Unleashing International Trade through Financial Integration: Evidence from a Cross-Border Payment System*

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Abstract

Using confidential administrative data on all South African exporters and the staggered rollout of a real-time gross payment system across 14 African countries, we study the causal effects of cross-border payment integration on trade. Following implementation, firms increase export volumes by 35% and transaction frequency by 45%—equivalent to a 6–8% tariff cut. We find no evidence of trade diversion, suggesting that integration creates trade rather than merely reallocating flows. Effects are concentrated where domestic fast-payment infrastructure pre-existed and among financially constrained firms. Our results underscore the policy relevance of fast and reliable payment integration in a high-tariff global environment.

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1 Introduction

Financial frictions impose substantial costs on the global economy. The global trade finance gap—the shortfall between trade finance requests and approvals—has reached an unprecedented $2.5 trillion in 2022.[1] Such frictions remain one of the key barriers to international economic integration, threatening firm survival and job creation—particularly in emerging markets lacking a sophisticated financial infrastructure. While extensive research has shown that financial development reduces trade frictions through stable access to credit, we identify an important and unexplored channel: cross-border payment system integration.[2] This evolution in the global financial architecture represents the most significant change since electronic banking, with great potential to reduce transaction costs, payment uncertainty, and settlement times. Previous studies show that time delays in export procedures can substantially reduce trade flows (Djankov, Freund, and Pham, 2010; Hummels and Schaur, 2013), suggesting that inefficiencies in cross-border payment settlement likely impose similar trade-inhibiting frictions.

While the theoretical literature has significantly advanced our understanding of how financial integration affects trade (e.g., Schmidt-Eisenlohr, 2013), the precise effects of payment system integration on international trade flows remain largely unexplored in the empirical literature. This limitation becomes even more pressing as policymakers have called for rigorous empirical evidence on these estimates to effectively design and implement strategies maximizing the gains from cross-border financial integration (see, e.g., Bindseil and Pantelopoulos (2022) and the G7 Finance Ministers and Central Bank Governors communiqué of 2025).[3] Yet, despite the economic magnitude of cross-border payments and their essential role in global trade, we lack causal evidence on how payment system integration affects trade patterns and firm behavior.

This paper exploits the staggered rollout of the Real-Time Gross Settlement (RTGS) system across the Southern African Development Community (SADC) to inspect how cross-border payment integration affects international trade. The RTGS system is a payment platform facilitating cross-border transactions among participating countries, with accounts centralized by the South African Reserve Bank and pre-funded to reduce settlement risk. Beyond speed improvements, the system reduces

[1] For trade finance gap statistics and their economic impact, see Asian Development Bank (2023).

[2] On financial development and trade, see Beck (2002), Manova (2008), and Paravisini, Rappoport, and Schnabl (2023). On financial disruptions, see Amiti and Weinstein (2011), Manova, Wei, and Zhang (2015), Paravisini, Rappoport, Schnabl, and Wolfenzon (2015), and Matray, Müller, Xu, and Kabir (2025).

[3] The integration was prominently stated as a G7 priority: *"Cross-border payments can have widespread benefits for citizens and economies worldwide. We remain committed to delivering cheaper, faster, more transparent, and more accessible cross-border payments."*

counterparty risk through its pre-funding mechanism and offers standardized processes, real-time notifications for errors or unfunded accounts, and a web dashboard displaying participants' balances in real-time. These features should reduce not only the costs of cross-border banking communication to nearly zero but also payment uncertainty, information frictions, and settlement risks.

The implementation of the SADC-RTGS system presents a series of empirical advantages for establishing the causal effect of international payment system integration on international trade. First, the system launched in 2013 and was adopted in a staggered fashion, with all member countries eventually joining by the end of 2016. This nature of the implementation allows us to address common concerns about the treatment timing and the selection of countries participating in the payment system. Second, there were no significant changes in regional trade agreements during the implementation time, which allows us to isolate the effect of payment integration from other changes in trade policy. Third, we provide evidence that the timing of entry into the RTGS is not predicted by origin, destination, or country-pair characteristics, including the past volume of trade between the countries. Instead, we show that our main findings are driven by the pre-existence of domestic payment systems, further suggesting that our effects isolate the payment system channel.

In addition to these empirical advantages derived from the nature of the SADC-RTGS system, African economies offer a particularly valuable context for studying these financial friction mechanisms. Firms in these markets are often subject to more severe financial constraints than those in developed economies (Islam and Meza, 2023), making the potential gains from improved payment systems especially significant. While this advantage typically comes with a significant downside—the lack of granular and reliable data from emerging market economies—our study overcomes this limitation through access to confidential regulatory data from South Africa, the continent's most advanced economy. This unique dataset allows us to estimate the impact of payment system integration with exceptional precision. Using administrative information from South African exporters covering all export transactions from 2010 to 2019, we estimate the causal effect of payment integration on firms' exports. Leveraging the staggered implementation of the payment system, our empirical strategy employs a stacked difference-in-differences approach to overcome challenges with traditional two-way fixed effects estimators in settings with heterogeneous treatment timing.

The detailed firm-level data enable us to isolate the causal effects of payment system integration across countries on international trade, providing numerous empirical contributions. First, we document substantial effects: firms increase their export volume by 35% and their number of export transactions by 45% to participant countries once they join the payment system. These magnitudes are consistent with other studies documenting large impacts from payment infrastructure improvements and financial integration.[4] Our results show that these effects are driven by pre-existing domestic payment infrastructure. We show that exports increase only in destinations that had domestic RTGSs, where firms can enjoy real-time settlements. These results provide evidence that the effects we find are directly linked to the increase in cross-border payment speed. Moreover, we document a sharp and immediate increase in trade following the payment system adoption, leveraging a high-frequency specification based on monthly firm-level exports.[5] The sharpness of the effect helps mitigate additional endogeneity concerns related to long-term trends in regional economic integration—typically associated with more gradual and smooth adjustments.

Second, the results also show that firms that export to participant countries do not reduce their export volume or number of transactions to other trade partners that do not participate in the system. The absence of negative spillover effects on non-members suggests that facilitating cross-border payments leads to trade creation between members and not to trade diversion. Moreover, our results also show that only firms with higher levels of external financial dependence increase their export volume in the years following the system launch. This result suggests that payment system integration serves as an effective channel to alleviate financial frictions, particularly for firms that rely more heavily on external financing.

Third, we identify the alternative mechanisms that might drive the increase in bilateral trade following payment system integration. The first mechanism we test examines heterogeneous effects across destinations with varying financial connectivity to South Africa through existing multinational banking networks. We find that these bank-connected destinations experienced a smaller increase in export volume or number of transactions after they joined the payment system, suggesting that the RTGS system provided the most significant improvements where previous financial connectivity was limited. Moreover, our results also indicate that the mechanism through which RTGS boosts exports is

[4]For comparison, Michalski and Ors (2012) find that domestic banking integration in the United States increased *domestic* (i.e., interstate) trade by 17–25%, while Matray et al. (2025) show that the shutdown of the U.S. Export–Import Bank reduced exports with a financing multiplier of 4–5. Borchert et al. (2024) find that banking shocks can reduce the likelihood of exporting by up to 35.2%, and Barrot and Nanda (2020) and Higgins (2024) highlight large real effects from payment speed improvements and cashless payments adoption.

[5]Our findings suggest that firms continue to use their banks to settle payments as before and that participation in the payment system occurs at the bank level. This institutional structure helps explain this sharp response.

by reducing transaction costs (e.g., counterparty risk), rather than exchange rate risk, since exchange rate volatility has very modest explanatory power in the effect of system integration on exports.

Fourth, using bank-level data, we show that banks with headquarters or other foreign subsidiaries in a country participating in the RTGS are much more likely to adopt the system. These banks are more likely to adopt the system and experience a significant increase in their interbank assets once the country in which they are located joins the RTGS. This result suggests that participant banks increase their correspondent banking activity in order to settle cross-border payment system transactions for other banks. Overall, these results provide further evidence that the RTGS, in fact, drives the effects we observe on exports.

Finally, using country-level trade flows and a gravity equation, we provide evidence of the aggregate consequences of countries participating in the RTGS. Trade between participant countries increases by around 35–49% on average. These results are robust to controlling for bilateral variables commonly used in gravity equation estimations, as well as fixed effects that account for the multilateral resistance components.[6] A back-of-the-envelope calculation reveals that the positive impact of payment integration on international trade is comparable to a reduction in tariffs by 6–8 percentage points.

Our paper is related to the broad literature on financial frictions, particularly studies that assess the impact of financial frictions on trade (Manova, 2013; Schmidt-Eisenlohr, 2013; Almeida et al., 2024). Existing studies have shown that financial development shapes international trade in several ways. For example, increased domestic financial development boosts trade flows (Beck, 2002; Contessi and De Nicola, 2012; Paravisini et al., 2023), and disruptions to credit and financial markets hinder both exports and imports (Amiti and Weinstein, 2011; Schnabl, 2012; Manova et al., 2015; Paravisini et al., 2015; Chaney, 2016; Niepmann and Schmidt-Eisenlohr, 2017a). Our distinctive contribution is identifying cross-border payment system integration as a novel channel through which financial development affects international trade.

Our paper also relates to the literature on the consequences of payment systems adoption and innovation on the economy. Beck et al. (2018) shows that mobile money adoption facilitates business

[6]Multilateral resistance terms arise from the canonical Anderson and Van Wincoop (2003) gravity model of trade, in which bilateral trade flows depend not only on trade costs between two countries, but also on each country's trade costs with all other potential partners in general equilibrium. Empirical studies show that origin-by-time and destination-by-time fixed effects appropriately account for these multilateral resistance terms (e.g., Head and Mayer, 2014; Yotov et al., 2016).

formation in developing economies. Barrot and Nanda (2020) finds that faster government payments improve employment outcomes for small businesses. Higgins (2024) examines the supply and demand responses and network externalities of cashless payments adoption in Mexico. These papers focus primarily on *domestic* innovations and new technology adoptions, whereas we focus on *cross-border* payment system adoption. Our work also relates to D'Andrea and Limodio (2024), who show that the expansion of high-speed internet makes commercial banks more likely to adopt real-time settlement systems, increasing credit supply and reducing banks' liquidity needs. We contribute to this literature by isolating the effects of cross-border payments on international trade—beyond any changes in local credit conditions—and by shedding light on the mechanisms through which faster and more reliable payment systems facilitate cross-border commerce.

We also contribute to the growing literature on banking integration and international trade. Using country and industry-level data, Caballero et al. (2018) shows that banking linkages are important determinants of international trade, especially for industries more exposed to export risk, while Claessens and Van Horen (2021) finds that foreign banks facilitate trade by reducing financial frictions for firms. More recently, Borchert et al. (2024) shows that disruptions to correspondent banking relationships have severe consequences for international trade. Our contribution to this strand of the literature is to use granular data to pin down the effects of cross-border payments from other channels through which multinational banks can affect trade beyond local expertise or market-specific risk assessment.

Our paper is most closely related to Michalski and Ors (2012), who find that lifting interstate bank branching restrictions in the United States led to higher trade between U.S. states. Their work focuses on *domestic* integration and its consequences to *domestic* trade. We contribute to this research by studying the causal effect of *cross-border* payment system integration on *cross-border* trade, showing that integration works despite significantly greater challenges in the international context. While domestic trade benefits from shared institutions—such as the same enforcement systems, language, cultural norms, regulatory standards, and tariff absence—international trade must overcome substantial heterogeneity in all these dimensions. As Schmidt-Eisenlohr (2013) demonstrates, international trade faces unique challenges from differing contracting environments, enforcement probabilities, and moral hazard faced by trading partners across countries. Our findings reveal that payment system integration can help overcome these significant cross-border frictions, substantially boosting international trade.

We contribute to the existing literature in several important ways. First, our paper provides novel causal evidence on how financial integration through faster and reliable payment systems affects international trade, with effects comparable to an 6–8% tariff reduction. Second, we identify specific mechanisms driving these effects, showing that benefits are concentrated in countries with pre-existing domestic payment infrastructure and firms with higher external financial dependence. Finally, our results offer practical guidance for central bankers and policymakers seeking to promote cross-border trade in today's environment of rising tariffs and trade policy uncertainty.[7]

2 Institutional Background

2.1 The SADC and its Real-Time Gross Settlement System

The Southern African Development Community (SADC) was established in 1992 and includes 16 member countries across southern Africa.[8] The community created a framework for financial cooperation through the Finance and Investment Protocol, approved in 2006 and ratified by the Heads of State of all original member countries. This treaty specifically encourages cooperation among central banks for payment, clearing, and settlement systems. Seychelles joined in 2008, and the Union of the Comoros joined in 2018. Our analyses only consider the SADC members as of 2013, when the payment system implementation began, excluding Comoros and Madagascar (suspended between 2009 and 2014 due to political instability).

A major advancement in the region's financial integration was the development of the Real-Time Gross Settlement (RTGS) system. In October 2010, the Committee of Central Bank Governors approved a proof of concept in the Common Monetary Area, comprising Lesotho, Namibia, South Africa, and Eswatini (formerly Swaziland). The system officially launched in July 2013. After this pilot phase, implementation expanded to other countries in stages, as detailed in Table 1. This electronic settlement

[7]See, e.g., how the shift toward higher tariffs and trade uncertainty in the last decade has created challenges for global trade as firms reconfigure their supply chain relationships (Monarch and Schmidt-Eisenlohr, 2023; Benguria et al., 2025) to offset higher input costs (Correa et al., 2024; Alfaro et al., 2024). For more recent evidence on rising trade uncertainty, see Brookings Institution, *"Tracking trade amid uncertain and changing tariff policies,"* April 2025.

[8]Angola, Botswana, Comoros, Democratic Republic of Congo, Eswatini (formerly Swaziland), Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Tanzania, Zambia, and Zimbabwe.

system enables either immediate or scheduled settlement of payments between participating banks. The system operates in South African rand (ZAR) during business hours (8 AM to 5 PM South African time) and is managed by the South African Reserve Bank on behalf of all participating central banks.

[INSERT TABLE 1 ABOUT HERE]

The payment system functions as a central electronic platform that processes rand-denominated payments to facilitate cross-border trade within the region. Participating banks can transfer funds and settle transactions across SADC countries immediately and on a gross basis, meaning each payment is settled individually. This design reduces banking costs by eliminating the need for intermediary correspondent banks. Participant banks can directly exchange payments with each other, allowing them to centralize their funds in a single account rather than maintaining separate accounts at different banks. The system also speeds up access to funds for businesses and other bank clients by reducing processing time.

Commercial and central banks participating in the system must pre-fund their accounts, which reduces settlement risks for transfers within the SADC. This pre-funding mechanism provides greater security for the 82 banks connected to the system. The platform has evolved from handling only high-value urgent payments to including scheduled payments, with plans to add batch processing for low-value payments in the future. The system follows principles focused on facilitating regional transactions, using existing infrastructure, adhering to international standards, and enabling straight-through processing.

The regional settlement system offers multiple capabilities, including electronic funds transfers, card and ATM transaction clearing, and settlement for cross-border securities transactions. Participants benefit from the system's ability to process payments that are immediate, final, and irrevocable. The system also offers reduced costs through standardized processes, real-time notifications for errors or unfunded accounts, and a web dashboard showing participants' balances in real-time.

For businesses and individuals in the SADC, the payment system has several advantages. It provides faster payment services, simplifies cross-border transactions, reduces the need for cash, and improves security. It also creates more transparent pricing and standardized payment methods. Users gain the flexibility to compare services and choose between immediate cash-out options or waiting for favorable exchange rates. Overall, the system represents a significant achievement in regional cooperation, promoting economic integration and delivering concrete benefits to participating countries and their financial institutions.

2.2 The SADC and International Trade Promotion

When examining how the RTGS system affected international trade, we must consider whether other simultaneous initiatives within SADC might have influenced trade patterns. The community has implemented various protocols to enhance regional cooperation. In 2008, the SADC established a Free Trade Area to promote regional trade, which was fully implemented by 2012 and includes 13 member countries (all except Angola, Comoros, and the Democratic Republic of Congo). Also in 2008, the Community agreed to join the Common Market for Eastern and Southern Africa and the East African Community to form the Tripartite Free Trade Area, also called the African Free Trade Zone. In 2015, member countries signed an agreement to establish this larger free trade area, though it has not yet been fully implemented.

While these trade liberalization initiatives represent important advancements to the region's economic integration, they were already in place before the payment system roll-out began. As such, these advancements in trade agreements do not present an identification threat to our current analysis. Our empirical strategy leverages the staggered timing of RTGS adoption across countries between 2013 and 2016, while controlling for time-invariant bilateral trade relationships through firm-destination-cohort fixed effects. This approach ensures that any estimated effects capture the impact of payment system integration rather than pre-existing trade agreements or other regional integration initiatives.[9]

3 Data and Sample Construction

3.1 Data Sources

Firm-Level Data. One of the major challenges in estimating the effects of financial integration on international trade is the limited availability of detailed, firm-level data that covers exporters and their clients (i.e., the export destinations). We address this by using administrative tax data at the firm level obtained from the South African Revenue Services for the 2010–2019 period. The primary source is

[9] Moreover, as we show in Appendix Table A.3, observable country characteristics (e.g, trade flows and economic indicators) do not predict the timing of RTGS entry.

the South African Corporate Income Tax data, collected annually for the tax year ending in February. Firms must submit corporate income tax returns with self-reported information about their income, expenditures, equity, liabilities, capital items, and tax credits. Almost all reporting items are compulsory, and compliance is high since the revenue service may audit firms in any given year. We use this data for our firm-level analysis of total exports, examining variables such as total sales, value added, receivables, payables, and labor costs in our tests of how RTGS exposure affects firm performance.

We complement this information with firm employment data from employee income tax certificates (IRP5 forms). These employment records are aggregated for each Pay-As-You-Earn reference number and linked to the corresponding firm's tax reference number. Companies identified by a unique tax reference number may have multiple employment reference numbers, so we match all employees with matching reference numbers to their corresponding firms (Pieterse et al., 2018).

A crucial feature of the South African Revenue Service and National Treasury Firm-Level Panel in our paper is the detailed firm-level customs records. The data covers 2010 to 2019 and contains transaction-level information providing detailed records of export value, destination, product, and transaction date. We use this customs data for our primary firm-destination-level analysis, creating measures of export volume (in South African rand, ZAR) and number of export transactions as our main dependent variables. This allows us to build a firm panel dataset with the total value of exports and the number of transactions performed with each destination country in any given year by product. We also use this data to construct our extensive margin measures, including the number of destination countries and the number of destination-by-product combinations at both the HS 4-digit and 6-digit levels.

Aggregate Data. Our second data source comes from the gravity database compiled by the *Centre d'Estudes Prospectives et d'Informations Internationales* (Conte et al., 2022). This dataset contains international trade information from more than 200 countries and 5,000 products between 1994 and 2022. It comes from reconciled data reported by almost 150 countries to the United Nations Statistics Division (United Nations, 2023). We use this bilateral trade flow data for our country-level gravity estimations to examine the aggregate effects of RTGS participation on trade between member countries. The dataset also contains information for origin–destination country pairs in each year, including geographic, cultural, trade facilitation, and macroeconomic variables. We use these bilateral controls in our gravity specifications, including geographical distance, shared borders, free trade agreements, customs unions, and measures of contiguity. Additionally, we use this data to construct our export demand controls for firm-level specifications, estimating destination-specific demand shocks by regressing bilateral trade flows on importer–year fixed effects while excluding South African trade flows.[10]

Bank-Level Data. Finally, we also use bank-level data from BankFocus in two empirical tests. We begin with the international network of South African banks, extracting information on all South African banks, their subsidiaries, and parent companies. We then identify 75 South African banks with more than 4,000 subsidiaries/parents in 128 countries. We complement this with information on the total assets of each bank before the payment system implementation in 2012. This information comes from regulatory forms that the South African Reserve Bank requires all commercial and mutual banks to complete monthly. We then use information from all international bank groups with at least one subsidiary in the African Continent to highlight the determinants of payment system adoption and the implications for interbank activity.

3.2 Empirical Strategy

A major challenge in studying the causal effect of increased financial integration on international trade is that both processes often happen simultaneously, making it difficult to isolate the causal effect. To address this challenge, our empirical strategy uses the staggered implementation of the payment system to understand the effects of increased financial integration on international trade. Recent research has highlighted that traditional two-way fixed effects models can produce misleading results when treatments occur at different times.[11]

Stacked Regression Estimation. Given the staggered implementation of the payment system, we stack implementation cohort-specific data to calculate an average effect across all participants to over-

[10] See Appendix B for details on how we estimate export demand. The intuition is as follows: if a country experiences a positive demand shock (e.g., economic growth, favorable policy changes), this should increase its imports from *all* trading partners, not just South Africa. Our approach captures this common demand component that affects all exporters to a same destination in a given year. Therefore, our estimated destination-specific demand shocks are orthogonal to bilateral factors (such as RTGS adoption) that affect only specific country pairs.

[11] See, e.g., Goodman-Bacon (2021); Callaway and Sant'Anna (2021); de Chaisemartin and d'Haultfœuille (2020). Goodman-Bacon (2021) shows that the treatment effects using this specification are a combination of the weighted average of the unit-time treatment effects. In the context of two-way fixed effects, these treatment effect coefficients can be potentially weighted by negative weights (de Chaisemartin and d'Haultfœuille, 2020).

come the problems highlighted above (Gormley and Matsa, 2011; Cengiz et al., 2019; Baker et al., 2022).[12] Although our empirical strategy does not require that the treated and control groups be similar, we use a matching procedure to find a control group similar to the treated units.[13] We construct cohorts by implementation year of RTGS in each country and stack the cohorts to estimate the average treatment effect. We use an estimation window of 3 years around each cohort year. This choice is made due to the availability of export data, which starts in 2010 (3 years before the 2013 cohort was treated), and to exclude the period after the COVID-19 pandemic started. Since all SADC participant countries eventually join the payment system, this choice is not endogenously determined in our setting. Moreover, we provide evidence in Table A.3 of the Appendix that pair-specific and country-specific characteristics do not predict the time of entry in the RTGS.

Firm-Level Matching. To enhance the credibility of our identification strategy, we use Coarsened Exact Matching (CEM) to construct a balanced control group (Iacus et al., 2011). The matching approach offers several advantages: it ensures that the matched samples satisfy the congruence principle (that is, treated and control groups have similar empirical distributions of confounding variables), it reduces model dependence, and it provides bounds on the degree of imbalance between groups.[14]

Our choice of matching variables is guided by trade and finance theory. First, we match on firm sector (2-digit ISIC classification) to capture systematic differences in technological intensity and financial vulnerability across industries. Manova (2013) shows that sectors requiring higher upfront investment or with fewer collateralizable assets are more exposed to financial frictions, making the sector a crucial balancing dimension. Second, we include firm size (proxied by total sales, coarsened into quartiles) since larger firms are typically less credit-constrained and more likely to overcome the fixed costs of entering export markets (Bernard et al., 2003). Third, we match on total factor productivity (TFP, coarsened into quartiles). In heterogeneous-firm models of trade, more productive firms are more likely to become exporters and earn higher revenues, conditional on exporting (Melitz,

[12]This specification uses stricter criteria for the choice of the control groups. By aligning events by the event time, we prevent the negative weighting of some events that may occur with a staggered design.

[13]Results for the non-matched sample are quantitatively similar to our baseline results and available in Table A.6.

[14]Unlike propensity score matching, CEM does not require iterative procedures or balance checking, and it automatically restricts the data to areas of common empirical support (Blackwell et al., 2009). This is particularly important in our setting, where firms self-select into exporting to different destinations.

2003; Manova, 2008). Balancing on productivity, therefore, ensures that treated and control groups do not differ systematically in their underlying export potential.

Our treated group consists of firms that exported to countries that eventually joined the RTGS system, while our control group includes matched firms that exported only to non-participating countries in 2012. This matching approach ensures that treated and control firms are similar across observable dimensions that could influence export performance, while preserving the natural randomness inherent in the staggered rollout of the payment system.

[INSERT TABLE 2 ABOUT HERE]

In Table 2, we show that our matching strategy successfully balances the treated and control groups across a comprehensive set of firm characteristics. The table reports summary statistics for our matched sample, showing that firms exporting to payment system participant countries are very similar to matched firms exporting solely to non-participant trade partners. Column (4) shows that all mean difference tests display statistically insignificant *p*-values (corrected using Clarke, Romano, and Wolf's (2020) adjustment for multiple hypothesis testing), confirming that our matching approach selects a control group that resembles treated firms across a variety of characteristics including financial variables (loans, receivables, payables), operational measures (capital stock, value added), and export intensity.

4 Firm-Level Evidence

4.1 Faster Cross-Border Payments and Firm Exports

Our empirical strategy uses a difference-in-differences analysis, leveraging the gradual implementation of the payment system across countries. To strengthen our approach, we implement a matching technique described above to obtain a more balanced sample. The control group is the sample of matched exporting firms of similar size, productivity levels, and sector that exported only to non-participating countries in 2012. This approach helps us estimate the treatment effects cleanly and enhances the reliability of our analysis. Specifically, we estimate the following baseline model:

$$T_{i,j,c,t} = \exp\left\{\alpha_{i,j,c} + \alpha_{c,t} + \beta_{RTGS} \cdot \left[RTGS_{j,c} \times Post_{c,t}\right] + \beta_d \cdot Export\ Demand_{j,t}\right\} \cdot \epsilon_{i,j,c,t} \quad (1)$$

in which i represents the firm, j the destination country, c cohort, and t year. $T_{i,j,c,t}$ is our firm-level outcomes for international trade: (*i*) the total volume exported (denominated in South African rand, ZAR), to country j in year t; or (*ii*) the total number of export transactions that firm i had with country j in year t. $\alpha_{i,j,c}$ are firm-destination-cohort fixed effects, $\alpha_{c,t}$ are cohort-year fixed effects. The firm-destination-cohort fixed effects control for any confounders specific to each firm and trade partner, which do not vary in our sample period, for example, any geographical or cultural connection between the firm and the destination country. Moreover, we control for the destination-country specific export demand ($Export\ Demand_{j,t}$), as detailed in Appendix B. $RTGS_{j,c}$ is the binary variable that equals one for the countries that participated in the RTGS in cohort c, and $Post_{c,t}$ is the binary variable that equals one for years after cohort c's entrance in the system. Our coefficient of interest is β_{RTGS}, representing the average effect of the trade partner j's inclusion in the payment system on firm i exports.

Finally, to account for heteroskedasticity in trade data and the presence of zeros in the dependent variables when analyzing export volume and the number of transactions, we use the Poisson Pseudo-Maximum Likelihood Estimator proposed by Santos Silva and Tenreyro (2006).

[INSERT TABLE 3 ABOUT HERE]

Table 3 shows the results estimating Equation (1). Columns (1) and (2) show the results when using the firm's export volume as the dependent variable, while Columns (3) and (4) use the number of transactions as the dependent variable. Our results show that firms exporting to countries participating in the SADC-RTGS increase their export volume (35–38.5%) and their number of export transactions (45–47%), on average.[15] These findings suggest that faster and more reliable cross-border payment systems substantially facilitate international trade by reducing transaction costs and uncertainty.

Our results are robust to controlling for firm-destination-cohort fixed effects, which suggests these effects are not driven by firms' characteristics that might affect exports to a specific destination. Notably, these results are not driven by destination country demand or other time-varying shocks that might affect export activity, such as an increase in credit supply caused by the payment system (see, e.g., D'Andrea and Limodio (2024)).

To assess the plausibility of our estimated effects, we benchmark them against other trade facilitation measures documented in the literature. Our finding of a 35% increase in export volume is

[15] The elasticities are calculated as $\exp(\beta) - 1$, from the estimates in Table 3.

substantial, but consistent with the magnitude of effects found for other frictions in cross-border commerce. The most directly comparable benchmark is Michalski and Ors (2012). The authors study domestic banking integration in the United States—one of the most developed economies—from the late 1970s through the mid-1990s. They show that banking integration across states increased domestic (interstate) trade by 17–25%. Several factors can explain why our effects are expected to be of a larger magnitude. First, we examine *international* rather than domestic trade, where frictions are substantially more restrictive (Schmidt-Eisenlohr, 2013). Second, our context focuses on emerging-market exporters, where financial constraints are more binding (Almeida et al., 2024) and improvements in payment infrastructure yield disproportionately larger gains. Third, the magnitude of our effects is also supported by recent studies documenting significant impacts from improvements in payment speed. Barrot and Nanda (2020) and Higgins (2024) highlight substantial real effects from faster payments and cashless adoption, while our cross-border payment integration represents an even more dramatic improvement—from multi-day correspondent banking to real-time settlement.

Recent studies document larger or similar impacts: Matray et al. (2025) show that the shutdown of the U.S. Export–Import Bank reduced exports with a financing multiplier of 4–5. Borchert et al. (2024) find that banking shocks strongly propagate into trade, with financially exposed exporters experiencing a large decline of up to 35.2% in the likelihood of exporting four years after the shock, further reinforcing the plausibility of our findings.

[INSERT FIGURE 1 ABOUT HERE]

One potential concern with our empirical approach is whether our control units are an appropriate comparison group to the firms that were exposed to the payment system. In Figure 1, we provide evidence suggesting that, before the implementation of the payment system, the treated and non-treated firms behaved similarly in terms of their export volume and transaction number. In other words, firms that did not export to countries participating in the SADC-RTGS behaved similarly to exporters that were exposed to the system in the years preceding its implementation. The figure also shows evidence of divergence in volume and transactions in the years following the implementation of SADC-RTGS, which provides reassuring evidence for our empirical strategy.

Our baseline results are robust to alternative control groups. Table A.6 in the Appendix shows that the results hold when using the non-matched sample. Additionally, Table A.7 demonstrates that our findings remain stable when restricting the control group to firms exporting only to other African countries that do not participate in the RTGS, addressing potential concerns about unobserved heterogeneity across global trade destinations.

4.2 Trade Diversion versus Trade Creation

Since we find that participating in the international payment system increases a firm's exports, one natural question is whether this increase in trade is due to trade flows being diverted from other countries outside the SADC to the participant countries. If firms are just switching the destination of their exports and not generating new trade flows, this could raise concerns about the global welfare implications of integrating payment systems. This problem, often referred to in the trade literature as *trade diversion*, has been extensively examined in the case of trade liberalization policies (Viner, 1950; Dai et al., 2014).

[INSERT TABLE 4 ABOUT HERE]

In Table 4, we test if the cross-border payment system is able to influence trade creation or if it just shifts trade away from one country towards the payment system participant countries. We test the hypothesis of trade diversion by including in Equation (1) one additional variable that captures the effect that the adoption of the RTGS may have caused on the exports to countries outside the payment system, which we refer to *RTGS Firms Spillover*. This consists of a binary variable that assumes a value of 1 when the destination country is not a member of the RTGS, but the firm is directly affected by the adoption of the RTGS by exporting to at least one participating country after the system adoption. In other words, this variable captures the marginal effect of a firm that is affected by the RTGS on its trade volume and transactions with countries outside the payment system.

Our results indicate that the volume of exports or the number of transactions from firms that export to SADC-RTGS participant countries to other trade partners that do not participate in the system do not change after the system launch.[16] These results suggest that facilitating cross-border payments contributes to trade creation and not to trade diversion at the firm level.

[16]This finding lessens concerns that the effects we observe are driven by improvements in, e.g., firms' productivity.

4.3 Validation: The Role of Domestic Payment Infrastructure

To validate our identification strategy and pin down the effects of faster payments from other possible confounders that may coincide with the SADC-RTGS implementation, we exploit the fact that only some destinations enjoyed real-time settlement stemming from the cross-border payment system integration. If our identification strategy is valid, then the pre-existence of domestic RTGS infrastructure should be a relevant factor in making payments faster, as it represents the necessary pre-existing infrastructure at the destination to enable true real-time settlement. To test for this, we exploit the fact that some destinations had the required domestic infrastructure to settle payments instantly, while others did not. Therefore, we include in Equation (1) a triple interaction term between the pre-existence of a domestic RTGS indicator variable and the indicator variables for treatment and post-adoption of the SADC-RTGS.

[INSERT TABLE 5 ABOUT HERE]

Table 5 displays the results, showing that exports only increase for destinations with pre-existing domestic real-time payment settlement. As expected, places with no domestic RTGS do not experience significant increases in exports in our preferred specification. These null results suggest that transaction speeds to those destinations do not change much, especially given that it may take time and substantial investment to develop the domestic infrastructure required for taking advantage of instantaneous cross-border payment settlements. Our results also align with the hypothesis that firms may experience payment settlement delays at the destination due to the absence of a domestic real-time settlement system.

4.4 Inspecting the Mechanisms

4.4.1 Heterogeneous Effects: The Role of Firms' External Financial Dependence

Having established that the RTGS system increases firm-destination exports, we now shift our focus to understanding how the payment system affects firms' *total* export performance across all destinations. A natural candidate mechanism is the alleviation of financial constraints. International trade is inherently capital-intensive: firms must finance production, inventory, and shipping before receiving payment from foreign buyers (Manova, 2013; Schmidt-Eisenlohr, 2013). When payment settlement is slow and uncertain, this extended cash conversion cycle ties up working capital and creates financing needs that are particularly binding for financially constrained firms. By reducing payment settlement times from several days to real-time and providing greater certainty about payment receipt, the RTGS system should disproportionately benefit firms that face tighter financial constraints—those with limited access to external finance or high dependence on trade credit.

This firm-level analysis allows us to directly test this mechanism by examining whether export responses to RTGS integration are concentrated among firms with higher external financial dependence, providing direct evidence on the mechanisms through which payment integration facilitates trade.

To conduct this analysis, we construct a measure of each firm's exposure to the RTGS based on its pre-existing trade patterns. This exposure measure captures the intensity with which each firm is affected by the staggered rollout of the payment system:

$$RTGS\ Exp_{i,t} = \sum_{j=1}^{n} \left[\frac{Exports_{i,j,2012}}{Total\ Exports_{i,2012}} \right] \cdot \left[RTGS_{j,c} \times Post_{c,t} \right] \tag{2}$$

where i denotes the firm, j the destination country, c the cohort, and t the year. The first term in brackets, $\frac{Exports_{i,j,2012}}{Total\ Exports_{i,2012}}$, represents the share of firm i's total exports that went to destination j in 2012, before any country joined the payment system. The second term captures the treatment status: $RTGS_{j,c}$ is an indicator variable that equals one if country j eventually joins the RTGS as part of cohort c (and zero otherwise), while $Post_{c,t}$ is an indicator variable that equals one for all years after cohort c joins the system (and zero otherwise). By construction, $RTGS\ Exp_{i,t}$ measures the share of a firm's 2012 exports going to countries that have adopted the payment system by year t. This measure varies across firms based on their pre-treatment export destinations and over time as more countries join the system. Specifically, we estimate:

$$\begin{aligned} y_{i,t} = \exp \Bigg\{ & \beta_{RTGS} \cdot RTGS\ Exp_{i,t} + \beta_{Het} \cdot \left[RTGS\ Exp_{i,t} \times High\ EFD_{s,2012} \right] + \\ & \alpha_i + \alpha_{s,t} + \sum_{\tau=2010}^{2019} \alpha_{TFP,\tau} \cdot \left[High\ TFP_{i,2012} \times \mathbb{I}\{t = \tau\} \right] + \beta_d \cdot Export\ Demand_{i,t} \Bigg\} \cdot \epsilon_{i,t} \end{aligned} \tag{3}$$

where $y_{i,t}$ represents firm i's total export volume in year t (aggregated across all destinations). Our coefficient of interest, β_{RTGS}, captures the average effect of RTGS exposure on total exports. The interaction term with coefficient β_{Het} tests whether effects differ by financial dependence: $\textit{High EFD}_{s,2012}$ is an indicator variable equal to one if firm i operates in a sector with above-median external financial dependence (EFD), measured as the ratio of trade credit payables to total sales in 2012. A positive β_{Het} would indicate that financially constrained firms benefit more from the payment system.

The specification includes firm fixed effects (α_i) to control for time-invariant firm characteristics, and sector-by-year fixed effects ($\alpha_{s,t}$) to absorb any sector-specific shocks over time. To flexibly control for productivity differences across firms, we include year-specific effects for high-productivity firms: $\textit{High TFP}_{i,2012}$ is an indicator for firms with above-median total factor productivity in 2012,[17] interacted with year dummies ($\mathbb{I}\{t = \tau\}$), allowing high-TFP firms to follow different time trends. Finally, $\textit{Export Demand}_{i,t}$ controls for time-varying demand conditions in each firm's destination markets, constructed by weighting destination-specific demand shocks (described in Appendix B) by the firm's 2012 export shares, analogous to the exposure measure in Equation (2).

Table 6 presents the estimation results. Column (1) shows a positive but statistically insignificant average effect of RTGS exposure on total exports when we do not account for firm heterogeneity. However, Column (2) reveals substantial heterogeneity by financial dependence: while the baseline effect for low-EFD firms is small and insignificant, firms in high-EFD sectors experience large and statistically significant increases in total exports following payment system integration. Columns (3)–(5) provide further evidence that these effects are driven by external financial dependence rather than other firm characteristics such as size, age, or total factor productivity. These findings align with Barrot and Nanda (2020), who document that faster payments alleviate financial constraints for U.S. firms, and contribute to the broader literature demonstrating the crucial role of financial frictions in international trade (Feenstra et al., 2014; Muûls, 2015; Niepmann and Schmidt-Eisenlohr, 2017b).

[INSERT TABLE 6 ABOUT HERE]

In addition, Table 7 provides complementary evidence by examining a broader set of firm-level outcomes. We find that firms in sectors with high external financial dependence not only increase their exports, but also experience a significant rise in receivables and payables, and a moderate increase in total sales in response to the RTGS. These findings are consistent with improved trade credit provision and enhanced trade activity following RTGS integration. Notably, the effects are concen-

[17] We estimate firm TFP by assuming a Cobb–Douglas aggregate production function.

trated among firms with higher financial dependence, further reinforcing the interpretation that faster cross-border payments help relax financial constraints.

[INSERT TABLE 7 ABOUT HERE]

Overall, the results in this section provide strong evidence that the cross-border payment system primarily benefits firms that are more financially constrained. By facilitating faster and more reliable payments, the RTGS integration appears to ease working capital pressures, enabling firms with higher external financial dependence to expand their trade activities. This mechanism helps explain the heterogeneous effects observed across firms and underscores the role of payment infrastructure as a key lever for alleviating financial frictions in international commerce.[18]

4.4.2 The Bank Adoption Channel

In this section, we provide direct evidence on how banks responded to the RTGS. Banks can use the cross-border payment system in two ways: by directly joining the system or using a domestic participant bank as a correspondent to settle transactions with another participating country. Leveraging bank-level information, we can provide corroborating evidence of RTGS usage by revealing the patterns of the system's adoption and utilization. First, we analyze the determinants of adoption by banks. Second, we investigate whether banks that are more likely to adopt the system increase their interbank market assets after the country in which they are located joins the payment system.

We use information from all banking groups in the BankFocus database with at least one subsidiary in Africa. We first analyze which banks are more likely to join the payment system by 2019.[19] We hypothesize that banks with subsidiaries in countries that also adopted the system will be more likely to join. To test this, we use the following model for all banks located in participating countries:

$$RTGS\ Participant_{b,2019} = \delta_{exp} \cdot RTGS\ Exposure_b + \beta \cdot X_b + \gamma_r + \varepsilon_b \tag{4}$$

[18] In Appendix Table A.5, we further test alternative mechanisms. We find that banking integration (measured by South African banks' presence in destination countries) explains part of the baseline effects, though to a lesser extent than domestic RTGS infrastructure. Exchange rate volatility, however, has very modest explanatory power, suggesting that the RTGS primarily reduces transaction costs and counterparty risk rather than exchange rate risk.

[19] See https://www.resbank.co.za/content/dam/sarb/what-we-do/payments-and-settlements/settlement-services/SADC-RTGS%20Newsletter_Issue%201.pdf.

where b denotes the bank, and r is the country where the bank is located. $\textit{RTGS Exposure}_b$ is a binary variable indicating whether the bank has another subsidiary or headquarters in a country that adopts the payment system. We include bank-level control variables $\mathbf{X}_b$ such as whether the bank belongs to a multinational conglomerate, its total assets, and operating revenue ratio to total assets. Our coefficient of interest, δ_{exp}, represents the likelihood of adopting the payment system when other parts of the same banking group are located in participating countries.

In a second part of our empirical test, we exploit the fact that these banks are more likely to adopt the payment system to estimate its effects on banks' interbank markets. We use the following stacked difference-in-differences specification:

$$y_{b,c,t} = \delta_{RTGS} \cdot \left[\textit{RTGS Exposure}_{b,c} \times \textit{Post RTGS}_{r,t}\right] + \gamma_{b,c} + \gamma_{h,c,t} + \gamma_{r,c,t} + \varepsilon_{b,c,t} \tag{5}$$

where b denotes the bank, r is the country where the bank is located, h is the banking conglomerate, and c is the treatment cohort. The variable $\textit{RTGS Exposure}_{b,c}$ corresponds to the *HQ/Foreign Subsidiary RTGS Exposure* measure described in Table 8, indicating if the bank's conglomerate has a presence in an RTGS-participating country. $\textit{Post RTGS}_{r,t}$ is an indicator variable that equals 1 when the country r, where bank b is located, joins the system. We include bank-cohort ($\gamma_{b,c}$), bank country-year-cohort fixed effects ($\gamma_{r,c,t}$), and conglomerate-year-cohort fixed effects ($\gamma_{h,c,t}$). Our granular set of fixed effects accounts for a large set of unobserved heterogeneity at the bank level as well as for time-varying unobserved heterogeneity at the country and conglomerate levels. Our coefficient of interest, δ_{RTGS}, represents changes in interbank market activity for banks more likely to adopt the payment system compared to other banks in the same country that are less likely to adopt it.

In Table 8, we focus on the fourteen countries adopting the RTGS, ending up with 119 banks. The table shows that the primary determinant of the system adoption is whether their conglomerate has the HQ or another subsidiary in a participant country. Moreover, we show that being a multinational conglomerate without a connection to another participant country does not affect the probability of adoption. Although the size of the bank significantly affects the adoption, having a foreign subsidiary in a participant country is much more relevant, representing an effect similar to an increase of 10 standard deviations in assets. Finally, we show that these effects are not driven by countries' unobservable characteristics, such as different levels of domestic financial development. Overall, our findings highlight the importance of pre-existing cross-border banking network connections in explaining the system adoption.

[INSERT TABLE 8 ABOUT HERE]

We exploit the fact that having a foreign subsidiary located in a participant country makes banks more likely to participate in the cross-border payment system to provide evidence of usage by focusing on the interbank markets. We focus on the interbank markets for two reasons. First, the information on interbank flows is available before and after the implementation of the system. Second, interbank flows are directly linked to non-participant banks using participant banks as correspondents, making it a prominent mechanism to observe banks' system usage. In Table 9, we employ a staggered difference-in-differences strategy focusing on the heterogeneous effects on banks that are likely to be RTGS participants. We show that banks that are less likely to participate do not experience any change in their interbank market behavior. In contrast, we show that banks that are more likely to participate experience a significant increase in their interbank market assets after the country in which they are located joins the system. Importantly, these effects are not driven by conglomerate and country unobserved heterogeneity. These results provide evidence that the RTGS-participating banks are acting as correspondent banks for non-participant counterparts.

[INSERT TABLE 9 ABOUT HERE]

Figure 2 displays the dynamic effects of the cross-border payments system on banks more likely to participate in the system. This figure provides reassuring evidence that the effects we observe are driven by the system's adoption and not by different growth rates in the interbank markets that are not linked to the country's participation in the system. Overall, the results in this section provide compelling evidence that banks with international presence in participating countries are more likely to adopt the system and significantly expand their correspondent banking activities after implementation.[20]

[INSERT FIGURE 2 ABOUT HERE]

[20] These results are robust to alternative transformations and specifications. Appendix Table A.9 shows that our findings hold when using $\log(1+y)$ transformations and PPML estimators, confirming that the observed effects are not sensitive to the specific functional form or estimation method.

5 Aggregate Evidence and Tariff Equivalents

In addition to investigating firm-level consequences, we also assess the payment system's impacts on bilateral international trade flows using a standard gravity model. Gravity models are widely used in the international trade literature due to their strong theoretical foundations and empirical properties (Head and Mayer, 2014). To incorporate payment system participation into the standard gravity equation, we assume it affects international trade flows through bilateral trade costs. Therefore, we estimate:

$$X_{r,j,t} = \exp\left\{\alpha + \beta_{RTGS} \cdot RTGS_{r,j,t} + \beta \cdot D_{r,j,t} + \gamma_{r,t} + \gamma_{j,t} + \varepsilon_{r,j,t}\right\} \tag{6}$$

$X_{r,j,t}$ represents the aggregated exports from country r to destination country j in year t. $RTGS_{r,j,t}$ is a binary variable that equals 1 when both countries r and j participate in the payment system in year t. We include exporter-by-year fixed effects and importer-by-year fixed effects. These are commonly used in gravity models to account for the "multilateral resistance" terms (Anderson and Van Wincoop, 2003). $D_{r,j,t}$ represents a set of bilateral control variables, including geographical distance and shared borders, commonly used in gravity estimations. We also include variables capturing dimensions of economic integration between countries, such as whether the countries have a free trade agreement or belong to the same customs union. We estimate.

We complement the findings of Equation (6) by estimating a similar specification when using alternative levels of aggregation of bilateral trade data. Specifically, we estimate:

$$X_{r,j,k,t} = \exp\left\{\alpha + \beta_{RTGS} \cdot RTGS_{r,j,t} + \beta \cdot D_{r,j,t} + \gamma_{r,k,t} + \gamma_{j,k,t} + \varepsilon_{r,j,k,t}\right\} \tag{7}$$

$X_{r,j,k,t}$ represents the aggregated exports from country r to destination country j in a product or industry k, in year t. The variables $RTGS_{r,j,t}$ and $D_{r,j,t}$ are defined as in Equation (6). However, the more disaggregated data allows us to employ a more demanding set of fixed effects, $\gamma_{r,k,t}$, and $\gamma_{j,k,t}$, which further interact the country-by-time fixed effects with the product or industry k.

Table 10 presents the estimates of Equations (6) and (7) using the Poisson Pseudo-Maximum Likelihood estimator of Santos Silva and Tenreyro (2006). Column (1) uses the data at the *Origin Coun-*

try × *Destination Country* dimension. Column (2) uses the data at the *Origin Country* × *Destination Country* × *Product* dimension, with products classified according to the 2-digit Harmonized System (HS). Columns (3) and (4) use the data at the *Origin Country* × *Destination Country* × *Industry* dimension. Industries are defined according to the ISIC classification. To conduct the analysis at the industry level, we perform a mapping of the trade data from the 2-digit Harmonized System to ISIC classification. To perform the cross-walk from products to industries, we use the concordance tables presented in Liao et al.'s (2020). Because some products can be matched to multiple industries, the results can be sensitive to the cross-walk process of mapping a product into multiple industries. To test the robustness of the results to the cross-walk, we conduct two alternative approaches. In column (3), we use the first industry matched to a product, and column (4) uses the last industry matched. Consistent with the firm-level results, Table 10 shows that the trade flows between participants of the payment system increase once countries join the system. Our results suggest an increase in such exports between 35% and 49%, on average.

The country-level and firm-level estimates deliver remarkably similar results, with aggregate effects (35—49%) slightly exceeding our firm-level estimates (35—38.5%), revealing complementary insights from these two approaches. While our firm-level analysis provides tightly identified causal effects by isolating intensive-margin adjustments of continuing exporters, it does not capture general equilibrium adjustments in response to payment system integrations. The larger aggregate estimates likely capture additional channels, including extensive margin adjustments through new firm entry and potential cross-firm spillovers.

To better illustrate the economic implications of these results, we can compute the *tariff equivalent* effect implied by these estimates, i.e., the equivalent *ad-valorem* tariff rate that, if removed, would have had the same effect on trade as the participation in the RTGS. Despite not including tariffs in our specification, we can compute the *tariff equivalent* effect of the RTGS by relying on (i) the structural gravity model properties and (ii) trade elasticity estimations from the literature (Yotov et al., 2016).[21] In the last three rows of Table 10, we compute the RTGS tariff equivalent effects using different estimates of the trade elasticity from the literature. Using the aggregate elasticity estimate from Caliendo and Parro (2015), we find that participating in the RTGS has an equivalent effect on trade as eliminating a

[21] The tariff equivalent effect can be calculated by $\left[e^{\hat{\beta}_{RTGS}/(\hat{\sigma})} - 1\right] \times 100$, where $\hat{\sigma}$ is the trade elasticity from the literature.

tariff rate of 6.8%–9.2%. Alternatively, using the trade elasticity estimate from Simonovska and Waugh (2014), the tariff equivalent effect is 7.8%–10.5%, while when using the elasticity estimate from Baier and Bergstrand (2007), we obtain rates between 6.2% and 8.3%. These magnitudes are comparable to previous studies that estimate the impact of time delays in export procedures. For example, Hummels and Schaur (2013) shows that each day in transit is equivalent to an ad-valorem tariff of 0.6–2.1%, implying that reducing payment settlement time from 7 days to real-time could generate tariff-equivalent effects of 4–14%—close to our calculated tariff equivalent of 6.2–10.5 percentage points.

[INSERT TABLE 10 ABOUT HERE]

In sum, the estimates presented in Table 10 confirm the substantial effect of participating in the RTGS on trade flows. The estimates from the gravity equations are similar but slightly larger than the coefficients obtained from the firm level analysis in Table 3. To further gauge the dynamic aggregate effects of the RTGS, we also run an aggregate event-study specification. Figure 3 shows that exports from participating countries had a similar trend in the years preceding the payment system implementation, but they started to diverge after the countries joined the system. Remarkably, we find the dynamic effects to be very similar to those at the firm level in Figure 1. These results provide evidence in support of our empirical strategy and suggest that the effects persist over time.

Overall, the aggregate analysis validates and extends our firm-level findings, demonstrating that payment system integration generates substantial trade gains comparable to a 6.2–10.5% tariff reduction. The convergence between our firm-level and country-level estimates provides robust evidence that cross-border payment integration generates significant impacts on international trade. This consistency across methodological approaches underscores that modernizing and integrating payment systems across countries can deliver trade benefits on par with major trade liberalization agreements, offering policymakers an alternative lever for promoting international trade.

[INSERT FIGURE 3 ABOUT HERE]

6 Identification Tests

In this section, we present a series of results that test the validity of our identification strategy by demonstrating sharp dynamic effects, consistency of the underlying mechanism, and quasi-random treatment assignment.

6.1 Empirical Identification

The following tests provide evidence supporting our identification strategy by exploiting the timing and nature of the RTGS implementation, examining heterogeneous responses consistent with our proposed mechanisms, and assessing the quasi-experimental nature of treatment timing.

6.1.1 High-Frequency Analysis: Sharpness of the Effects

In this section, we employ a high-frequency empirical strategy to assess the immediate effects of the RTGS implementation on firms' exports to participating countries. By focusing on narrow time windows around the system implementation date, this approach enables us to detect sudden changes in export behavior that are closely tied to the RTGS going live, thereby strengthening our identification. In particular, the sharpness and timing of the export response provide compelling evidence that our results are driven by the implementation of the payment system itself, rather than by confounding factors or broader, slower-moving processes such as regional trade integration or macroeconomic trends, which would be expected to generate more gradual and diffuse effects.

In Table A.1, we exploit a temporal regression discontinuity design (RD) centered on the implementation date of the RTGS system in each trade partner country. This design uses time as the forcing variable and adopts a within-firm perspective, comparing export outcomes in a short window before and after the policy change (e.g., Davis, 2008). By holding firm characteristics constant over this narrow time horizon, we reduce the influence of time-varying confounders and isolate the causal impact of the RTGS introduction. The RD approach leverages the quasi-experimental nature of the implementation timing and the high-frequency data structure to deliver a clean identification of the treatment effect.

[Insert Table A.1 About Here]

Using optimal bandwidths, we find that the introduction of the RTGS led to a sharp and statistically significant increase in export volumes—by 21.8%—as well as a 15.4% rise in the number of export transactions in the months immediately following implementation. These discontinuous jumps in the outcome variables around the threshold reinforce the view that the effects we document are directly attributable to the RTGS adoption, underscoring the causal interpretation of our results.

6.1.2 Trade Margin Differentiation: Intensive vs. Extensive Margins

Our main findings demonstrate a sharp increase in intensive trade margins—export volume and transaction counts—shortly after RTGS adoption. In contrast, we observe no statistically or economically significant change in extensive trade margins over the same short-run window. This pattern is presented in Table A.2, which reports results for three outcomes: the number of export destinations (Columns 1–2), the number of destination-by-product combinations at the HS 4-digit level (Columns 3–4), and destination-by-product combinations at the HS 6-digit level (Columns 5–6). Across all specifications—and even when interacting RTGS exposure with high external financial dependence—the estimated coefficients remain small in magnitude and statistically insignificant.

The absence of extensive margin effects provides important insights into the mechanisms through which payment system integration operates. Our null results for the number of export destinations and product-market combinations suggest that the RTGS system does not meaningfully reduce the fixed costs or informational barriers that impede firms from entering new markets, at least not within the time frame of our analysis. This pattern aligns with empirical evidence from Paravisini, Rappoport, Schnabl, and Wolfenzon (2015), who documents that credit shocks have strong and immediate effects on export volumes, but no impact on firms' entry into new markets or products.

[INSERT TABLE A.2 ABOUT HERE]

Taken together, our findings indicate that faster and more reliable cross-border payments primarily alleviate variable trade costs related to working capital and payment frictions, thereby facilitating more frequent and higher-volume transactions. However, they may not be sufficient to overcome the structural barriers that prevent firms from expanding into new destinations or products. This pattern reinforces our interpretation that the causal effect of the RTGS implementation drives the observed short-run trade response. If our results were driven by confounding factors such as broader regional economic integration, improved diplomatic relations, or general business environment reforms, we would expect to observe simultaneous changes in both intensive and extensive margins. The fact that only intensive margins respond while extensive margins remain unchanged suggests that our estimates capture the specific impact of cross-border payment system integration rather than spurious correlations with other unobserved trends affecting trade more broadly.

6.1.3 Predicting the Timing of RTGS Adoption

In Appendix Table A.3 and Table A.4, we examine whether observable pair- and country-specific characteristics predict the timing of RTGS adoption. We regress indicator variables for treatment in 2013 and 2014 on standardized measures—including lagged bilateral trade, geographic distance, time-zone differences, GDP per capita, ease-of-doing-business metrics—with destination fixed effects. The comparison group in each specification consists of pairs treated in later years.

The results indicate that these pre-determined characteristics do not systematically predict treatment timing. The lone exception is a marginally significant coefficient on origin trade flows in 2014; however, this isolated finding does not suggest a broader pattern. When we focus specifically on South African trade partners (Table A.4), we find similar results: no characteristic significantly predicts timing, and the overall explanatory power (R^2) remains low.

These findings contribute to internal validity by alleviating concerns about endogenous timing. If treatment timing were driven by observable factors, it would raise the possibility of confounding. However, the lack of predictive power supports the identification assumption that timing is "as good as random" conditional on destination fixed effects. Empirical best practices for causal inference in staggered adoption settings emphasize the importance of such checks. In DiD and event-study frameworks, demonstrating that pre-determined covariates do not correlate with treatment timing enhances credibility and helps justify the parallel trends assumption across groups.

In sum, the null results from our timing regressions underscore that neither trade intensity nor geographic or institutional characteristics appear to drive RTGS entry timing. This finding strengthens our causal claims: the observed changes in trade volumes and transactions are unlikely to reflect selection into treatment based on pre-existing conditions.

7 Conclusion

Our study provides causal evidence of the significant positive impact of faster and reliable cross-border systems on international trade. The adoption of a payment integration platform resulted in a substantial increase in export volumes for participating firms, equivalent to a reduction in tariffs by 6 to 8 percentage points. Importantly, our results are consistent with trade creation and not trade diversion. We provide evidence that the reduction in transaction costs (risk) emerged as a key driver of this trade boost, highlighting the crucial role of efficient payment systems in promoting cross-border commerce.

Firms with higher external financial dependence experienced a more pronounced increase in their exports, suggesting that enhanced financial accessibility plays a crucial role in leveraging the benefits of international financial integration for export activities. Our findings isolate the importance of cross-border payment from other channels in which multinational banks can influence trade. Moreover, we highlight the determinants of cross-border payment system adoption by banks and provide suggestive evidence that adopting banks are more likely to increase correspondent banking activity after the country in which they are located joins the system. Overall, our main contribution is to provide evidence of how a new form of financial integration——cross-border payment systems——deepens economic integration by spurring international trade.

While our study focuses on the SADC-RTGS system and South African firms, the findings have broader implications for understanding the role of payment infrastructure in international trade. The mechanisms we identify—reduction in settlement time, payment uncertainty, and working capital requirements—are not unique to the African context but represent fundamental frictions in cross-border commerce that exist globally. Our institutional setting provides a particularly clean identification of these mechanisms due to the staggered implementation and the substantial baseline frictions in emerging market payment systems. The magnitude of effects we observe should be interpreted in light of the significant improvement in payment infrastructure and the high baseline costs in emerging markets, but the directional effects and underlying mechanisms are relevant across different economic contexts.

The policy implications extend beyond regional payment integration initiatives. Our results suggest that investments in cross-border payment infrastructure can serve as effective trade facilitation tools, particularly for developing economies seeking to increase their integration into global value chains. The concentration of effects among financially constrained firms highlights the importance of payment system design that addresses the needs of small and medium enterprises, which often face the most significant barriers to international trade participation.

Future work could explore the long-term impacts of payment integration on global trade dynamics, especially for SMEs. Examining policy implications for trade facilitation and growth can inform strategies for inclusive international trade. Probing digital currencies' role in cross-border trade, particularly services, may illuminate the increasing influence of financial technologies on international commerce.

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Figures

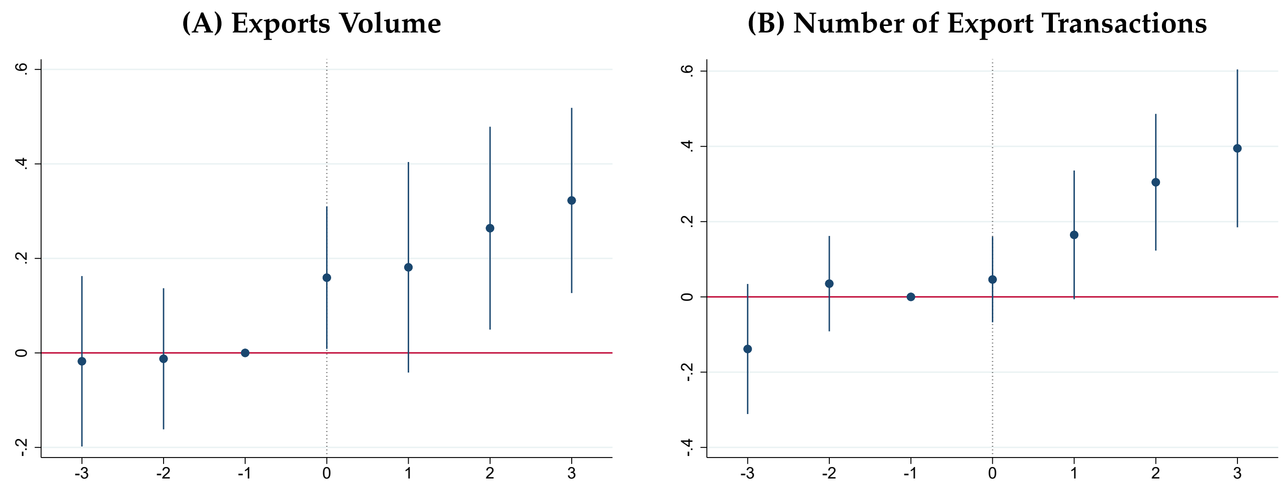

Figure 1. Firm-Level Exports around the Payment System Integration. This figure shows the dynamic effects of the implementation of the Real-Time Gross Settlement (RTGS) system on firm-destination export volumes (Panel A) and the number of transactions (Panel B). The event-study coefficients are estimated relative to the year before the RTGS implementation ($t-1$). Reported 95% confidence intervals are based on standard errors clustered at the *Firm* × *Destination Country* × *Cohort* and the *Firm* × *Date* × *Cohort* levels. All specifications include *Firm* × *Destination Country* × *Cohort* and *Year* × *Continent* × *Cohort* fixed effects, as well as time-varying trade partner export demand. Estimation uses the Poisson Pseudo-Maximum Likelihood (PPML) method of Santos Silva and Tenreyro (2006).

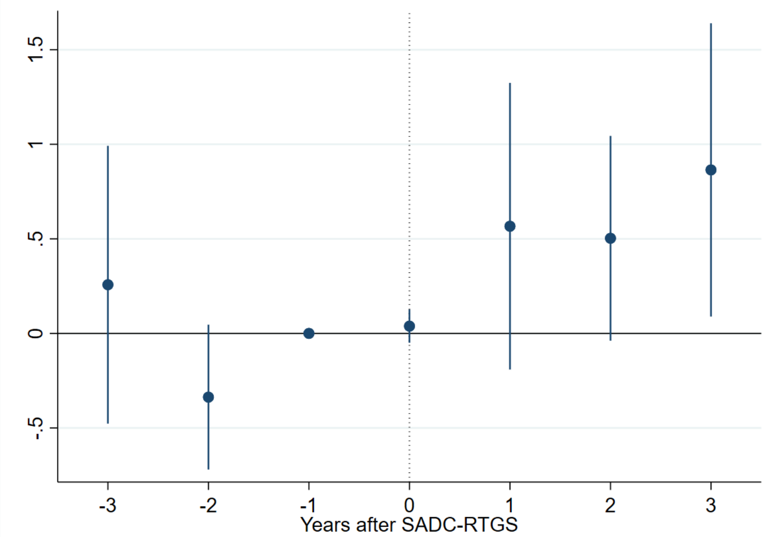

Figure 2. The Response of Interbank Assets to Payment System Integration. This figure shows the evolution of interbank assets following the implementation of the Real-Time Gross Settlement (RTGS) system. Estimates are relative to 2012, one year before the initial implementation in July 2013. Reported 95% confidence intervals are based on standard errors clustered at the bank-cohort level. The figure displays the dynamic specification of Column 3 from Table 9. The dependent variables use inverse hyperbolic sine transformation. The specification includes *Origin Bank* $\times$ *Cohort*, *Country* $\times$ *Cohort* $\times$ *Year*, and *Conglomerate* $\times$ *Cohort* $\times$ *Year* fixed effects.

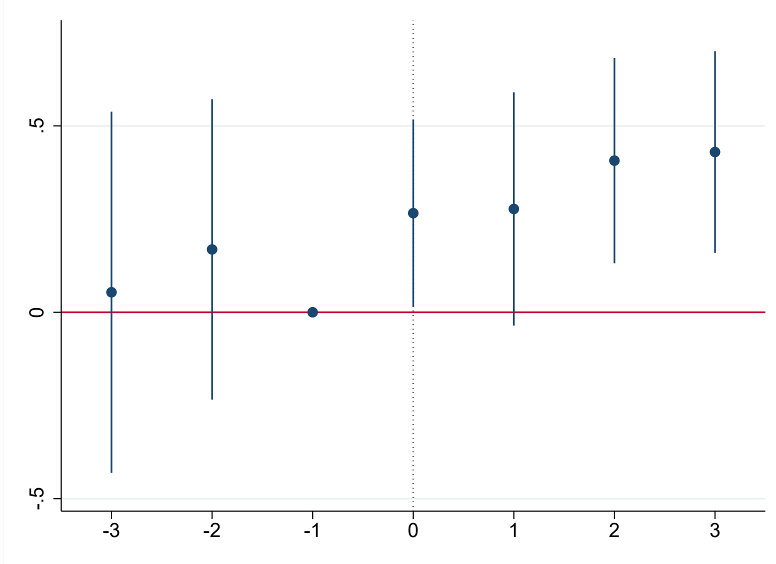

Figure 3. Country-Level Bilateral Trade Flows and Cross-Border Payment System Integration. This figure shows the dynamic effects of the Real-Time Gross Settlement (RTGS) system participation on bilateral trade flows between member countries. Estimates are relative to one year before the initial implementation in July 2013. Reported 95% confidence intervals are based on standard errors clustered at the *Origin Country* × *Destination Country* level. All specifications include *Origin Country* × *Cohort* and *Time* × *Cohort* fixed effects, as well as pair-specific controls (Southern African Customs Union, Southern African Development Community Free Trade Area, Free Trade Agreement, Customs Unions, geographical contiguity indicators, and log(distance)). Estimation uses the Poisson Pseudo-Maximum Likelihood (PPML) method of Santos Silva and Tenreyro (2006).

Tables

Table 1. Real-Time Gross Settlement System: Implementation Timeline. This table presents the chronological development of the Southern African Development Community's (SADC) Real-Time Gross Settlement (RTGS) system from 2010 to 2016. It shows the key milestones in the approval process and the dates when different member countries joined the system. The implementation followed a phased approach, beginning with countries in the Common Monetary Area (CMA) in July 2013 and expanding to include all fourteen participating countries by November 2016.

Date	**Event**
October 2010	SADC Committee of Central Bank Governors (CCBG) approves undertaking the proof of concept in the CMA region.
April 2013	CCBG approves the legal agreements. CMA Governors sign the agreements.
July 2013	SADC-RTGS goes live in Lesotho, Namibia, South Africa and Swaziland.
April 2014	SADC-RTGS goes live in Malawi, Tanzania, and Zimbabwe.
September 2014	SADC-RTGS goes live in Mauritius and Zambia.
July 2016	SADC-RTGS goes live in Seychelles.
October 2016	SADC-RTGS goes live in Angola, Botswana, and Mozambique.
November 2016	SADC-RTGS goes live in The Democratic Republic of Congo.

Table 2. Summary Statistics: Firm-Level Matched Sample. This table reports summary statistics for firms in our matched sample, constructed using Coarsened Exact Matching on firm sector, size, and total factor productivity (TFP). The treated group consists of firms exporting to countries that joined the payment system, while the control group includes comparable firms exporting only to non-participating countries. All variables are measured at baseline (i.e., $t-1$), one year before the Southern African Development Community's Real-Time Gross Settlement (RTGS) inclusion. Monetary values are in millions of South African rand (ZAR), deflated to 2012 prices using the Consumer Price Index (CPI). The p-values in column 4 are adjusted for multiple-hypothesis testing following Clarke, Romano, and Wolf (2020) with 5,000 repetitions.

	All Firms (1)	Treated Firms (2)	Control Firms (3)	Mean Difference Test p-value (4)
Loans	0.130	0.128	0.135	0.610
Receivables	1.060	0.547	1.936	0.610
Payables	0.598	0.639	0.528	0.341
Capital Stock	0.579	0.486	0.736	0.348
Value Added	1.123	1.174	1.035	0.376
Exports to Sales Ratio	0.040	0.037	0.046	0.230
Exports	0.248	0.193	0.341	0.312
Observations	52,694	33,199	19,495	

Table 3. Baseline Results: Firm-Destination Exports and Cross-Border Payment Integration. This table examines the effects of the Real-Time Gross Settlement (RTGS) system on firm-destination export outcomes. Columns 1-2 present results for export volume, while columns 3-4 show effects on the number of export transactions. All regressions use a matched sample constructed via Coarsened Exact Matching on firm sector and sales. Standard errors are clustered at the *Firm* $\times$ *Destination Country* $\times$ *Cohort* and *Firm* $\times$ *Year* $\times$ *Cohort* levels. Estimation uses the Poisson Pseudo-Maximum Likelihood (PPML) method of Santos Silva and Tenreyro (2006). Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	Exports Volume		Exports Transactions	
	(1)	(2)	(3)	(4)
Post-RTGS	0.326***	0.300***	0.385***	0.374***
	(0.082)	(0.079)	(0.078)	(0.076)
Export Demand	0.643***	0.637***	0.493***	0.483***
	(0.123)	(0.123)	(0.110)	(0.105)
Firm $\times$ Cohort FE	✓		✓	
Destination Country $\times$ Cohort FE	✓		✓	
Firm $\times$ Destination Country $\times$ Cohort FE		✓		✓
Continent $\times$ Cohort $\times$ Year FE	✓	✓	✓	✓
Observations	1,507,450	1,507,389	1,507,552	1,507,491
R^2	0.643	0.873	0.742	0.876

Table 4. Spillover Analysis: Effects on Non-RTGS Destinations. This table examines whether the Real-Time Gross Settlement (RTGS) system implementation affects exports to non-participating countries. The variable *RTGS Firm Spillover* captures potential effects on exports to non-RTGS countries by firms that also export to RTGS-participating countries. Columns (1) and (2) present results for export volume, while columns (3) and (4) show effects on the number of export transactions. Standard errors are clustered at the *Firm* $\times$ *Destination Country* $\times$ *Cohort* and *Firm* $\times$ *Year* $\times$ *Cohort* levels. Estimation uses Santos Silva and Tenreyro's (2006) Poisson Pseudo-Maximum Likelihood (PPML) method. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	Exports Volume		Exports Transactions	
	(1)	(2)	(3)	(4)
Post-RTGS	0.392***	0.386***	0.357***	0.384***
	(0.090)	(0.095)	(0.088)	(0.087)
RTGS Firm Spillover	0.094*	0.122*	-0.039	0.013
	(0.052)	(0.071)	(0.062)	(0.061)
Export Demand	0.646***	0.644***	0.493***	0.483***
	(0.123)	(0.122)	(0.110)	(0.105)
Firm $\times$ Cohort FE	✓		✓	
Destination Country $\times$ Cohort FE	✓		✓	
Firm $\times$ Destination Country $\times$ Cohort FE		✓		✓
Continent $\times$ Cohort $\times$ Year FE	✓	✓	✓	✓
Observations	1,507,450	1,507,389	1,507,552	1,507,491
R^2	0.643	0.873	0.742	0.876

Table 5. Firm-Destination Exports and RTGS Integration: The Role of Fast Payments. This table examines how domestic Real-Time Gross Settlement (RTGS) adoption interacts with cross-border RTGS participation to affect exports. The variable *Post-RTGS* indicates when a destination country joins the RTGS system, while *Domestic RTGS* is a binary variable indicating whether the destination country had implemented its own domestic real-time gross settlement system. *RTGS Firm Spillover* captures potential effects on exports to non-RTGS countries by firms that also export to RTGS-participating countries. *Export Demand* controls for destination-country specific demand conditions. Standard errors are clustered at the *Firm* × *Destination Country* × *Cohort* and *Firm* × *Year* × *Cohort* level. Estimation uses the Poisson Pseudo-Maximum Likelihood (PPML) method of Santos Silva and Tenreyro (2006). Information on domestic RTGS adoption dates comes from D'Andrea and Limodio (2024). Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	Exports Volume		Exports Transactions	
	(1)	(2)	(3)	(4)
Post-RTGS	–0.083	0.008	–0.376**	–0.232
	(0.176)	(0.178)	(0.186)	(0.171)
× Domestic RTGS	0.481**	0.383**	0.746***	0.627***
	(0.193)	(0.190)	(0.220)	(0.209)
RTGS Firm Spillover	0.094*	0.122*	–0.039	0.013
	(0.052)	(0.071)	(0.062)	(0.061)
Export Demand	0.657***	0.653***	0.538***	0.521***
	(0.125)	(0.124)	(0.117)	(0.113)
Firm × Cohort FE	✓		✓	
Destination Country × Cohort FE	✓		✓	
Firm × Destination Country × Cohort FE		✓		✓
Continent × Cohort × Year FE	✓	✓	✓	✓
Observations	1,507,389	1,507,389	1,507,491	1,507,491
R^2	0.643	0.873	0.742	0.876

Table 6. Firms' Total Exports and RTGS Integration: Heterogeneous Effects by External Financial Dependence. This table analyzes how a firm's exposure to the RTGS system affects its total exports, with a focus on sectoral financial constraints. The variable $RTGS\ Exp$ is the exposure variable defined in Equation (2), measuring the percentage of a firm's 2012 exports going to countries that participated in the RTGS system in year t. *High EFD* represents sectors with above-median external financial dependence, measured as the ratio of payables (trade credit) to total sales in 2012. The interactions with firm characteristics examine heterogeneous effects: *Big* represents firms with above-mean sales in 2012, *Older* represents firms with above-median age in 2012, *High TFP* indicates firms with above-median total factor productivity in 2012, while *Primary* and *Services* are sector classification dummies. Standard errors are clustered at the *Firm* × *Sector* × *Year* level. Estimation uses the Poisson Pseudo-Maximum Likelihood (PPML) method of Santos Silva and Tenreyro (2006). Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	Total Exports				
	(1)	(2)	(3)	(4)	(5)
RTGS Exposure	0.045	–0.170*	–0.197*	–0.163	–0.183*
	(0.076)	(0.104)	(0.114)	(0.113)	(0.104)
× High EFD		0.449***	0.413***	0.403***	0.445***
		(0.140)	(0.144)	(0.142)	(0.144)
× Big			–0.003		
			(0.077)		
× Older				0.083	
				(0.076)	
× High TFP					0.272*
					(0.148)
Export Demand	0.073	0.041	0.041	0.046	0.041
	(0.116)	(0.116)	(0.116)	(0.115)	(0.116)
Firm FE	✓	✓	✓	✓	✓
TFP × Year FE	✓	✓	✓	✓	✓
Sector × Year FE	✓	✓	✓	✓	✓
Observations	40,748	40,748	40,748	40,748	40,748
R^2	0.926	0.926	0.924	0.924	0.924

Table 7. Firms' Additional Outcomes and RTGS Integration Outcome variables include: Total Sales (gross sales revenue), Value Added (gross sales minus cost of sales), Receivables (net trade and other receivables after provisions), Payables (trade and other payables), and Labor Costs (wages including medical benefits, pensions, and direct remuneration). The variable $RTGS\ Exp$ is the exposure variable defined in Equation (2), measuring the percentage of a firm's 2012 exports going to countries that participated in the RTGS system in year t. *High EFD* represents sectors with above-median external financial dependence, measured as the ratio of payables (trade credit) to total sales. Standard errors are clustered at the Firm × Destination Country × Cohort and Firm × Year × Cohort level. Regressions use the matched sample from the Coarsened Exact Matching procedure using the firm sector and firm sales. Our specification uses Santos Silva and Tenreyro's (2006) Poisson Pseudo-Maximum Likelihood Estimator (PPML). Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	Total Sales		Value Added		Receivables		Payables		Labor Costs	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
RTGS Exposure	–0.025	–0.107	0.022	0.002	–0.017	–0.132**	0.071*	–0.033	–0.000	0.002
	(0.041)	(0.068)	(0.029)	(0.034)	(0.043)	(0.059)	(0.043)	(0.043)	(0.026)	(0.029)
RTGS Exposure × High EFD		0.168**		0.038		0.214***		0.186**		–0.005
		(0.078)		(0.054)		(0.078)		(0.074)		(0.051)
Export Demand	–0.000	–0.002	0.107*	0.106*	0.046	0.046	0.083	0.081	0.027	0.027
	(0.054)	(0.053)	(0.063)	(0.063)	(0.076)	(0.075)	(0.079)	(0.078)	(0.040)	(0.040)
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
TFP × Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	40,684	40,684	40,293	40,293	39,209	39,209	40,023	40,023	39,618	39,618
R^2	0.950	0.950	0.934	0.934	0.888	0.888	0.918	0.918	0.926	0.926

Table 8. RTGS Bank Adoption. Standard errors are clustered at the *Bank* and *Country* levels. A multinational conglomerate is a dummy variable that indicates if the conglomerate has at least one subsidiary in a country other than the headquarter (HQ) country. HQ/Foreign Subsidiary RTGS Exposure is a dummy variable indicating that the conglomerate has at least one subsidiary or the HQ in a country that adopts RTGS at time t. Measures of total assets and operating revenues to asset ratio are standardized. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	SADC-RTGS Participant in 2019			
	(1)	(2)	(3)	(4)
HQ/Foreign Subsidiary RTGS Exposure	0.361**	0.361**	0.382**	0.458***
	(0.143)	(0.157)	(0.154)	(0.144)
Multinational Conglomerate	–0.131	0.196		
	(0.148)	(0.128)		
Total Assets				0.041**
				(0.019)
$\frac{\text{Operating Revenues}}{\text{Total Assets}}$				0.020
				(0.020)
Country FE		✓		
Country × Multinational Cong. FE			✓	✓
Observations	119	119	118	102
R^2	0.111	0.401	0.445	0.519

Table 9. RTGS Bank Adoption and Interbank Markets. The dependent variables are the inverse hyperbolic sine transformation of the original variables. Standard errors are clustered at the *Bank* × *Cohort* level. A multinational *Conglomerate* is defined as a binary variable that indicates if the conglomerate has at least one subsidiary in a country other than the HQ country. HQ/Foreign Subsidiary RTGS Exposure is a dummy variable indicating that the conglomerate has at least one subsidiary or the HQ in a country that adopted the RTGS at time t. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	Interbank Assets / T. Assets			Interbank Liabilities / T. Assets		
	(1)	(2)	(3)	(4)	(5)	(6)
Post-RTGS at Country	–0.010			–0.063*		
	(0.042)			(0.037)		
Post-RTGS at Country	0.206***	0.297**	0.503**	0.028	0.005	0.039
× HQ/Foreign Subsidiary RTGS Exposure	(0.079)	(0.137)	(0.248)	(0.068)	(0.094)	(0.160)
Bank × Cohort FE	✓	✓	✓	✓	✓	✓
HQ Country × Cohort × Year FE	✓	✓		✓	✓	
Country × Cohort × Year FE		✓	✓		✓	✓
Conglomerate × Cohort × Year FE			✓			✓
Observations	13,046	12,374	11,174	12,114	11,432	10,306
R^2	0.481	0.544	0.606	0.474	0.541	0.595

Table 10. Country-Level Evidence: Gravity Estimations. Standard errors in parentheses are clustered at the level of the respective fixed effects. Our specification uses Santos Silva and Tenreyro's (2006) Poisson Pseudo-Maximum Likelihood (PPML) Estimator. Control variables include the geographical distance between countries, contiguity, whether countries have a free trade agreement, and whether they belong to the SADC customs union or other customs unions. Column (1) uses the data at the *Origin Country* × *Destination Country* dimension, column (2) uses the data at the *Origin Country* × *Destination Country* × *Product* dimension, with products classified according the 2-digit Harmonized System (HS). Columns (3) and (4) use the data at the *Origin Country* × *Destination Country* × *Industry* dimension. Industries are defined according to the ISIC classification. To conduct the analysis at the industry level, we perform a mapping of the trade data from the 2-digit Harmonized System to ISIC classification. Columns (3) and (4) represent the alternative approaches for mapping of products into industries. The last three rows compute the tariff equivalent effect of the SADC-RTGS using different trade elasticity estimates from the literature. The tariff equivalent effects are calculated using $\left[e^{\hat{\beta}_{RTGS}/(\hat{\sigma})} - 1\right] \times 100$. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	Bilateral Trade Flows			
	Country Level	Country-Product Level	Country-Industry Level	
	(1)	(2)	(3)	(4)
RTGS × *Post*	0.399**	0.384***	0.331***	0.299**
	(0.163)	(0.128)	(0.126)	(0.119)
Control Variables	✓	✓	✓	✓
Origin Country × Year FE	✓			
Destination Country × Year FE	✓			
Origin Country × Product × Year FE		✓		
Destination Country × Product × Year FE		✓		
Origin Country × Industry × Year FE			✓	✓
Destination Country × Industry × Year FE			✓	✓
Observations	355,320	29,396,253	7,916,271	7,697,008
Post RTGS Tariff Equivalent				
$\hat{\sigma} = 4$ (Simonovska and Waugh, 2014)	10.5%	10.1%	8.6%	7.8%
$\hat{\sigma} = 4.55$ (Caliendo and Parro, 2015)	9.2%	8.8%	7.5%	6.8%
$\hat{\sigma} = 5$ (Baier and Bergstrand, 2007)	8.3%	8.0%	6.8%	6.2%

Appendix A Additional Results

(A) Spillover Effects on Exports Volume **(B) Spillover Effects on Number of Transactions**

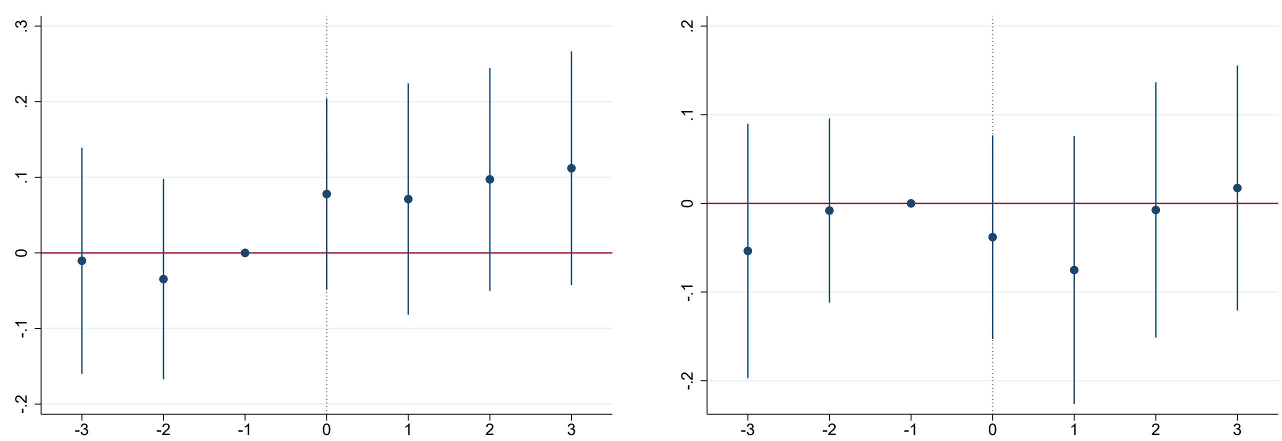

Figure A.1. Firm-Destination Exports and RTGS Integration. Reported 90% confidence intervals are based on standard errors clustered at the *Firm* × *Destination* × *Cohort* and *Firm* × *Year* × *Cohort* level. All specifications include *Firm* × *Destination* × *Cohort* and *Year* × *Continent* × *Cohort* fixed effects as well as time-varying trade partner export demand. Our specification uses Santos Silva and Tenreyro's (2006) Poisson Pseudo-Maximum Likelihood (PPML) Estimator.

Table A.1. High-Frequency Identification using Monthly Firm-Destination Exports: Regression Discontinuity Design. Standard errors clustered at the *Firm* × *Destination Country* × *Cohort* level. Our specification uses Santos Silva and Tenreyro's (2006) Poisson Pseudo-Maximum Likelihood (PPML) Estimator. The local linear regression includes a dummy for post-RTGS implementation, time since the cutoff date, squared value of time since the cutoff date, and the interactions between these two variables and the Post-RTGS implementation dummy. Each pair of columns estimates separate regressions for the different windows around the implementation date represented in months, as indicated in their title. The controls include demand export and *Firm* × *Destination Country* fixed effects. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

	Bandwidth (-2,2)		Bandwidth (-3,3)		Bandwidth (-4,4) **Opt. Band. Exp. Vol.**		Bandwidth (-5,5) **Opt. Band. Exp. Trans.**	
	Exp. Volume	Exp. Trans.	Exp. Volume	Exp. Trans.	Exp. Volume	Exp. Trans.	Exp. Volume	Exp. Trans.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post-RTGS	0.114*	0.173***	0.127	0.279***	0.197**	0.258***	0.115*	0.143***
	(0.066)	(0.041)	(0.144)	(0.100)	(0.094)	(0.041)	(0.066)	(0.030)
Firm × Destination FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	92,267	92,267	143,030	143,030	192,187	192,187	246,929	246,929
R^2	0.842	0.847	0.825	0.841	0.821	0.838	0.811	0.837

Table A.2. Effects of the RTGS Integration on Firms' Export Destinations and Products. Standard errors clustered at the *Firm* $\times$ *Sector* $\times$ *Year* level. *RTGS Exp* is the exposure variable defined in Equation (2). Regressions use the matched sample of the Coarsened Exact Matching procedure using the firm sector and firm sales. Our specification uses Santos Silva and Tenreyro's (2006) Poisson Pseudo-Maximum Likelihood (PPML) Estimator. High EFD represents sectors with above the median payables (trade credit) to total sales. Columns 1 and 2 show the estimates using the number of destination countries as the dependent variable. Columns 3 and 4 use the destination-number of products at the 6-digit (HS6) level of the Harmonized System classification, while Columns 5 and 6 use the destination-number of the more aggregated 4-digit (HS4) level products as the dependent variable. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	Number of Destinations		Destination 4-digit HS Products		Destination 6-digit HS Products	
	(1)	(2)	(3)	(4)	(5)	(6)
RTGS Exp	–0.015	–0.014	0.024	0.060	0.032	0.070*
	(0.019)	(0.020)	(0.029)	(0.037)	(0.031)	(0.040)
$\times$ High EFD		–0.002		–0.077		–0.082
		(0.036)		(0.051)		(0.056)
Export Demand	–0.006	–0.006	0.093	0.095	0.121*	0.123*
	(0.034)	(0.034)	(0.059)	(0.059)	(0.067)	(0.067)
Firm FE	✓	✓	✓	✓	✓	✓
TFP $\times$ Year FE	✓	✓	✓	✓	✓	✓
Sector $\times$ Year FE	✓	✓	✓	✓	✓	✓
Observations	40,895	40,895	40,866	40,866	40,866	40,866
R^2	0.308	0.308	0.730	0.730	0.780	0.780

Table A.3. Predictors of RTGS Treatment Timing. Robust standard errors are shown in parentheses. All predictors are the standardized original variable at the entry year. The control group for each regression is comprised of trade pairs treated afterward. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

	SADC-RTGS in 2013	SADC-RTGS in 2014
	(1)	(2)
Pair Specific Characteristics		
Previous Year Bilateral Trade flows (1,000 Current USD)	–0.903	3.364
	(0.918)	(2.230)
Time Difference (hours)	0.048	0.144
	(0.168)	(0.368)
Distance (1,000 km)	–0.264	0.312
	(0.211)	(0.338)
Origin Specific Characteristics		
Origin Time to start a business (days)	0.016	0.054
	(0.028)	(0.047)
Origin GDP, PPP (1,000 Current USD)	0.328	0.744
	(0.416)	(0.461)
Origin Trade flows (1,000 Current USD)	1.372	–4.251*
	(1.243)	(2.560)
Destination FE	✓	✓
Observations	133	121
R^2	0.309	0.519

Table A.4. Predictors of RTGS timing: South African Trade Partners. Robust standard errors are shown in parentheses. All predictors are the standardized original variable at the entry year. The control group for each regression is comprised of trade pairs treated afterward. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

	SADC-RTGS in 2013	SADC-RTGS in 2014
	(1)	(2)
One year lag bilateral trade	–0.415	–2.225
	(0.962)	(1.466)
Time Difference (hours)	0.959	–0.188
	(1.310)	(3.166)
Distance (1,000 km)	–1.665	–1.662
	(1.394)	(3.599)
Destination's time required to start a business (days)	0.109	–0.057
	(0.187)	(0.305)
Observations	13	10
R^2	0.281	0.289

Table A.5. Firm-Destination Exports and RTGS Integration: Mechanisms. Standard errors clustered at the *Firm* × *Destination Country* × *Cohort* and *Firm* × *Year* × *Cohort* level. Regressions use the matched sample from the Coarsened Exact Matching procedure using the firm sector and firm sales. Our specification uses Santos Silva and Tenreyro's (2006) Poisson Pseudo-Maximum Likelihood Estimator (PPML). Information from the date of adoption of the Domestic RTGS comes from D'Andrea and Limodio (2024). Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	Exports Volume			Exports Transactions		
	(1)	(2)	(3)	(4)	(5)	(6)
Post-RTGS	0.021	–0.005	0.020	–0.256	–0.220	–0.241
	(0.178)	(0.179)	(0.178)	(0.174)	(0.174)	(0.175)
× Domestic RTGS	0.419**	0.388**	0.425**	0.693***	0.619***	0.699***
	(0.196)	(0.191)	(0.198)	(0.232)	(0.212)	(0.233)
× Banking Integration	–0.395*		–0.407*	–0.397**		–0.409**
	(0.219)		(0.223)	(0.170)		(0.171)
× Exc. Rates Vol.		–0.001	–0.003		–0.008	–0.010*
		(0.005)	(0.005)		(0.006)	(0.006)
RTGS Firm Spillover	0.118	0.122*	0.119	–0.033	0.005	–0.038
	(0.078)	(0.071)	(0.079)	(0.071)	(0.060)	(0.071)
× Banking Integration	0.033		0.031	0.296*		0.303*
	(0.184)		(0.184)	(0.157)		(0.158)
× Exc. Rates Vol.		–0.000	–0.000		0.001	0.001
		(0.001)	(0.001)		(0.001)	(0.001)
Export Demand	0.676***	0.662***	0.681***	0.599***	0.507***	0.602***
	(0.129)	(0.129)	(0.130)	(0.145)	(0.119)	(0.146)
Firm × Destination Country × Cohort FE	✓	✓	✓	✓	✓	✓
Continent × Cohort × Year FE	✓	✓	✓	✓	✓	✓
Observations	1,457,158	1,457,158	1,457,158	1,457,260	1,457,260	1,457,260
R^2	0.873	0.873	0.873	0.877	0.877	0.877

Table A.6. Firm-Destination Exports and RTGS Integration: Non-Matched Sample. Standard errors clustered at the *Firm* $\times$ *Destination Country* $\times$ *Cohort* and *Firm* $\times$ *Year* $\times$ *Cohort* level. Our specification uses Santos Silva and Tenreyro's (2006) Poisson Pseudo-Maximum Likelihood (PPML) Estimator. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	Exports Volume		Exports Transactions	
	(1)	(2)	(3)	(4)
Post-RTGS	0.316***	0.332***	0.379***	0.354***
	(0.078)	(0.080)	(0.077)	(0.081)
Export Demand	0.606***	0.600***	0.453***	0.433***
	(0.125)	(0.125)	(0.105)	(0.113)
Firm $\times$ Cohort FE	✓		✓	
Destination Country $\times$ Cohort FE	✓		✓	
Firm $\times$ Destination Country $\times$ Cohort FE		✓		✓
Cohort $\times$ Year FE	✓	✓	✓	✓
Observations	1,562,916	1,562,978	1,563,020	1,563,082
R^2	0.883	0.672	0.875	0.743

Table A.7. Firm-Destination Exports and RTGS Integration: Only African Trade Partners as Controls. Standard errors clustered at the *Firm* × *Destination* × *Cohort* and *Firm* × *Year* × *Cohort* level. Regressions use the matched sample of the Coarsened Exact Matching procedure using the firm sector and firm sales. Our specification uses Santos Silva and Tenreyro's (2006) Poisson Pseudo-Maximum Likelihood (PPML) estimator. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	Exports Volume		Exports Transactions	
	(1)	(2)	(3)	(4)
Post-RTGS	0.223***	0.220***	0.384***	0.381***
	(0.079)	(0.080)	(0.077)	(0.078)
Export Demand	0.176*	0.178*	0.469***	0.477***
	(0.103)	(0.104)	(0.122)	(0.118)
Firm × Cohort FE	✓		✓	
Destination Country × Cohort FE	✓		✓	
Firm × Destination Country × Cohort FE		✓		✓
Cohort × Year FE	✓	✓	✓	✓
Observations	707,374	707,318	707,409	707,353
R^2	0.663	0.813	0.812	0.890

Table A.8. Country-Level Evidence: Gravity Estimations excluding South African exports/imports. Standard errors in parenthesis are clustered at the *Origin Country* × *Destination Country*. Our specification uses Santos Silva and Tenreyro's (2006) Poisson Pseudo-Maximum Likelihood (PPML) Estimator. The last three rows compute the tariff equivalent effect of the SADC-RTGS using different trade elasticity estimates from the literature. The tariff equivalent effects are calculated using $\left[e^{\hat{\beta}_{RTGS}/(\hat{\sigma})} - 1\right] \times 100$. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	Bilateral Trade Flows					
	(1)	(2)	(3)	(4)	(5)	(6)
Post RTGS	0.402**	0.479**	0.309*	0.368*	0.339*	0.411*
	(0.188)	(0.193)	(0.170)	(0.192)	(0.200)	(0.210)
Southern Africa Customs Union	0.704**	0.884***	1.373***	1.503***	0.985***	1.048***
	(0.285)	(0.321)	(0.235)	(0.301)	(0.349)	(0.402)
SADC FTA	-0.038	0.042	0.108	0.280	0.204	0.336
	(0.185)	(0.199)	(0.200)	(0.279)	(0.286)	(0.322)
Customs Union	0.697***	1.568***	0.706***	1.576***	0.702***	1.570***
	(0.087)	(0.124)	(0.087)	(0.123)	(0.087)	(0.123)
FTA	0.286***	0.842***	0.282***	0.837***	0.281***	0.844***
	(0.051)	(0.096)	(0.051)	(0.096)	(0.051)	(0.098)
Log(Distance)	-0.617***	-0.338***	-0.616***	-0.337***	-0.616***	-0.337***
	(0.029)	(0.041)	(0.029)	(0.041)	(0.029)	(0.041)
Contiguous Countries	0.559***	0.137	0.560***	0.139	0.560***	0.137
	(0.068)	(0.130)	(0.068)	(0.130)	(0.068)	(0.130)
Origin × Time FE	✓	✓	✓	✓	✓	✓
Destination × Time FE	✓	✓	✓	✓	✓	✓
Internal Trade		✓		✓		✓
Exclude SA Exports	✓	✓			✓	✓
Exclude SA Imports			✓	✓	✓	✓
Observations	353,440	355,191	353,440	355,191	351,560	353,311
R^2	0.297	0.287	0.297	0.287	0.298	0.288

Table A.9. Robustness: RTGS Bank Adoption and Interbank Markets. This table shows that our main findings from Table 9 are robust to alternative model specifications and estimators. Columns 1–3 report OLS estimates using the logarithm of interbank assets over total assets (plus one) as the dependent variable. Columns 4–6 use the Poisson Pseudo-Maximum Likelihood (PPML) estimator (Santos Silva and Tenreyro, 2006), with the interbank assets over total assets as the dependent variable. Standard errors are clustered at the bank-cohort level. A multinational *Conglomerate* is a dummy variable that indicates if the conglomerate has at least one subsidiary in a country other than the HQ country. HQ/Foreign Subsidiary RTGS Exposure is a dummy variable indicating that the conglomerate has at least one subsidiary or is headquartered in a country that adopts RTGS at time t. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	$\log(1 + \frac{\text{Interbank Assets}}{\text{T. Assets}})$			$\frac{\text{Interbank Assets}}{\text{T. Assets}}$		
	(1)	(2)	(3)	(4)	(5)	(6)
Post-RTGS at Country	–0.009			–0.290		
	(0.035)			(0.260)		
Post-RTGS at Country	0.161**	0.241**	0.411**	1.085***	1.655**	1.431
× HQ/Foreign Subsidiary RTGS Exposure	(0.063)	(0.112)	(0.208)	(0.396)	(0.712)	(1.217)
Bank × Cohort FE	✓	✓	✓	✓	✓	✓
HQ Country × Year × Cohort FE	✓	✓		✓	✓	
Country × Year × Cohort FE		✓	✓		✓	✓
Conglomerate × Year × Cohort FE			✓			✓
PPML Specification				✓	✓	✓
Observations	13,046	12,374	11,174	12,959	12,287	11,119

Appendix B Export Demand

Our main goal is to identify the effect of the cross-border payment system integration on international trade. Despite the empirical design and the inclusion of the control variables described in Section 4, there is still a concern that our estimates can be contaminated by the presence of additional country-specific shocks that are relevant both for our dependent variables and our measure of exposure to the RTGS system. One potential issue would be the existence of trade-partner-specific demand shocks that are also correlated with the country's participation in the SADC–RTGS.

We address this potential confounding factor and estimate a destination-specific component that captures year-by-year aggregated shocks to the country's demand for global exports. The idea is that this measure can capture the overall changes in the country's demand for global exports, excluding trade with South Africa.

Following a similar strategy as Costa, Garred, and Pessoa (2016), we estimate an auxiliary regression, using aggregated bilateral trade data between 2010 and 2019 (as discussed in Section 3), and excluding South Africa. Specifically, the estimated model is:

$$X_{i,j,t} = \alpha + \sum_{i,t} \delta_{i,t} \cdot \Big[\mathbb{1}\{\text{Importer} = i\} \times \mathbb{1}\{\text{Year} = t\} \Big] + \gamma_{i,j} + \epsilon_{i,j,t},$$

where $X_{i,j,t}$ is the volume of trade between importer i, and exporter j in year t. $\gamma_{i,j}$ represents a set of country-pair dummy variables that capture the time-invariant pair-specific determinants of bilateral trade, such as distance, common language, and contiguity. Our coefficient of interest is $\delta_{i,t}$, obtained from the interaction between an importer-specific dummy and a year-specific dummy variable. This means that the importer-year-specific coefficients represent the average deviations in bilateral trade of that country's imports in any given year, excluding trade with South Africa. We refer to the estimates $\hat{\delta}_{i,t}$ as the export demand component and include it as a control variable in our specifications to control for the destination-specific demand shocks.