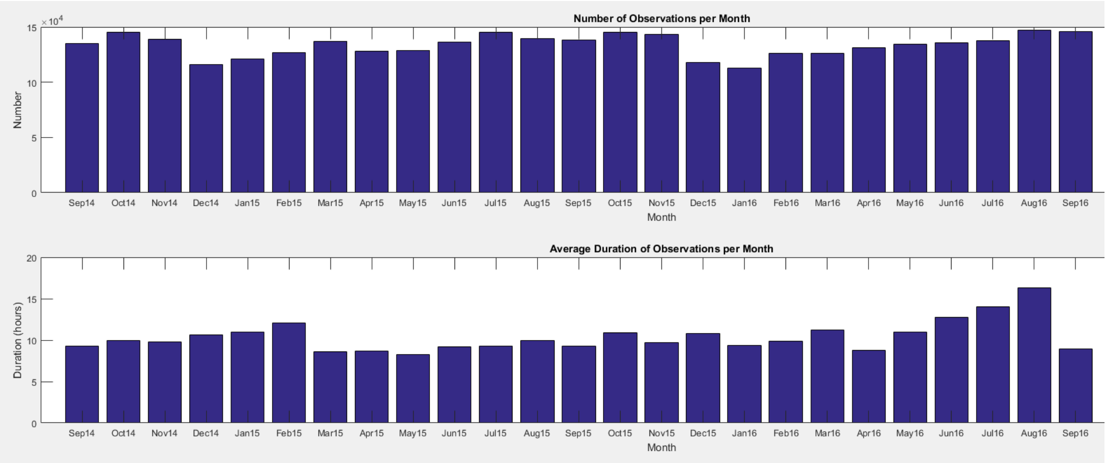


Table 4 displays a comparison between consignments delayed by customs (stopped) versus consignments immediately released by customs (not stopped). Table 4 shows that stopped consignments (all outcomes not falling in the category 'not stopped') represent approximately 22 per cent of the total number but approximately 61 per cent of total delays experienced by all consignments combined. This provides justification for further investigation into the 'stopped' category.

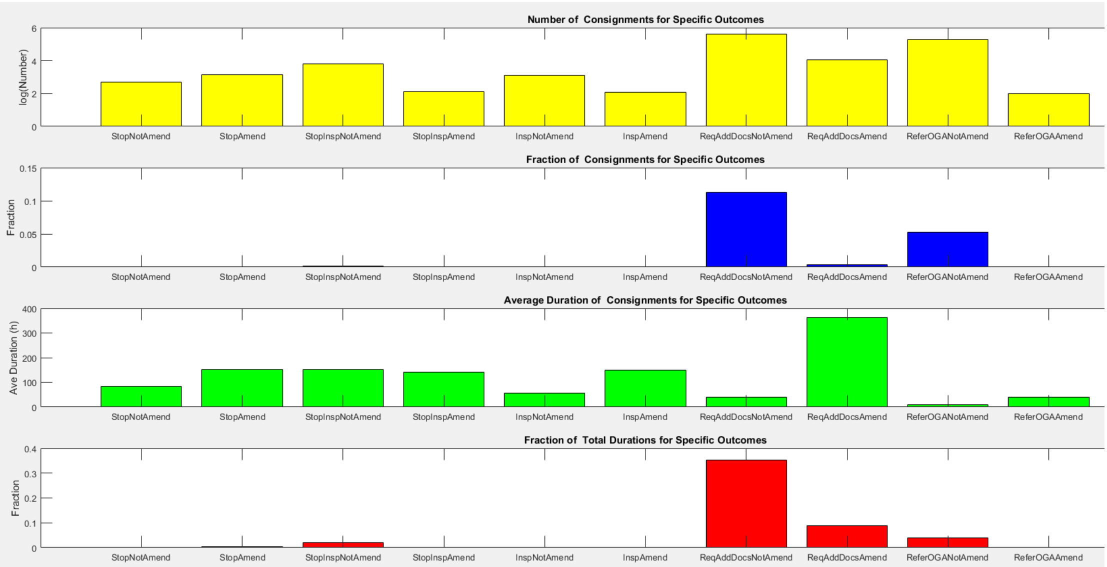
Table 4: Statistics for all consignments over total time period

Category	Number	Average duration	Fraction of total	Fraction with infractions	Fraction of total duration
All	3 520 977	11.3	1.00	0.007	1.000
Not stopped	2 755 894	6.1	0.78	0.000	0.421
Stopped but not inspected	1 995	133.9	0.00	0.742	0.007
Stopped and inspected	7 669	136.9	0.00	0.031	0.026
Request for additional documents	410 951	48.6	0.12	0.027	0.501
Referred to OGAs	187 747	9.6	0.05	0.001	0.045
Infractions	25 706	179.2	0.01	1.000	0.116

Figure 2 breaks down the possible actions for stopped consignments into the categories outlined in Table 3.

Requests for additional documents represent the biggest contribution to stopped consignments, both in terms of the number of cases and the total time duration consumed by this activity. In all cases where an amendment was made, the time delay tended to be much longer compared to cases that are not amended, which can be expected.

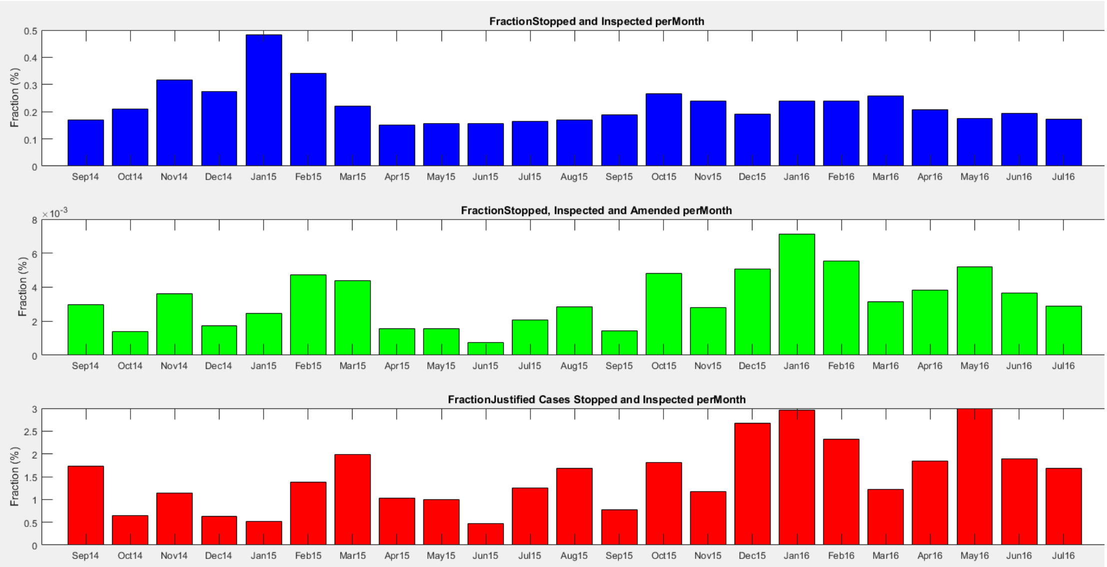
Figure 2: Statistics for different stopped outcomes



A question that arises is whether observed behaviour remains constant over time or if it only occurs sporadically. We calculated time trends for consignments stopped, including the fraction of total cases that are stopped and the fraction of total delay time represented by the various types of stops. For reasons of brevity only one of these graphs is displayed in Figure 3. The following observations were made:

- While the number of observations per month remained approximately constant over the period, the average duration to process consignments increased by approximately a factor of 2 over the same period.
- The number of consignments subjected to physical inspections displays peaks during specific months.
- An upward trend can be observed over the time period for both the fraction of consignments stopped and the average time delay per stopped consignment. A similar trend is observed for consignments with infractions.
- The fraction of consignments for which additional documents were requested increased from 5–10 per cent in September 2014 to 15 per cent by September 2016.
- As the fraction of justified cases for requesting additional documents did not increase similarly, there is an increase in the time lost by trade due to unnecessary requests that did not lead to amendments or rejections.
    - Only a small fraction of consignments subjected to physical inspections or for which additional documents were requested resulted in rejections or amendments.
    - The fraction of customs stops that are justified (i.e. that resulted in amendment or rejection) is consistently small—this aspect of customs performance is not restricted to specific time periods.

Figure 3: Comparison of time trends: Stopped and inspected vs stopped, inspected and amended



The most important general observation that can be made from the data thus far is that the large majority of consignments that are stopped for one of the identified reasons are not amended at all and are eventually released without an amendment or a rejection. It can therefore be argued that with a more accurate customs screening system in South African Customs, it should be possible to drastically reduce this fraction of consignments for which the normal flow of cargo is disrupted without a valid reason. The following section will provide further breakdown of the results per category.

4.2 Imports, exports, ex-bond and in-transit

The first method for categorisation:

- imports
- imports ex-bond (where goods first went into a bond store before duties eventually became payable)
- exports
- exports ex-bond
- BLNS Transit (goods in transit to other countries in the SACU region, namely Botswana, Lesotho, Namibia and Swaziland).

The vast majority of declarations that formed part of this study was for imported goods; of these about 10 per cent were imports ex-bond. The reason for focusing on imports, rather than exports, is that the customs authority tends to focus more on collecting customs duties on imported goods. A small fraction of export, ex-bond import/export and in-transit consignments were included in the dataset. Some observations made include:

- imports represented the bulk of the available data
- imports ex-bond experienced a smaller fraction of stops compared to other imports; the average duration of delays was however larger compared to other imports

- export ex-bond experienced a small fraction of stops but higher average delay times compared to imports
- for BLNS transit, the average delay for consignments not stopped was much higher compared to imports
- the fraction of total time delays caused by a request for additional documents is higher for imports.
- BLNS transit experienced a much higher fraction of physical inspections compared to average, and also experienced a much higher fraction of infractions.
- The fraction of justified stops (physical stops and requests for additional documents) was consistently low for all categories over the entire time period.

Performance per customs office

The next categorisation was the customs office in South Africa in which the declarations were processed. It would be reasonable to expect significant differences in performance between these categories due to the volume processed (e.g. Durban, Africa's busiest freight port, compared to small border offices like Vioolsdrif or Ficksburg), as well as the mode of transport (e.g. Durban processes mostly large maritime consignments vs OR Tambo Airport processing mostly small air cargo consignments).

The purpose of this section is to identify those offices that may be causing the most delays and to verify if deviations between sample averages and the population average are statistically significant. For this purpose, we calculated the t-statistics for the averages calculated per category as follows:

$$t - statistic = \frac{\mu_s - \mu}{\sigma_s / \sqrt{N_s}} \qquad \textbf{(\textit{Equation 1})}$$

with μ_s the average of the sample of which the t-statistic is determined, μ the population average, σ_s the standard deviation of the sample and N_s the sample size. If the t-statistic > 3, there is only a 1 per cent chance that the deviation of category behaviour from population behaviour is due to the randomness in the data—in such cases there is an underlying reason why observed category behaviour is different.

In Figure 4 the average duration per customs office, as well as the t-statistics of these averages, are displayed in ranking order from highest to lowest average duration. Vioolsdrif (VLD) displayed the highest average duration of more than 300 hours. While the average for Beitbridge (BBR), the busiest road freight border post, is much lower at 46 hours, its t-statistics is the highest (about 40) due to the much larger number of consignments moving through that border. Durban (DBN) seems to be only slightly above overall average; its t-statistic, however, indicates a significant deviation from the overall mean, given the very large numbers processed by Durban. This illustrates the value of using additional statistical measures to evaluate performance.

Figure 5 displays the fraction of consignments stopped and inspected per customs office. Upington experienced the highest fraction stopped and inspected, followed by Komatipoort and Bloemfontein. Skilpadshek experienced by far the highest average duration for stopped and inspected consignments. As can be seen, many of the figures per category have very high t-statistics, implying that there must be underlying reasons why their behaviours deviate so much from population averages.

The statistics for stopped and inspected but not amended is almost identical to those for all consignments stopped and inspected—in almost all cases only a small fraction of consignments stopped and inspected were in fact amended or rejected. This is indicative of a high potential for reduction in unnecessary stops without a negative impact on customs compliance levels. For many customs offices, 100 per cent of consignments stopped and inspected were not amended or rejected. The customs offices performing the best only achieved a ‘hit rate’ of around 25 per cent for consignments stopped and inspected. Durban has the highest t-statistic for unjustified stop percentages.

Figure 4: Average duration to process declarations per customs office

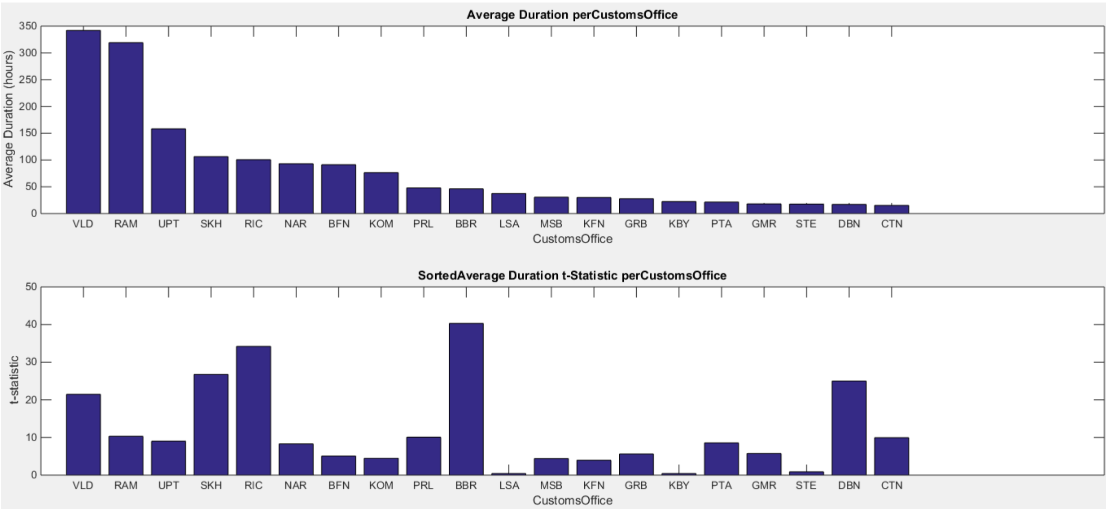
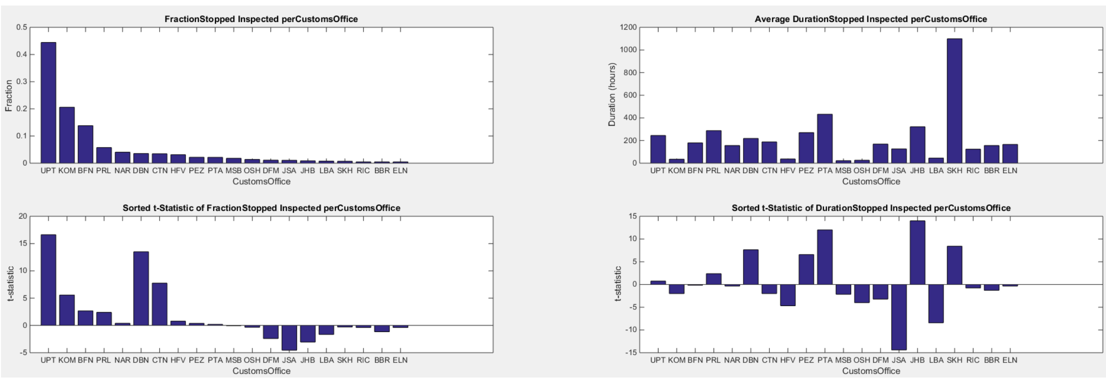


Figure 5: Comparison of share stopped and inspected between different customs offices

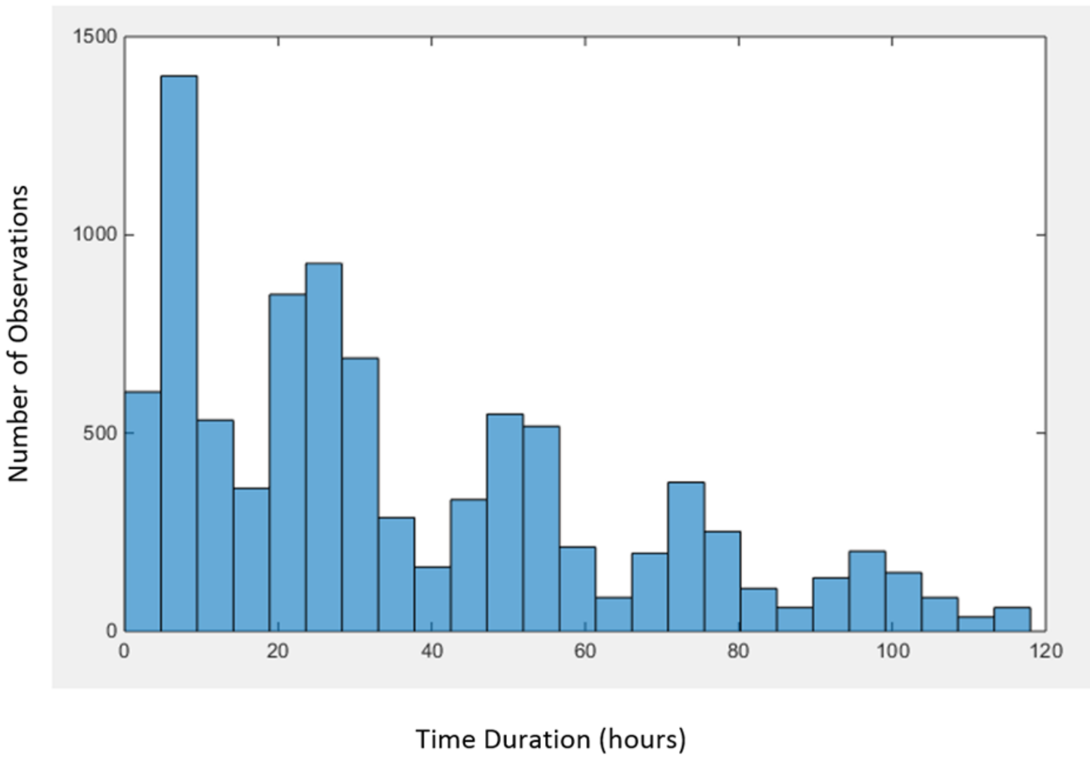


From similar results for requests for additional documents, the following comments can be made:

- Some customs offices (e.g. Komatipoort) request additional documents for more than 40 per cent of consignments; in such cases consignments can be delayed for more than two weeks (300–350 hours).
- One customs office (Komatipoort) did not amend or reject 90 per cent of the 40 per cent consignments for which additional documents were requested—most of the delays ranging from several days to two weeks were thus unnecessary.
- As in previous cases, the t-statistics for many categories indicate systematic deviations from average behaviour rather than mere random fluctuations.
- The fraction of unjustified requests for additional documents is even worse than for unjustified stops and inspections—on average around 95 per cent.
- Only one customs office (HFV) achieved a ‘hit rate’ of better than 20 per cent.

Further insight into the nature of the customs process can be obtained by observing the histogram of time duration per border post. For example, Beitbridge border post's time delays reflect specific aspects of operation and suggest possible reasons for delays. As can be seen in Figure 6, delays at Beitbridge display a clear 24-hour cyclic behaviour: consignments processed on the same day take a few hours; if not completed it typically takes another 24 hours, resulting in peaks within the 24-hour cycle time. The large fraction of consignments not amended but also not cleared on the same day is indicative of the presence of extraneous factors justifying further investigation. In some studies, interviews with trucking companies and clearing agents provided possible reasons for this behaviour. Truck drivers often spend several hours after reaching the border post on personal activities before handing in their documentation at a clearing agent; quite often this may only happen the next morning, even though the goods had arrived on the previous day.

Figure 6: Histogram of customs processing time in hours at Beitbridge border post



By quantifying the total contribution to unjustified stops, it is possible to identify the customs offices that present the biggest overall delay. Figure 7 shows that Durban contributes most to the total duration of unjustified stops, followed by JSA (OR Tambo airport). They are also amongst the customs offices that spent the largest fraction of overall time on unjustified stops. Durban is therefore selected for further investigation.

In Figure 8 it can be seen that the approximately 6.5 per cent of consignments that are stopped at Durban contribute more to total time delay than the approximately 93.5 per cent of consignments that are not stopped, and that approximately 90 per cent of the time delays for stops were unjustified as they did not lead to a rejection or amendment. As this is a very busy port that requires all available space for fast processing of cargo, the time wasted on unnecessary customs stoppages is a cause for concern.

We then analysed time trends for the performance of the six busiest customs offices: OR Tambo Airport (JSA), Durban port (DBN), Johannesburg dry port at City Deep (JHB), Durban freight terminal (DFM), Cape Town (CTN) and Port Elizabeth (PEZ). A gradual increase in the average duration to process declarations can be observed for most of these customs offices over the two-year period. The fraction of consignments subjected to physical inspections tend to show peaks during specific periods, as is evident from Figure 9. The number of infractions did not display a similar increase during months of increased physical inspections, leaving the impression that there were periodic efforts of increased intervention by customs officials but with no measurable positive outcomes.

Figure 7: Time durations of unjustified stops per customs office

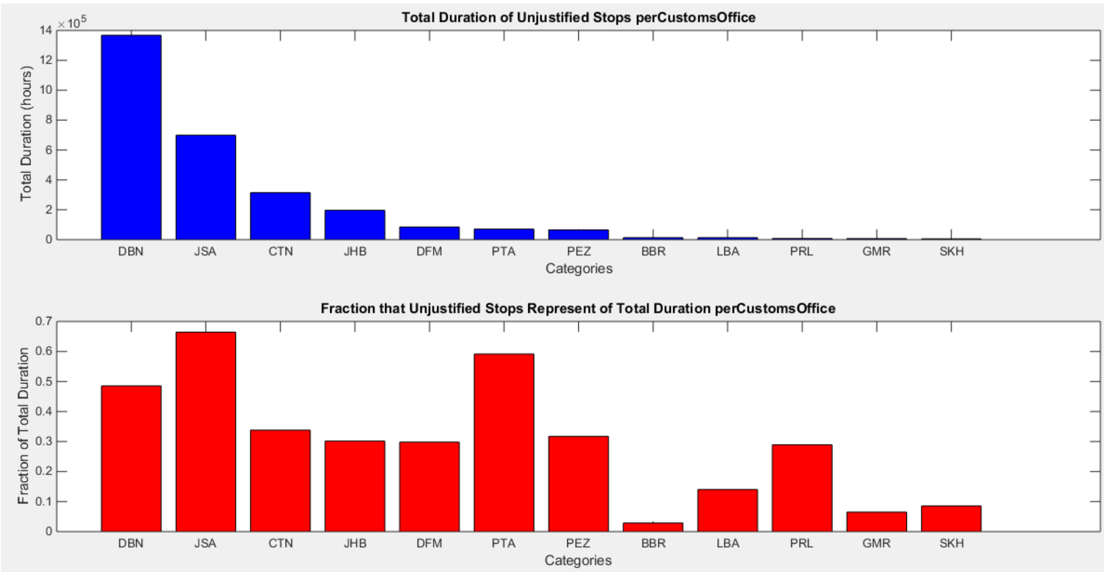
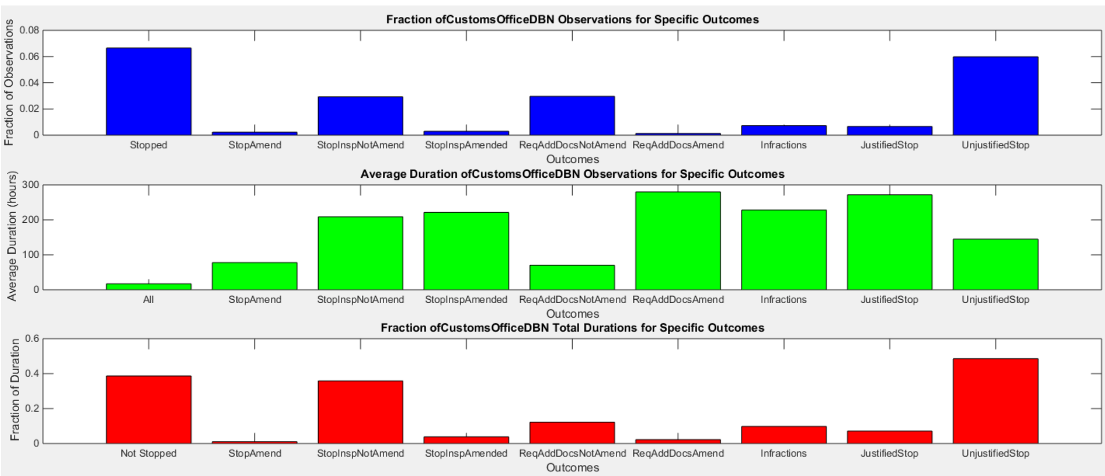


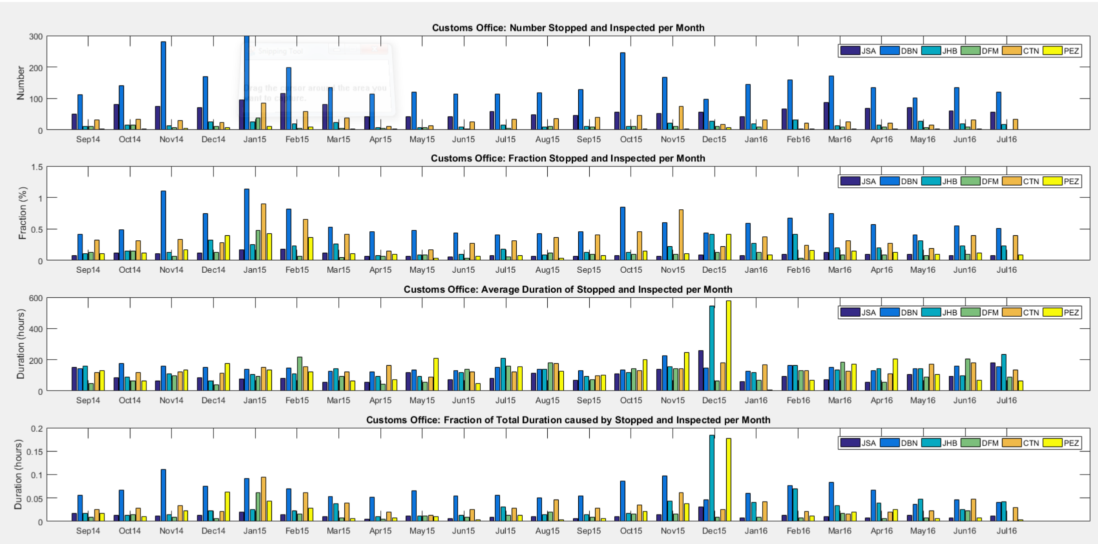
Figure 8: Time durations for different outcomes at Durban customs office



From further analysis the following observations can be made:

- The number of infractions significantly increased at JSA and Durban over the observation period.
- There was a significant increase in the average time to process infractions, from about 150 hours to around 250 hours, mainly due to the increased time caused by requests for additional documents.
- While the number of justified stops show increases at JSA and Durban, the fraction of justified stops is consistently low, particularly if the number of infractions is compared against the much larger number of stops and requests for additional documents.

Figure 9: Time trends: Different customs offices: physical inspections

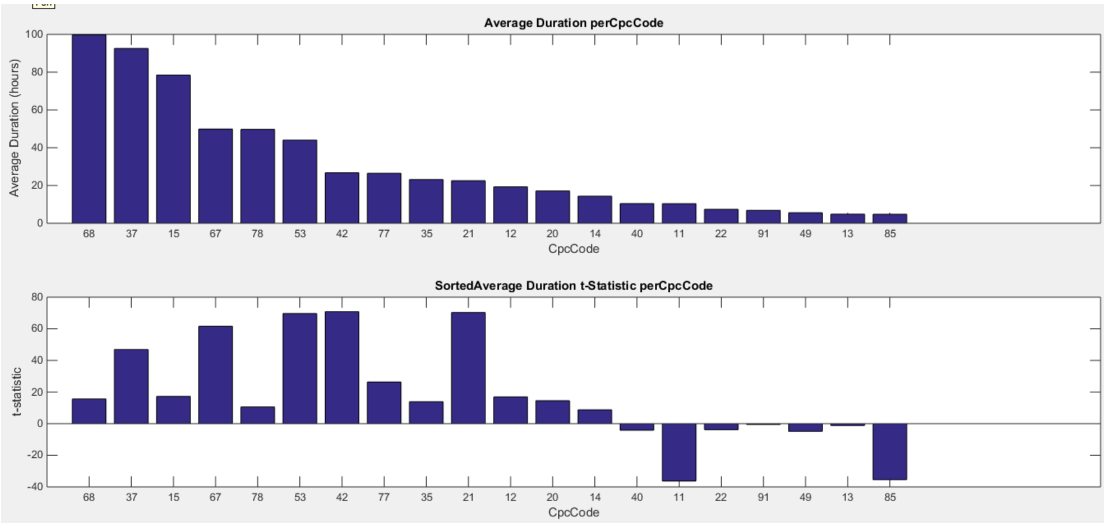


4.3 Performance per CPC code

The average duration and t-statistics by CPC code is displayed in Figure 10. The following is observed:

- Many CPC codes that do not appear frequently have, on average, very high delays of 80 to 100 hours compared to the average of approximately 11 hours.
- The high t-statistic values indicate that, even taking into account the small numbers in those categories, these deviations cannot be attributed to random behaviour.
- Time durations for unjustified stops is dominated by code 11 (imported for local consumption) as could be expected, as this is the most populous category.
- There are large variations between CPC codes in terms of fraction of total time represented by unjustified stops (e.g. for code 77 this fraction is larger than 60%).
- Although only 5 per cent of consignments for CPC code 11 are stopped, these represent approximately 60 per cent of total time delay, of which about 80 per cent are unjustified stops.

Figure 10: Comparison of average durations between different CPC codes

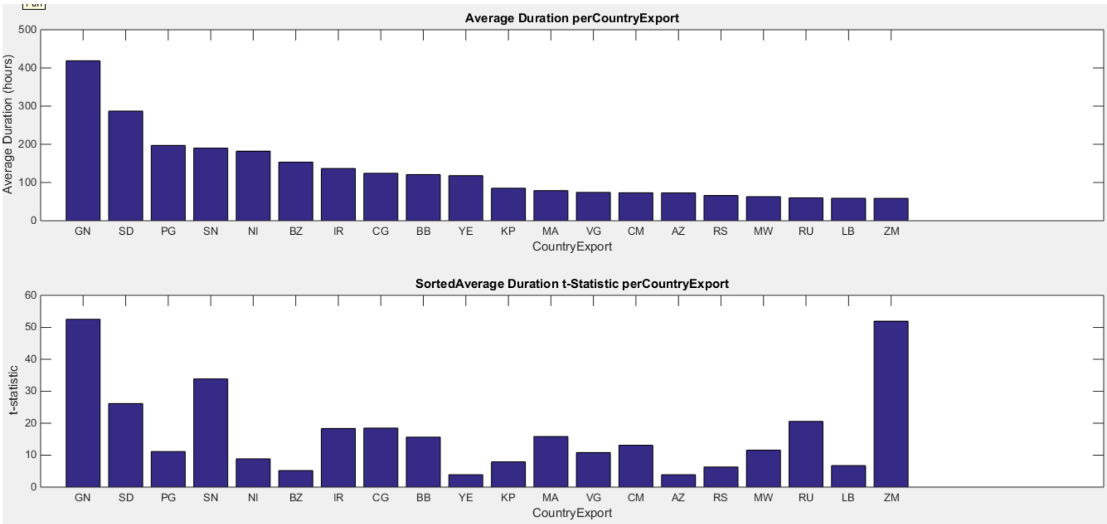


4.4 Performance per country of export

Previous studies (e.g. Laporte, 2011) have indicated that the origin of goods is an important criterion used by customs authorities to estimate the probability of infractions. It could, therefore, be expected to observe significantly different behaviour for different countries of export. Figure 11 displays the average time duration for those origin countries experiencing the longest delays. For many countries the average time duration is far above the population average; in some cases, their t-statistics are above 50. From Figure 11 and further analysis we make the following observations:

- Consignments from many countries of export experience average delays in excess of 100 hours, in some cases more than 400 hours.
- Overall unjustified stops are dominated by imports from China.
- The fraction that unjustified delays represent of overall time delays per country does not deviate from the population mean as much as for other input factors (it varies between 20% and 50%).
    - For other African countries like Zambia, with averages around 50 hours, the t-statistics indicate systematic bias in the system against specific origins for imported goods. Given that most of these goods are imported by road via Beitbridge, the time delay for Zambia is close to that for Beitbridge border post.

Figure 11: Comparison of average durations between different countries of export



4.5 Performance per mode of transport

Imports arrive in South Africa primarily by road (from other African countries), sea (bulk imports from overseas countries) and air (small sized high value goods from overseas). Table 5 provides a description of the codes used for different transport modes.

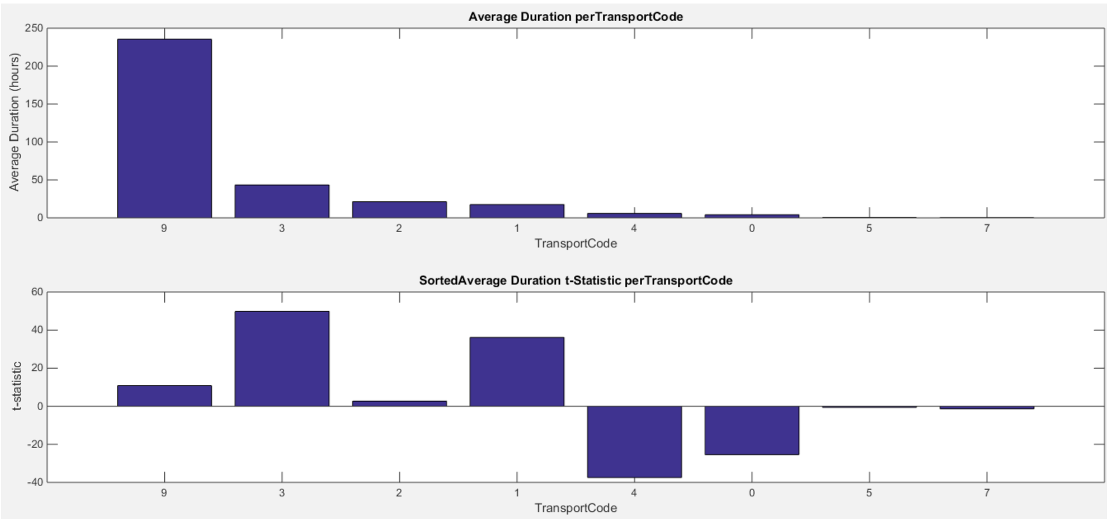
Table 5: Transport mode codes

Code	Description
0	Transport mode not specified
1	Maritime transport
2	Rail transport
3	Road transport
4	Air transport
5	Mail
6	Multimodal transport
7	Fixed transport installation
8	Inland water transport
9	Transport mode not applicable

Figure 12 confirms that the average duration for each of the three main modes of transport more or less equal the time delays for Beitbridge (road), Durban (sea) and JSA (air), as these are the biggest ports of entry handling goods arriving through these modes of transport. We can make the following general observations:

- Amongst the transport modes, road experiences the longest delays, and very significantly so in terms of t-statistics, most likely due to long delays at border posts like Beitbridge.
- Sea transport dominates in terms of total duration of unjustified stops, followed by air and then road.
- For air transport, unjustified stops represent the largest fraction of total delays within its own category.
- A concerning factor in terms of data capture is that the largest average delays occur in the category 'Transport mode not specified', although this category represents only a small fraction of the total population.

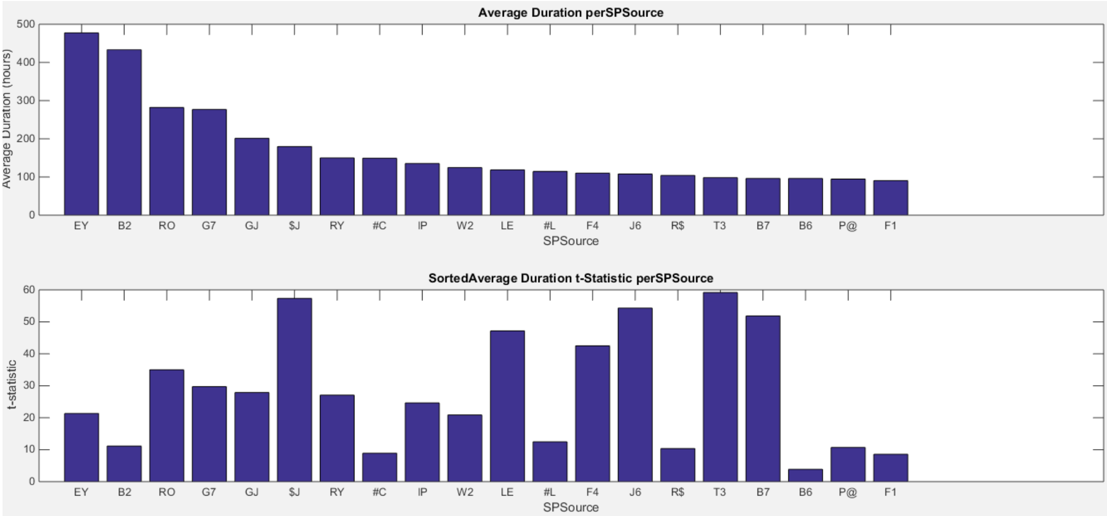
Figure 12: Comparison of average durations between different modes of transport



4.6 Performance per consignor

Previous work (e.g. Laporte, 2011) has indicated that the entity importing the goods is also an important determinant of perceived customs risk. Figure 13 shows that some consignors experience average delays in excess of 400 hours; this confirms that Customs appears to target specific consignors. The t-statistics confirm that there appears to be systematic discrimination against specific consignors. For some consignors unjustified delays represent approximately 80 per cent of total delays.

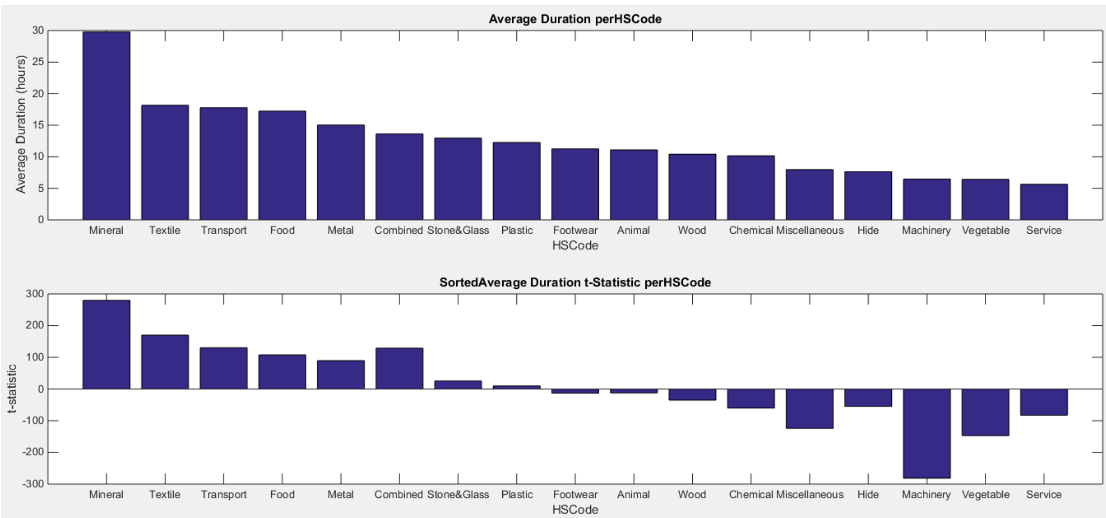
Figure 13: Comparison of average durations between different consignors



4.7 Performance per HS code

The cargo type as indicated by the HS code is important as it determines the level of customs duties payable by the importer. Figure 14 shows that, while minerals experience the highest average delays, differences between HS code categories are not as big as other inputs factors. However, some do experience delays that are five times longer than categories on the low end of the spectrum; t-statistics that are mostly either high positive or high negative also indicate that Customs applies different rules for different HS codes.

Figure 14: Comparison of average durations between different HS codes



The combined category (consolidated consignments) also dominates the total duration of unjustified stops; this could be expected as any of a number of manifests associated with the same consignment could trigger a delay for the entire consignment. Previous studies have shown that, on average, consolidated consignments experience longer cross-border delays than the population average. While the differences in unjustified stops between HS code categories are not as severe as for some other input factors, it is still interesting to note that the fraction of time represented by such stops is much higher for textiles than for footwear. This may be because there is still some protection in place for the local textile industry in South Africa.

4.8 Correlation analysis between input factors and outcomes

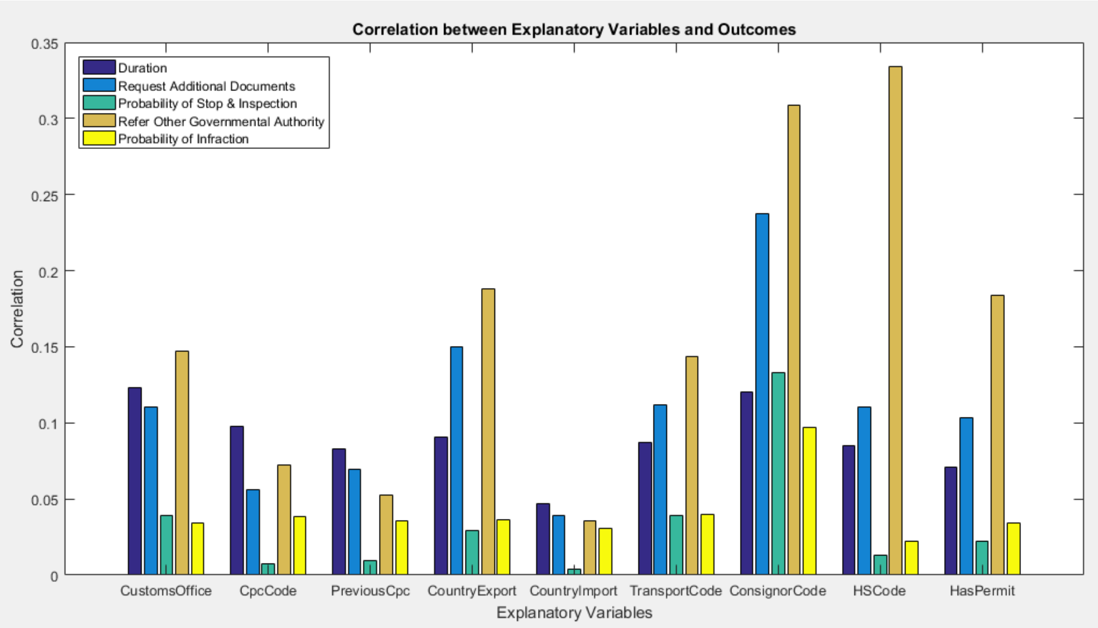
The previous section provided an overview of the extent to which different input factors have an impact on observed time delays and unjustified stops. In order to perform a direct comparison between the impact of each input factor on the various outcomes, we implemented a correlation analysis as described in section 3 above.

Correlations were firstly determined with respect to time delay, as follows: for each new observation and each input factor (e.g. customs office), the mathematical correlation was calculated between the time duration to process that specific consignment and the historical average time to process consignments within that specific category (e.g. Durban).

Figure 15 displays the correlations of various outcomes (customs decisions and resulting infractions) with respect to all the input factors. The input factor that displays the largest correlation with most customs decisions is the consignor code (entity submitting the declaration). This confirms some of the suspicions by the private sector in South Africa that the identity of the importer is used by customs to target specific consignments for scrutiny.

Other input factors with significant correlation with customs decisions are HS code, country of export and customs office. It should be noted that the correlations of the same input factors with resulting infractions are much weaker than the correlations with customs decisions. While consignor code is still the most prominent input factor, the correlation value is much smaller, while the correlation with ‘probability of request for additional documents’ is almost 0.25 and with ‘refer to OGA’ is about 0.32, the correlation with ‘probability of infraction’ is less than 0.1. This indicates that, while consignor identity is used by Customs as the primary determinant for stops, the infractions that are actually found do not fully justify this strategy as consignor identity is not as strongly correlated with actual infractions. It would, therefore, appear that some consignors are unjustifiably discriminated against, with very significant implications in terms of overall time delays.

Figure 15: Correlation between various customs outcomes and 9 explanatory variables



5. Conclusions and recommendations

This study was a first attempt at better understanding the customs risk processes in South Africa, and the impact it has on trade in the region. The study applied statistical data analysis to a set of South African customs data that represents a significant fraction of the total amount of imports over the period September 2014 to September 2016. The study not only delivered interesting results, but also demonstrated that it is possible to generate performance statistics as a function of various input variables and thereby analyse the efficiency of a customs process in much more detail than in previous studies.

The available data for South Africa indicated an increasing trend in the average time consumed by South African customs to process consignments, mostly due to an increase in the number of consignments for which customs request additional documentation. Of this fraction of consignments, only about 5–10 per cent were amended or rejected, which implies that it should be possible to improve the efficiency of the risk identification process applied by the customs authorities. More than 90 per cent of the delays caused by South African Customs could have been avoided if shipments were screened differently. The amount of time consumed by these unjustified stops represents almost 50 per cent of the overall time delays experienced by all consignments in the dataset, which suggests that there is significant room for improvement in the current system.

From the correlation analysis it was clear that Customs use specific inputs factors to target consignments for scrutiny; the most import factors appear to be the identity of the consignor, followed by country of origin and cargo type. The fact that correlations between these factors and infractions found are much lower compared to correlations with number of consignments stopped indicates that the current strategy is not fully justified and does not produce high ‘hit rates’.

This study provides an example of the value of detailed statistical analysis based on transaction-level data over a sufficiently long period of time to extract reliable results. Other developing countries in Africa should consider building these kinds of capabilities to drive further trade facilitation in the region.

Future work will include the development of a customs risk model that will allow the more accurate targeting of consignments for inspections, based on historical relationships between input factors and outcomes. It will also be beneficial to demonstrate the use of the performance statistics extracted through this study as benchmarks to be used by individual traders to evaluate their internal performance.

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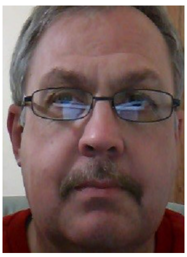
Sonja Grater is an associate professor in the School of Economics at the North-West University in South Africa. Before joining the university, she gained practical experience in the freight forwarding industry. She lectures undergraduate and post-graduate courses in the field of international trade. Her research specialisation is trade in services and trade facilitation and has authored several publications in this field. She has also been invited to participate in several research projects for organisations such as the Department of Trade and Industry (dti) in South Africa, trade promotion organisations such as Wesgro and TIKZN, and private sector organisations such as the South African Association of Freight Forwarders (SAAFF). She has also done projects for the International Centre for Trade and Sustainable Development (ICTSD), Department for International Development UK (DFID) and the World Trade Organisation (WTO).

Willem C Venter



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David Liebenberg

David Liebenberg is a Customs and Trade Consultant in South Africa. Before opening his own Consulting Company in 2014 he worked for South African Customs in Durban (1990–1996) and then the freight forwarding industry. David has also served on the South African Freight Forwarders Association Board as a Director of Customs. In his current capacity as a consultant he provides services to a number of global companies that include importers, exporters and freight forwarding companies. He also provides training at a learnership level and guest lectures at the North-West University in South Africa.

Notes

1 For the purposes of this study, we define the term customs infraction as any customs declaration that was stopped by customs, and either amended or rejected.