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(UN)COMPETITIVE DEVALUATIONS AND FIRM DYNAMICS

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Abstract

This paper studies monetary and exchange rate policy in a world of global value chains. Using recent microdata from Japan and Russia, devaluations are shown to negatively affect exporters in terms of employment, domestic revenue and profitability relative to nonexporting firms. Given their substantial dependence on imported intermediate inputs, exporting firms are more exposed to marginal cost shocks following exchange rate movements. Standard macro models are too simplistic in their microstructure to capture these transmission channels. I propose a New Keynesian general equilibrium model with firm heterogeneity, varying intermediate import intensities, and international dollar pricing to explain the findings. Strategic complementarities improve the quantitative performance of the model without changing its qualitative properties. The new paradigm is successful in matching key firm-level moments as well as the evolution of inflation and net exports. *JEL Codes*: E52, E65, F23, F31, F41, F42, G32.

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1 Introduction

How are monetary policy shocks transmitted in open economies, and how do they affect firm dynamics? Are competitive devaluations effective in helping countries pursue export-led expansions in the face of increasingly complex global supply chains? Competitive devaluations, or currency wars, are said to occur when a country eases monetary policy specifically to depreciate its exchange rate, with the ultimate objective of making exports relatively cheap and gaining a competitive advantage in international trade. Yet despite such measures being a prominent component of policy discourse, the usually assumed transmission mechanism seems to be at odds with microdata as well as the evolution of inflation and net exports.[1]

Manipulation of the exchange rate to gain an edge over a country's trading partners has long been recognized as a significant danger to the stability of the international monetary system. Institutions and rules have been established to explicitly prevent countries from resorting to beggar-thy-neighbor devaluation spirals. Such concerns were strong during the Asian crises in the late 1990s as well as following the financial crisis of 2008, once recovery was underway and national economic interests began to diverge. Some emerging-market policymakers famously argued that the Fed's aggressive unconventional monetary policy initiatives were detrimental to other economies (Bernanke (2016)). Indeed, in the new open economy macroeconomics literature, as in the traditional Mundell–Fleming–Dornbusch model, positive monetary shocks increase domestic output, employment and depreciate the real exchange rate, thereby improving the trade balance as expenditure switches toward domestic exports.

This paper dissects the mechanisms of two recent devaluation episodes and develops a theoretical framework to analyze the effects of monetary policy on firm dynamics in open economies. Identification relies primarily on a difference-in-differences approach, comparing firms that operate in the same general equilibrium environment but are distinct in terms of their exposure to exchange rate fluctuations over time. The investigation starts with post-2012 Japan as a laboratory to study competitive devaluations. That Japanese episode stands out with regard to its magnitude and nature: the yen weakened by a staggering 50% within two years after gradually reaching postwar highs against the U.S. dollar, a development which, according to consensus, had been driven by purely monetary factors.[2]

[1] In the aftermath of Brexit, the devalued pound led to an increase of the trade deficit as exports dropped. See, for example, Wall Street Journal article "Currency declines lose export punch" on June 12 of 2017.

[2] More precisely, to raise inflation, stimulate growth, and weaken the currency following years of relatively timid

And while the Bank of Japan (BoJ) more than doubled its balance sheet from 2013 to 2015, prevailing views contend that none of the other arrows were successful. Japan's public debt looks as bad as ever despite an increase in the consumption tax in 2014, and almost nothing has been done in such areas as labor-market reform (Krugman (2016)). Those background details lay the foundation of a two-tiered identification strategy: first and most importantly, companies differ at the micro level in terms of their exposure to exchange rate fluctuations; secondly, at the macro level, Abenomics represented a new monetary response to persistent economic issues, making the episode an innately suited natural experiment to isolate the effects of competitive devaluations not just on firms dynamics but also on aggregate outcomes.[3]

In contrast to Japan, the nominal devaluation of the Russian ruble in late 2014 was the result of an exogenous collapse in oil prices, which led to an abrupt nominal devaluation of 70%. Even though this occurred without monetary interventions and against the backdrop of a worsening macroeconomic environment, with travel bans and asset freezes being imposed on Russian individuals and groups seen as pivotal in the separation of Crimea from Ukraine, the unique combination of firm-level customs data with a cross-sectional identification strategy that differences out aggregate shocks to the economy provides external validity and confirms the same micro-transmission channel as for Japan.[4]

Contrary to the predictions of standard open economy macro models, I find that more productive exporters shrank relative to nonexporting firms in terms of domestic revenue, employment and profitability following both depreciation episodes. At the aggregate level, Japanese output and consumption reacted sluggishly to the monetary stimulus and subsequent depreciation while the trade balance remained unaffected. The feeble response of exporters has additional implications for total output and welfare since it entails a reallocation of resources toward smaller, less productive nonexporting firms. Furthermore, all of the main results hold within and not just across industries, and the patterns are strongest in sectors that are more reliant on imported intermediate inputs. Taken together, these findings point to an underappreciated mechanism of competitive devaluations: consistent with extant work on exchange rate pass-through into prices (Amiti, Itskhoki, and Konings (2014)), exporters are also the largest importers and their expansion may be hampered by offsetting exchange rate movements on the marginal cost side. Direct

monetary interventions, the Abe government proposed three policies of what has come to be known as Abenomics: monetary stimulus, fiscal flexibility, and structural reform.

[3] See Nakamura and Steinsson (2018) for a recent discussion of identification in macroeconomics.

[4] The Russian customs data allow one to compute import intensities at the firm level. The focus is entirely on non-financial and non-resource sectors as the latter were also directly affected by falling oil prices.

cross-sectional tests of the mechanism with unique Russian firm-level customs data yield the exact same findings.

Motivated by these empirical results, this paper develops a two-country New Keynesian general equilibrium model of a monopolistically competitive industry that incorporates accepted ingredients from international trade to understand the channels behind the main reallocation patterns and analyze the effects of monetary policy in open economies. To the best of my knowledge, the framework in this paper is the first to combine heterogeneity among firms (in the spirit of Melitz (2003)), imported intermediate inputs (as in Halpern, Koren, and Szeidl (2015)), and international dollar pricing (Gopinath, Itskhoki, and Rigobon (2010) and Gopinath (2016)) to analyze the effects of competitive devaluations on firm dynamics.[5] More productive companies end up sourcing a larger amount of their inputs from abroad, which is a consequence of the intermediate input aggregator in the production function displaying a "love of variety" feature, with inputs being imperfectly substitutable as in Ethier (1982). The framework is then used to analyze the implications of an imported input cost shock on the economy and serves as a final, model-based approach to identification of the mechanism.

The model is calibrated to match the empirical regularities for Japan using standard parameters. The effect of a competitive devaluation on firms' relative profitability, domestic revenue, and employment allocations is simulated for an economy with or without firm heterogeneity, assuming different price setting rules and for varying import intensities. The quantitative results reproduce the main patterns in the microdata, with international dollar pricing and incomplete financial markets being necessary to replicate the economy's aggregate response. Because exporters tend to be the largest importers, they are forced to raise prices at home relative to less productive nonexporting firms, which remain unexposed to the cost shock. Without changing the qualitative predictions of the model, the quantitative fit of these relative adjustment patterns is improved via the addition of strategic complementarities in price setting. The model is closed by assuming that central banks set the nominal quantity of money.

While a standard New Keynesian framework with producer currency pricing, homogeneous firms, and no import intensities, as in the traditional Mundell–Fleming case, predicts that net exports and inflation increase by around 2% and 4%, respectively, the benchmark model matches these aggregate moments with much greater success, suggesting a muted response of the trade

[5] Gopinath (2016) documents that the overwhelming share of world trade is invoiced in very few currencies, which has implications for exchange rate pass-through. Chen, Chung, and Novy (2018) document a related set of facts using transactions data for UK imports.

balance and an increase in CPI of 3%. These results highlight the role of firm heterogeneity and intermediate import intensities in mediating the monetary transmission mechanism; import substitution along global value chains—rather than the growth of export champions—is a salient channel of recent nominal devaluations.

This research builds on the new open economy macro literature. Obstfeld and Rogoff (1995) develop a two-country model to think about global macroeconomic dynamics in an environment with monopolistic competition and sticky nominal prices. Corsetti, Pesenti, Roubini, and Tille (2000) develop a general equilibrium model nominal rigidities to study the impact of a devaluation by one country on its trading partners and find that neighboring economies may benefit from an improvement in their terms of trade. Corsetti, Dedola, and Leduc (2010) study optimal monetary stabilization policy in interdependent open economies in a unified framework. While the mechanisms under consideration are distinct, Corsetti and Pesenti (2001) similarly find that an unanticipated exchange rate depreciation can be beggar-thyself rather than beggar-thy-neighbor as gains in domestic output are offset by deteriorating terms of trade. The monetary block in the paper is close to the modeling choices in Kehoe and Midrigan (2007), while a central ingredient generating the results is international dollar invoicing, as presented in Gopinath, Itskhoki, and Rigobon (2010), Gopinath (2016) and contemporaneously modeled in Casas, Díez, Gopinath, and Gourinchas (2017). The latter paper proposes a "dominant currency paradigm" (DCP) and finds support for it in the data. In contrast, the focus in the present work is on firm heterogeneity, which is an important ingredient to help explain why exporters grow little after devaluations besides DCP and imported inputs. Attention is further devoted to domestic rather than international transmission channels using mainly cross-sectional identification strategies for inference. Cravino (2017) uses customs data with invoicing information from Chile to study how nominal exchange rate movements impact aggregate output and productivity. Mukhin (2017) presents a general equilibrium multi-country framework with endogenous currency choice that is consistent with the dominant role of the U.S. dollar.

This paper also speaks to the literature on currency wars and large shocks to the nominal exchange rate. As in Caballero, Farhi, and Gourinchas (2016), countries are seen as shifting output gaps between each other in a zero-sum game following competitive devaluations. This means that domestic stimulus effects are absent and only the expenditure switching mechanism remains. Similarly, Eggertsson, Mehrotra, Singh, and Summers (2016) find that exchange rates have powerful effects when the economy is in a global liquidity trap. Caballero and Lorenzoni

(2014) model the need for intervention in the foreign exchange market to protect the export sector after currency appreciations; Itskhoki and Moll (2018) study exchange rate policies in a standard growth model with financial frictions; Rodrik (2008) shows that undervaluation of the currency stimulates economic growth; Bergin and Corsetti (2016) develop a two-country New Keynesian model with one perfectly and another monopolistic competitive sector to show that monetary policy can foster investment and entry into the differentiated sector; Alessandria, Pratap, and Yue (2015) explore the source and aggregate consequences of the gradual export expansion in emerging markets following large devaluations; Burstein, Eichenbaum, and Rebelo (2005) argue that the primary force behind large drops in real exchange rates after large devaluations is the slow adjustment in the price of nontradable goods. Cravino and Levchenko (2017a) look into the distributional consequences of large devaluations and show that consumption costs rise most in the bottom decile of the income distribution.

The paper is further related to numerous empirical works on exchange rate pass-through in international trade. Atkeson and Burstein (2008) build a model of imperfect competition and variable markups to explain the main features of fluctuations in international relative prices. Auer, Burstein, and Lein (2017) study pass-through of the sudden Swiss franc appreciation after the removal of the euro peg in early 2015.[6] Berman, Martin, and Mayer (2012) find that high-performing firms absorb exchange rate movements in their markups so that export volumes react less. Similar to this paper, Mendoza and Yue (2012) show that efficiency losses result when imported inputs are replaced by imperfect substitutes. Halpern, Koren, and Szeidl (2015) estimate a model of importers in Hungarian microdata and find large effects from imported inputs on firm productivity. Amiti, Itskhoki, and Konings (2014) show that large exporters are simultaneously large importers, which helps explaining low pass-through, whereas Amiti, Itskhoki, and Konings (2016) use a similar framework to estimate strategic complementarities in price setting across firms. Benigno and Fornaro (2012) argue that firms in the tradable sector absorb foreign knowledge by importing intermediate inputs, and Dekle, Jeong, and Kiyotaki (2014) build a dynamic general equilibrium model with heterogeneous firms to reconcile the disconnect between exchange rate movements and net exports. Looking at firm-level reactions to exchange rate shocks, Gopinath and Neiman (2014) find that productivity implications depend on individual firm adjustments that cannot be summarized by the aggregate import share.

[6] Gopinath and Itskhoki (2010) and Burstein and Gopinath (2014) survey the pricing-to-market literature, which documents that firms use markup variation to smooth the effects of exchange rate shocks across destinations.

A number of papers have explored the link between firm-level outcomes and exchange rate devaluations. Griffin and Stulz (2001) investigate the presence of significant competitive effects of exchange rate shocks on firms' stock prices.[7] Aguiar (2005) shows that firms with lots of short-term foreign currency debt undertake relatively low levels of post-devaluation investment. In a recent contribution, Alfaro, Cuñat, Fadinger, and Liu (2018) document that firm-level TFP reacts heterogeneously to real exchange rate movements across developing and developed countries. Using the same firm-level accounting data as in the present paper, Cravino and Levchenko (2017b) demonstrate how multinational firms contribute to the transmission of shocks across countries. Desai, Foley, and Forbes (2008) find that U.S. multinational companies increase revenues, assets, and investment significantly more than local firms following depreciations. Hofmann, Shim, and Shin (2016) explore sovereign yields and the risk-taking channel of currency appreciation; Avdjiev, Bruno, Koch, and Shin (2018) explore the relationship between the strength of the U.S. dollar, cross-border bank flows and real investment.

The structure of this paper is as follows. Section 2 lays out the main institutional background details for Japan and Russia. Section 3 describes the data sources, presents the identification strategy, and walks through the empirical results. Section 4 develops a framework of competitive devaluations featuring accepted ingredients from international trade that have not yet been combined for thinking about monetary policy. Section 5 numerically evaluates the impact of competitive devaluations on firm dynamics and aggregate outcomes. Section 6 concludes.

2 Devaluation Episodes

This section describes the main events leading up to the Japanese and Russian exchange rate shocks, highlighting important commonalities and differences. Abenomics constitutes a particularly clean example of a recent competitive devaluation and is, therefore, an ideal laboratory for studying the dynamic adjustment paths following such policies. Russia's 2014 ruble devaluation provides external validity to the mechanism despite having been driven by a negative shock to export prices rather than monetary interventions.

[7]In related work, Gorodnichenko and Weber (2016) show that the conditional volatility of returns increases relatively more for companies with stickier prices in the aftermath of monetary shocks.

2.1 Japan: Abenomics

Having fought deflation for more than two decades, Japan remains plagued by weak growth and feeble consumer sentiment despite countless attempts to revitalize the economy. Short-term nominal interest rates have hovered around zero since the mid 1990s, meaning that conventional monetary policy has long exhausted its potential, and, in spite of a mild economic recovery in the 2000s along with various fiscal stimulus programs, aggregate consumption and investment remain subdued. It is against that backdrop of perpetual malaise that shortly after taking office in December 2012, Japan's new prime minister, Shinzo Abe, announced a novel array of unorthodox policies aimed at breaking through Japan's deflationary spiral.

Abe's approach, soon labeled *Abenomics*, consisted of three pillars and was meant to combine aggressive monetary easing with fiscal policy and structural reforms. Its immediate goal was to boost domestic growth while raising inflation to a newly set target of 2 percent. Abe's less-well-implemented structural policies were meant to improve economic performance by increasing competition, overhauling corporate governance, and making labor markets more flexible.

The first, and central, pillar of Abenomics was an unprecedented policy of monetary easing. Soon after Abe's election, the Bank of Japan (BoJ) was given a mandate to generate two percent inflation as measured by the consumer price index (CPI), while the introduction quantitative easing (QE) meant that the monetary base would increase at an annual pace of about 60-70 trillion yen.[8] The BoJ began buying Japanese government bonds (JGBs), increasing their outstanding amount at an annual pace of about 50 trillion yen, and JGBs of all maturities, including 40-year bonds, were made eligible for purchase. With the objective of lowering risk premia, the BoJ also started purchasing ETFs and real estate investment trusts (J-REITs) on a much smaller scale, with annual paces of 1 trillion yen and 30 billion yen, respectively.

Yet the economy continued to recover moderately and inflation remained subdued following a consumption-tax hike and a substantial decline in crude oil prices. The BoJ voted for an acceleration of its JGB purchases on October 31, 2014. The amount outstanding of JGBs would now increase at an annual pace of about 80 trillion yen (an addition of about 30 trillion yen compared with the first round). The average remaining maturity of the BoJ's JGB purchases was also extended to about 7-10 years. Overall, and compared with past efforts to revive the economy, this monetary component of Abenomics achieved a great deal by beating core deflation (excluding

[8] As a result, high-powered money reached approximately 200 trillion yen at the end of 2013 and 270 trillion yen at the end of 2014, starting from 138 trillion yen outstanding at the end of 2012.

energy prices) and, importantly, devaluing the yen by 50% in just under two years.

In the meantime, structural reforms and fiscal policies have advanced haltingly. An increase in the consumption tax from 5% to 8% in April 2014 caused damage to household spending and GDP growth despite an initial fiscal stimulus bill of 10.3 trillion yen targeting disaster prevention, spending on infrastructure, and reconstruction. A second value-added tax rise to 10% has been announced and twice postponed. Essentially, with a public debt level of 250%, Japan's ability to use expansionary fiscal policy is limited by the important challenge of fiscal consolidation. Consistent with the identifying assumptions in this paper, Japanese growth has been disappointing in part due to the missing second and third arrows.[9]

Abe's efforts at structural reforms failed to deliver breakthroughs. The few adopted policies introduced new corporate governance codes for Japanese institutional investors. In 2012, only two-fifths of leading companies had independent directors, whereas nearly all of them do now. However, those changes were introduced after the yen depreciation and the main cross-sectional patterns discussed in section 3.3 began to emerge. Besides, any governance reforms should have penalized nonexporting firms and depressed their equity prices relative to the larger and less opaque multinationals—indicating that the main estimates are likely to be lower bounds on the effects of the devaluation.[10]

2.2 Russia: 2014 Devaluation

In 2014, a decline in investor confidence led to a rapid fall in the value of the Russian ruble. Falling confidence in the Russian economy stemmed from two major sources: first, the price of crude oil, a key Russian export, declined by nearly 50% from June 2014 to December 2014; second, the annexation of Crimea in March 2014 precipitated Western asset freezes on Russian energy and banking sectors that were implemented by July 2014.[11] In response, Russia implemented a wide-ranging food import ban against the EU, although no other trade was restricted.

The partial cutoff from western sources of financing is unlikely to have exerted a differential influence on importing versus nonimporting firms in Russia. Besides, it can hardly explain the observed domestic revenue and employment reallocation in favor of smaller, more finan-

[9] In fact, the IMF estimates that overall fiscal policy has actually gotten tighter due to the described consumption-tax increase (Krugman (2016)).

[10] Overall, structural reforms remain largely unimplemented, and unconventional monetary policy has unanimously been seen as the only potent arrow of Abenomics (Hausman and Wieland (2015)).

[11] See, for example, the New York Times article "Raising Stakes on Russia, U.S. Adds Sanctions" on July 17 of 2014.

cially constrained nonimporters after the devaluation. Further, the cross-sectional transmission patterns are robust to the exclusion of not just financial firms, some of which underwent direct scrutiny, but also the entire oil and gas extraction sector. Excluding those resource sectors from the analysis is important because of the direct negative shock to their revenue streams in the aftermath of the oil price collapse, which would confound the impact of the ruble devaluation. Removing oil and gas firms also helps identify the intermediate inputs channel as the bulk of all pre-devaluation dollar borrowing occurred in precisely those sectors.[12] Finally, given the large size of the baseline sample for Russia and a regression model that accounts for a differential response to the devaluation by firms with varying debt levels, the result are unlikely to be contaminated by negative balance sheet effects stemming from currency mismatch.

In general, and in spite of the contrasting macroeconomic environment, the availability of Russian firm-level customs data with import intensities for each company, a cross-sectional identification strategy that strips out aggregate shocks, as well as a focus on non-financial and non-resource oriented industries provides for meaningful external validity and confirms the significance of the imported intermediate inputs channel through direct examination.

2.3 Aggregate patterns

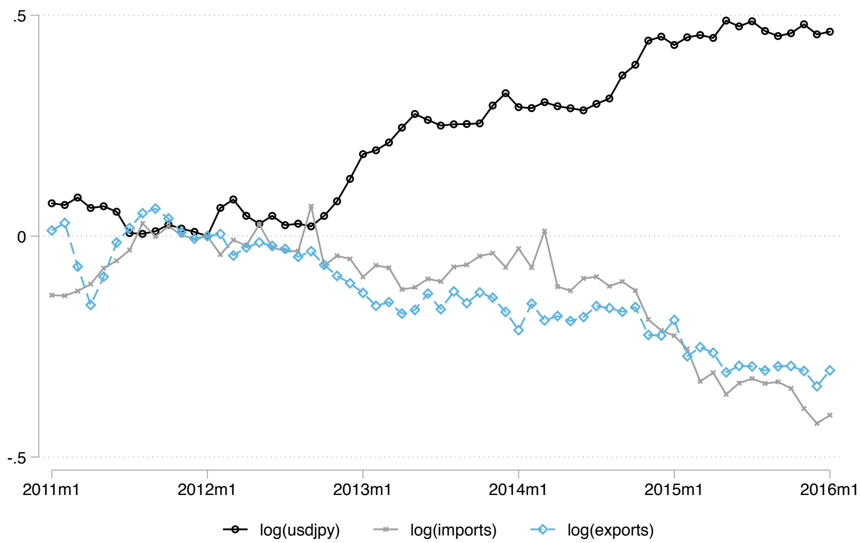
Panel (A) of Figure 1 displays Japan's nominal exchange rate and trade balance over time. As the yen devalued rapidly against most currencies at the end of 2012, both exports and imports (measured in U.S. dollars) declined modestly for around two years, until the second wave of QE further depreciated the yen and appeared to put a dent into the growth of imports. Exports, however, still failed to increase—the initial deterioration of the trade balance, which started to improve only around 2015 is not simply the J-curve effect: while a low substitutability between domestic and imported inputs ensured that Japanese firms were reluctant to decrease their imports for a long time, standard open economy reasoning would dictate that the trade balance should eventually improve due to rising exports.[13] Moreover, Japan's aggregate patterns are at odds with the well-known local currency pricing (LCP) paradigm as one would not expect imports (valued in dollars) to remain insensitive to a devaluation of such magnitude under that particular form of

[12] According to Thomson Reuters SDC data, from 2006 until 2014 Russian companies operating in non-natural resource and non-financial industries issued only 66 foreign-denominated bonds.

[13] Apart from Amiti, Itskhoki, and Konings (2014), multiple other studies suggest that firm-level import intensities are time-invariant. Boehm, Flaaen, and Pandalai-Nayar (2017) argue that the elasticity of substitution between imported and domestic inputs is extremely low and nearly that implied by a Leontief production function; Barrot and Sauvagnat (2016) estimate the elasticity of substitution across intermediate inputs to be around zero.

price rigidity. Panel (B) of Figure 1 shows the same graphs for Russia. Since the ruble devaluation was even more abrupt, it led to a much more rapid decline in both dollar exports and imports, as would be symptomatic of a crisis episode.

(A) Japan



(B) Russia

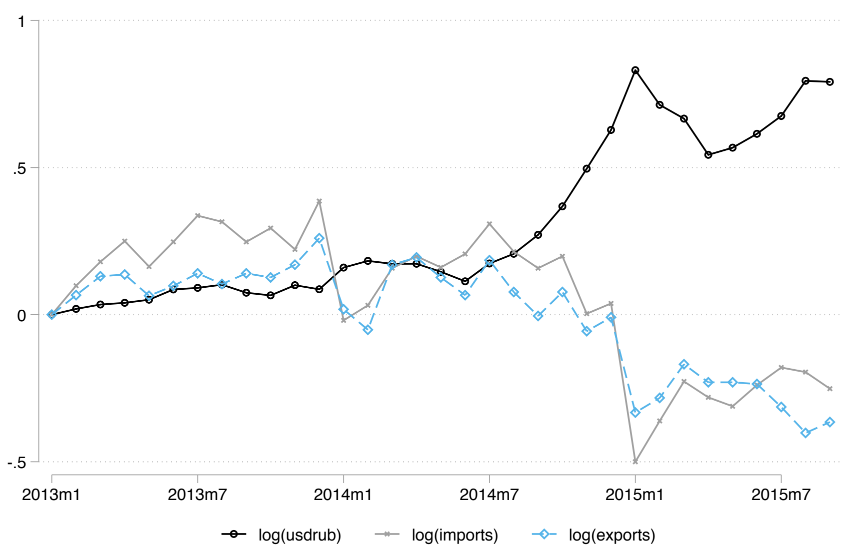
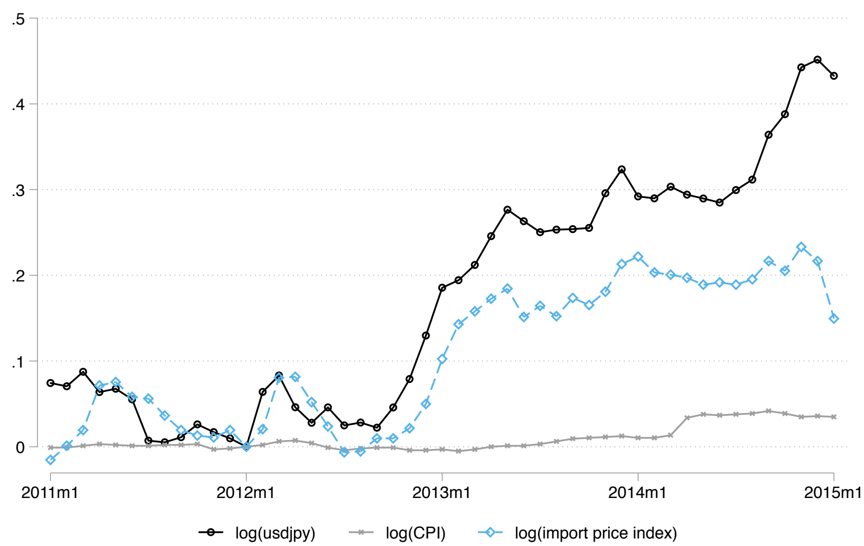


Figure 1: **Exchange rates and trade balances**
Note: Panel (A) shows the evolution in logarithms of the following time series for Japan (normalized to zero in January 2012): the USDJPY exchange rate, imports in USD, and exports in USD. Panel (B) plots analogous time series for Russia from January 2013 until 2015.

(A) Japan



(B) Russia

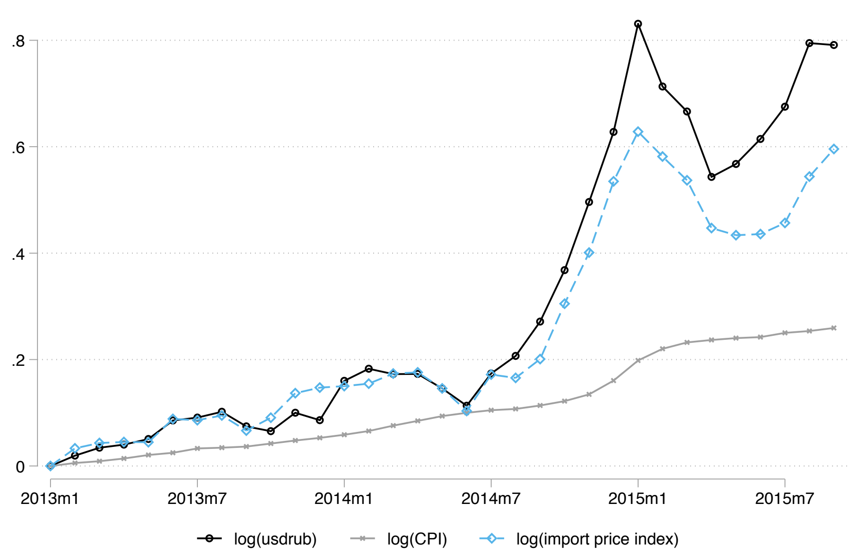


Figure 2: **Price indexes**

Note: Panel (A) shows the evolution in logarithms of the following time series for Japan (normalized to zero in January 2012): the USDJPY exchange rate, CPI, and the import price index. Panel (B) plots analogous time series for Russia from January 2013 until 2015.

Figure 2 documents the evolution of the consumer price indexes (CPI) and the import price indexes, plotted against the nominal exchange rates of both countries. The increase of the import price indexes is conspicuous, as should be expected under international dollar pricing. The consumer price index (CPI) barely moves following the monetary expansion in Japan, rising by only 3% two years after the devaluation started.[14] This comes despite a 50% nominal devaluation but is only partially surprising given that Japan is a fairly closed economy—exports and imports each represent about 14% of GDP—and another important source of much of the observed price rigidity is nominal wage stickiness.[15]

3 Data and Empirical Results

This section describes the microdata, the methodology used for identification, and presents key empirical results on the expansion paths of nonexporting/nonimporting and multinational firms following both devaluation episodes.

3.1 Data construction

The operating information on Japanese firms and their international revenues is sourced from the Worldscope, Capital IQ, and ORBIS data sets. The former two sources mostly cover big listed companies, and they are combined for cross-checking reasons and to limit the number of missing observations. The ORBIS database, compiled by Bureau van Dijk Electronic Publishing (BvD), provides firm-level microdata for many countries around the world and contains financial accounting information from detailed, harmonized balance sheets and income statements of private companies. The main sample contains annual firm-level data on public Worldscope and Capital IQ as well as private ORBIS firms over the period from 2010 to 2015.

The Russian firm-level operating data are sourced from Amadeus, a more comprehensive subset of ORBIS that specializes in collecting financial information on millions of publicly traded and private companies in Western and Eastern Europe. As with ORBIS, the data usually come from local information providers and company registers. The customs data are obtained from the Fed-

[14]The increase in the sales tax from 5% to 8% in April 2014 contributed partially to CPI inflation, generating a further rise of about 1.2 percentage points in May of 2014.

[15]According to Japan's Ministry of Health, Labor and Welfare, nominal wages were perfectly sticky over this time period while the real wage index declined by exactly the same amount as overall inflation increased. Those patterns imply that both sticky wages and international dollar pricing are key features of the macroeconomic environment—an observation that informs modeling choices in section 4.

eral Customs Service of Russia and include information on the universe of Russian importers and exporters from January 2013 until April 2014, just before the abrupt ruble devaluation in late 2014. The data are reported at daily frequencies and include firms' unique tax identification number (INN), a nine digit HS product code, the invoice currency for each transaction, the gross and net weights, the ruble and U.S. dollar values of each shipment, the country of origin and destination, as well as other pertinent details. Those customs data are then linked to each Amadeus firm using the INN, and firms that have missing identifiers are hand-matched by zip code, industry and name. The resulting merged data files allow for the calculation of import intensities of each Russian firm in the Amadeus data.

All main specifications restrict attention to a balanced sample, and firm-years for which information on revenue, employment, and total assets is not available are excluded from the analysis. Observations with negative equity, revenue, or revenue growth larger than 200% are similarly omitted. Industries are classified at the four-digit SIC level and all financial firms (6000−6800 SIC range) are dropped. In the merged Japanese public and private firm data, this selection procedure leaves 593 four-digit industries and 30,916 companies operating mainly in manufacturing sectors. The average number of firms per industry is about 52, and the number of companies with multinational operations and exports constitutes 14% of the total number of firms in an industry. Analogous preprocessing for Russia generates a baseline sample with 263 four-digit NAICS industries and 69,036 firms operating in non-financial and non-resource industries. The mean number of firms per sector is 262 and importers amount to 12% of this total. Appendix A provides definitions of the variables used in the empirical section and describes well-known techniques to avoid missing-data problems when downloading the ORBIS data.

The main empirical results for Japan are based on the pooled public and private firm data set.[16] However, the main results are unchanged when the analysis is confined to the subsample of listed firms. Many investors and market participants have further noted the relatively strong performance of small-caps in Japan, even when judged against some of the biggest exporters since the onset of Abenomics.[17] And given that the largest exporters are usually also the biggest importers (Amiti, Itskhoki, and Konings (2014)), this preliminary evidence lends support to the

[16]Japan has one of the highest percentages of publicly listed firms compared with other industrialized nations. According to the World Bank, the market capitalization of listed domestic companies in Japan as a percentage of GDP was about 119% in 2015, whereas the same number for Germany stood at 51.1%.

[17]See, for example, The Japan Times article "Japan's small-caps doing well while big exporters get a bruising" on January 15 of 2016.

intermediate inputs channel stressed in the paper.[18]

Panel (A) of Table 1 provides summary statistics on a range of key firm-specific characteristics for Japan in 2012, one year prior to the onset of Abenomics. The exporter indicator represents the treatment variable for Japanese firms, and it is equal to 0 whenever a firm has no foreign sales and 1 if the company is a continuing exporter between 2010 and 2015. As in other countries, the incidence of exporting is rare for both Japan and Russia, and, whenever firms export, they still cater primarily to the domestic market.[19] Panel (B) of Table 1 lists analogous summary statistics for Russian non-financial companies. Again, importing is extremely rare on average, and, as can be seen from Table 2, even though 91.71% of firms do not import any intermediate inputs, the largest 2.17% of importers account for 73.13% of the overall import value. Furthermore, exporters capture 22% of the domestic revenue volume in Japan in 2012, whereas importers account for 46% of total domestic sales in Russia in 2013.

The aggregate data on output, inflation, trade balances, and interest rate statistics are collected from the Japanese Ministry of Finance, the Bank of Japan, and the Russian Federal State Statistics Service. Spot and forward exchange rate information is sourced from IHS Global Insight, and the Japanese import content of production is measured at the industry level, based on the 2011 OECD input-output tables. The observed variation in import intensities across sectors is exploited to reveal the precise mechanisms underlying the cross-sectional firm-level results.

3.2 Identification

This section lays out the identification strategy for estimating the adjustment paths of relatively exposed and unexposed firms to both devaluation episodes. Methods for gauging the importance of different mechanisms are discussed.

At the macro level, the identification challenge stems from the endogeneity of nominal exchange rate movements. Many countries have experienced periods of large real exchange rate devaluations, and in general many factors have the potential to fuel such currency fluctuations.

[18] For Japan, the analysis relies on a company's segment files to identify exporters. While foreign sales combine exports together with total revenues generated in other countries, extant trade research points to most international commerce as being carried out by multinationals that both export and use their foreign affiliates to serve the host market (e.g., Antràs and Yeaple (2014), Tintelnot (2017), Rob and Vettas (2003)). The Russian firm-level customs data allow one to dissect the mechanism directly and confirm the baseline results for Japan.

[19] Previous work has documented that exporting firms ship a relatively small fraction of their total produce abroad. For example, computer and electronic industries have the highest fraction of exports to total shipments in the U.S., and yet that number is only 21% (Bernard, Jensen, Redding, and Schott (2007)).

Table 1: Summary statistics

	Mean	SD	p25	p50	p75	No. obs.
(A): Japanese firm-level variables						
Exporter indicator	0.01	0.08	0.00	0.00	0.00	30,916
Import content of production	11.36	4.61	9.30	11.30	11.30	30,916
Employment	138	1753	7.00	15	37	30,916
Log domestic revenue	9.13	3.33	7.53	8.67	9.76	30,916
Log gross profit	7.48	3.34	5.92	6.93	8.03	30,916
Return-to-assets	0.77	34.44	0.06	1.07	3.56	30,915
Log cost of goods sold	8.84	3.37	7.23	8.42	9.54	30,751
Firm age (as of 2012)	34.21	17.25	21.00	33.00	46.00	30,851
Firm size (log assets)	8.73	3.47	7.02	8.29	9.51	30,916
Leverage (debt-to-equity)	32.90	58.44	4.66	23.35	45.79	30,916
Cash-to-assets	0.26	0.19	0.11	0.21	0.36	30,916
Log market capitalization	23.25	1.63	22.02	23.09	24.26	1,113
Tobin's Q ratio	2.02	2.19	1.61	1.87	2.19	1,113
(B): Russian firm-level variables						
Import intensity, φ_i	0.02	0.12	0.00	0.00	0.00	69,073
Employment	131	3484	29	44	85	67,577
Log domestic revenue	17.25	2.12	15.77	17.14	18.61	67,080
Log gross profit	15.53	2.40	13.97	15.52	17.13	48,484
Return-to-assets	8.62	19.80	0.41	5.23	15.12	66,213
Log cost of goods sold	17.31	2.21	15.78	17.24	18.78	52,683
Firm age (as of 2013)	14.52	8.13	9.00	13.00	19.00	69,073
Firm size (log assets)	16.80	2.30	15.13	16.69	18.33	67,572
Leverage (debt-to-equity)	54.91	136.03	0.00	0.11	36.92	59,634
Cash-to-assets	0.10	0.17	0.01	0.03	0.11	64,762

Note: This table presents summary statistics for the main variables used in the empirical analysis. Panel (A) reports summary statistics for private firms in the Bureau van Dijk (BvD) ORBIS database as of 2012, together with public firms from Thomson Reuters Worldscope. Panel (B) contains summary statistics for Russian Amadeus firms in 2013.

For example, those factors can stem from domestic policies aimed at combating deflationary risks, to large capital outflows caused by domestic or external factors, to exchange rate interventions at home or abroad, to domestic consumption booms, or to a sharp fall in the terms of trade in commodity producing economies.

The Japanese exchange rate devaluation from late 2012 until 2014 was a new policy response to persistent issues—Abenomics entailed an unprecedented monetary expansion that resulted in a yen depreciation of roughly 50% against the U.S. dollar within two years. Attributing any aggregate reaction to a competitive devaluation would be complicated if, for example, adverse

Table 2: Distribution of import intensity among importers

	No. of firms	Fraction of firms	Fraction of import value
$\varphi_i = 0$	63,539	91.71%	0%
$0 < \varphi_i \leq 0.1$	2,976	4.30%	7.62%
$0.1 < \varphi_i \leq 0.2$	635	0.92%	6.67%
$0.2 < \varphi_i \leq 0.3$	370	0.53%	5.34%
$0.3 < \varphi_i \leq 0.4$	256	0.37%	7.24%
$\varphi_i > 0.4$	1,506	2.17%	73.13%

Note: This table shows the distribution of import intensity among Russian non-financial companies for 2013. *Import intensity, φ_i, is defined for each firm as the share of imported intermediate inputs from outside of Russia in total variable costs.*

productivity shocks were the true underlying force instead.

At the micro level, accounting information and novel firm-level customs data from Russia are used to investigate the response of firms that vary in their exposure to exchange rate fluctuations while stripping out aggregate shocks to the economy.

3.2.1 Cross-sectional evidence

Much of the evidence relies on nominal exchange rates affecting nonexporting/nonimporting companies differentially compared to multinationals in Japan and Russia. Because the objective is to discipline the transmission mechanism of devaluations using firm-level data, the main focus will be on investigating the causal impact of the devaluations on domestic revenue, employment, and profitability via a difference-in-differences estimation strategy.

Another important concern has to do with the timing of the effects. In particular, any disparities between the more affected exporters/importers and the relatively unaffected, purely domestic firms might be driven by pre-existing trends that originated before the onset of Abenomics or the ruble devaluation. To lend additional support to the causal interpretation of the results, the next series of tests relies on using repeated observations for the same company over time. The following fixed-effects regression allows one to see whether causes happen before consequences and not vice versa:

$$\log(Y_{i,t}) = \alpha_i + \theta' X_{i,t} + \sum_t \gamma_t \mathbf{D}_t + \sum_t \delta_t \left(\mathbf{D}_t \cdot X_{i,t}\right) + \sum_t \psi_t \left(\mathbf{D}_t \cdot Treat_i\right) + \epsilon_{i,t} \qquad (1)$$

$$\forall i,\ \forall t \in \{2010, \ldots, 2015\} \setminus \{2012\}$$

where Y_{it} are either domestic revenue, employment, or profitability (return on assets or market capitalization) of company i in year t, α_i are firm fixed effects, $Treat_i$ is an indicator variable equal to 1 whenever a firm is a Japanese exporter and 0 when the firm is entirely domestic, $\mathbf{D}_t$ is an indicator for the time period (year), with 2012 taken as the omitted category for Japan, $(\mathbf{D}_t \cdot Treat_i)$ represents an interaction term between the year dummies and the treatment indicator defined by the disparity between solely domestic versus exporting firms, and $X_{i,t}$ is a matrix of control variables that includes size (log of assets), leverage, as well as cash-to-assets—covariates that are widely used in the literature. All standard errors are clustered at the firm-level to allow for serial correlation across time. When implementing this framework on the merged Russian firm-level customs data to test the imported intermediate inputs channel directly, $Treat_i$ becomes a firm's import intensity rather than an exporter dummy.[20]

As required with any difference-in-differences estimation approach, this specification also provides evidence on the parallel trends assumption in all outcome variables. That is, in the absence of treatment, the unobserved disparities between exposed and less exposed companies should be constant over time; the validity of the estimation procedure relies on outcome variables that would have continued to develop as they did before either devaluation episode. Unless this assumption is valid, the estimated treatment effects would be biased versions of the true impact. As an additional robustness check on the identification strategy, all control variables are interacted with the $\mathbf{D}_t$ time indicators to allow for possible heterogeneous reactions to the devaluations across different types of firms over time. For example, a prominent alternative hypothesis involves simultaneous interest rate changes that occurred as a consequence of QE, yet even if movements in interest rates had nonuniform repercussions for exporting and nonexporting firms, the interaction of all control variables, especially leverage, with the full set of year dummies would soak up the bulk of that variation.

The main parameters of interest are the ψ_t coefficients as they capture the difference between more strongly affected exporters/importers and less affected nonexporting/nonimporting firms over time. For Japan, the estimated fixed-effects model includes leads going back to 2010 and lags reaching 2015. The available data for Russia allows one to include three leads starting from 2011 and one post-devaluation lag in 2015. The specification tolerates any causal direction of the findings and assesses whether the effects grow or fade over time.

[20]This treatment intensity is defined as the share of imported intermediate inputs in total variable costs of a firm in 2013 (right-winsorized at the 99.5 percentile). 2014 becomes the omitted year category.

Appendix B lays out a triple difference methodology to tease out the transmission mechanism in Japan as firm-level customs data is unavailable to facilitate a direct test as for Russia.

3.3 Empirical results

This section presents the main cross-sectional findings in Japan and Russia following both devaluation episodes. Heterogeneous import intensities are shown to be the key driving force behind the unorthodox adjustment patterns across firms.

3.3.1 Cross-sectional evidence

Before turning to the baseline results, the data reveal some pertinent information about entry into exporting (or foreign sales). As confirmed in previous trade studies (e.g., Bilbiie, Ghironi, and Melitz (2012)), this extensive margin is inconsequential in terms of the overall trade volume. The distinction between new exporters and nonexporting firms is thus also left out from subsequent analysis—attention is devoted to purely domestic firms and continuing exporters when evaluating the cross-sectional impact of both devaluation episodes.[21]

As revealed by the summary statistics, companies that engage in export activity are distinct along a number of relevant dimensions. Table 3 tests whether multinationals are in fact systematically different from their counterparts based on more formal regression analysis. Panel (A) of Table 3 presents estimated model coefficients of the export status of Japanese firms on various firm-level characteristics in 2012. Panel (B) does the same for Russian companies with import intensity, φ_i, as the dependent variable in 2013.

Indeed, exporters (and importers) are much larger than purely domestic firms in terms of their balance sheet size (log assets) as well as employment or domestic revenue; they tend to be differentially levered in both countries; they are distinct as far as their cash-to-assets ratio is concerned, and they are characterized by a higher price-to-book ratio for public firms, meaning that they are growth stocks in larger proportions than nonexporting/nonimporting companies. Those differences suggest that all regressions should control for key time-varying disparities

[21] Even though Japan experienced a feeble aggregate reaction of export volumes (as shown in Figure 1), the weaker yen appears to have induced entry into foreign sales. Unreported results show that there was a steep increase in the proportion of companies with positive foreign sales after the devaluation. However, the evidence also indicates that, despite growing at a faster rate than existing multinationals, the cohort of 2013 entrants (firms that have never listed any foreign sales prior to 2013) represents a negligible fraction of the total foreign sales volume. Indeed, newcomers turn out to resemble purely domestic firms more closely than continuing exporters in terms of size and other pertinent operating characteristics.

Table 3: Correlates of import intensity and export status

	Coefficient	S.E.	R^2	No. obs.
(A): Japanese firm-level variables, x_i				
Log employment	0.014***	0.004	0.064	30,916
Log domestic revenue	0.008***	0.002	0.125	30,916
Log gross profit	0.008***	0.002	0.127	30,915
Return on assets	0.000	0.000	0.000	33,379
Size (log assets)	0.008***	0.002	0.128	30,916
Leverage	-0.000**	0.000	0.000	30,916
Cash-to-assets	-0.008**	0.004	0.000	30,916
Log market capitalization	0.044***	0.015	0.038	1,113
Tobin's Q ratio	0.018***	0.006	0.012	1,113
(B): Russian firm-level variables, x_i				
Log employment	0.016***	0.003	0.018	67,546
Log domestic revenue	0.010***	0.002	0.034	67,052
Log gross profit	0.011***	0.002	0.040	48,462
Return on assets	0.000*	0.000	0.001	66,183
Size (log assets)	0.009***	0.002	0.031	67,541
Leverage	0.000***	0.000	0.002	59,608
Cash-to-assets	-0.004	0.008	0.000	64,732

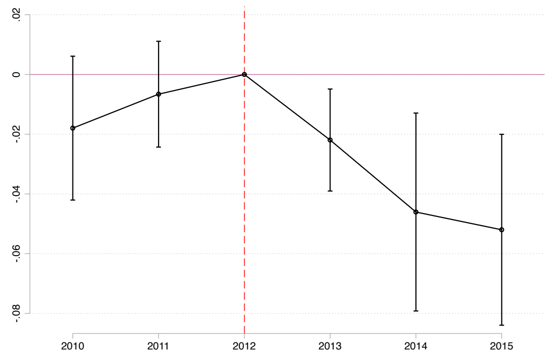
*Note: Panel (A) presents regressions of the export status of Japanese firms as the dependent variable on various firm-level characteristics. Panel (B) does the same for the import intensity, φ_i, of Russian firms in 2013: $\varphi_i = \alpha + \beta x_i + u_i$. The table shows that importing (or exporting) firms tend to be a lot bigger in terms of assets, revenue and employment. Those companies also tend to have different leverage or cash-to-assets ratios when compared with their nonimporting (or nonexporting) peers. Standard errors are clustered at the two digit SIC level. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.*

among companies, such as size and other balance sheet items that have been widely used in the finance literature and are pertinent to revenue and employment choices. Importantly, the inclusion of those control variables based on correlations in Table 3 has almost no bearing on the responsiveness of all main outcomes to the devaluation episodes. At the same time, it is important to account for major dissimilarities between exporting and nonexporting firms to elicit unbiased treatment effects of both nominal devaluations.

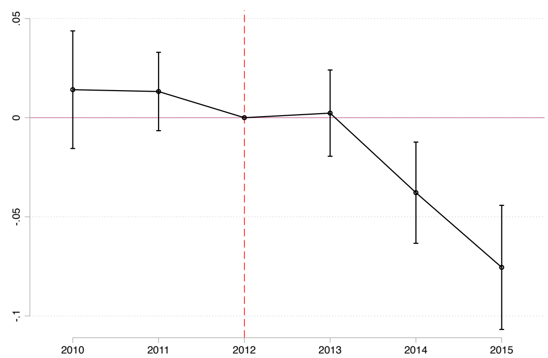
The results in Figure 3 restrict attention to Japanese firms and plot the estimated ψ_t coefficients of equation 1 for employment, domestic revenue, and market capitalization as outcome variables with 95% confidence intervals around them.[22] As would be consistent with the parallel

[22]Market capitalization is taken to be the baseline profitability measure for Japan as there is no consistent return on assets variable in the combined public and private firm database due to deviations in accounting conventions used by ORBIS and Worldscope. Nonetheless, the results are qualitatively very similar for the gross profit margin as

(A) Employment



(B) Domestic revenue



(C) Market capitalization

Figure 3: **Coefficient plots for Japanese firms**
Note: These figures plot the estimated ψ_t coefficients from equation 1 for employment, domestic revenue and market capitalization as outcome variables with 95% confidence intervals. Time is measured in years and the vertical red (dashed) lines mark the beginning of Abenomics.

trends assumption, the estimates in Figure 3 show no robust differences between exporters and nonexporting firms in the years prior to the onset of quantitative easing: the estimated treatment effects—capturing differences between both types of companies over time—are indistinguishable from zero before the intervention, whereas they become negative and highly significant in the years following Abenomics. The results indicate that exporters' domestic revenues shrink by approximately 7%, employment gradually decreases by about 5%, and market capitalization falls by about 10% relative to purely domestic nonexporting firms.[23]

Overall, and in sharp contrast to conventional open economy macro wisdom, exporters gain less from the nominal devaluation than exclusively domestic small caps and private firms. The results are also robust to the inclusion of industry-year fixed effects, which further suggests that the adjustment patterns are driven by firm heterogeneity *within* rather than across industries—an observation that is built into the theoretical framework in section 4. A question arises as to why Abenomics had this puzzling differential impact on the dynamics of continuing exporters versus purely domestic companies. After all, baseline models would predict that the former group should gain competitiveness in export markets as a result of the yen devaluation. One possible explanation is the countervailing influence of rising marginal costs due to increasingly more expensive and poorly substitutable imported intermediate inputs. In fact, the findings thus far are consistent with the marginal cost channel outweighing any positive effects in export markets and showing no signs of attenuating later on.[24]

3.3.2 Mechanisms

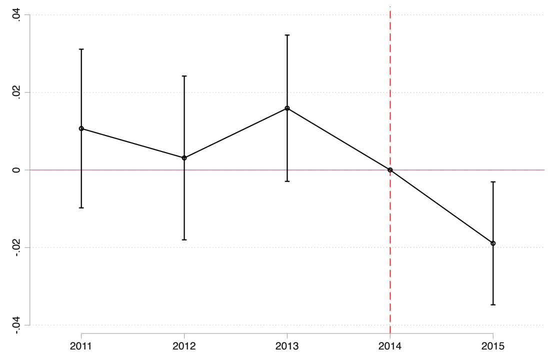
Despite the starkly different macroeconomic conditions in Russia around 2014, the availability of firm-level customs data with import intensities for each company implies that the above cross-sectional identification strategy can be applied to test the mechanism directly while stripping out aggregate shocks that affect all types of firms in the same way. As discussed in section 3.1, identification is further bolstered through the exclusive focus on non-financial and non-resource oriented industries to provide external validity.

the outcome variable.

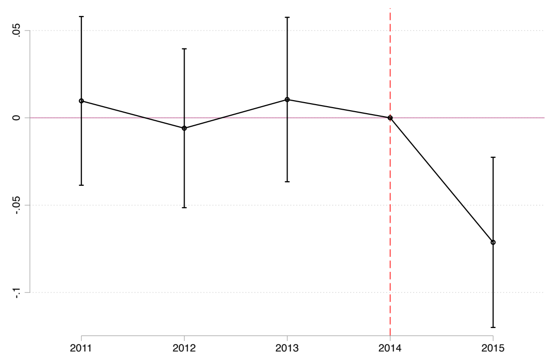
[23]In unreported figures, all of these outcome variables are shown to expand in *levels* and not just in relative terms between exporters and nonexporters. The steep reaction of stock prices to the yen devaluation is particularly surprising given the low overall levels of inflation observed during this period and the fact that exchange rates are often seen as "disconnected" from other variables.

[24]Other narratives, such as a foreign demand shock, the presence of foreign subsidiaries, or hedging exposure could influence firm profits but cannot explain the joint reallocation patterns for domestic revenue and employment.

(A) Employment



(B) Domestic revenue



(C) Return on assets

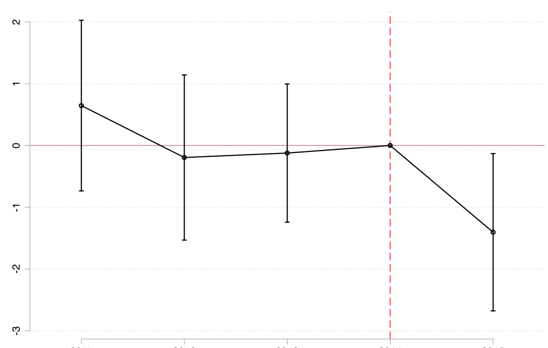


Figure 4: **Coefficient plots for Russian firms**

Note: These figures plot the estimated ψ_t coefficients from equation 1 for employment, domestic revenue and return on assets as outcome variables with 95% confidence intervals. Time is measured in years and the vertical red (dashed) lines mark the 2014 ruble devaluation episode.

The results in Figure 4 plot the estimated ψ_t coefficients of equation 1 using the Russian data for employment, domestic revenue, and return on assets as outcome variables with 95% confidence intervals around them. As in the case of Japan, the estimates in Figure 4 show no robust differences between importers and nonimporters in the years prior to the 2014 ruble devaluation and are, therefore, entirely consistent with the parallel trends assumption. The results indicate that importers' domestic revenues shrink by approximately 7%, employment decreases by about 2%, and the return on assets falls by about 12% relative to smaller nonimporting firms one year after the abrupt devaluation. These findings lend additional support to the significance of imported intermediate inputs in the transmission channel.[25]

The analysis in this section has relied on the identifying assumption that exchange rate movements rather than any other factor exerted the primary differential influence on firms and led to the trends observed following both devaluation episodes. Another prominent hypothesis emphasizes interest rate shifts. Yet the evidence is limited as far as downward pressure on the yield curve is concerned—Japanese long-term interest rates were already very low when Abenomics came into force, and they actually increased following the announcement of U.S. tapering in early 2013. This can be seen from Panel (B) in Figure B.1, which shows the 8-year yield on JGBs, a security class that was heavily targeted during Japan's QE interventions. Long-term interest rates only declined somewhat further toward 2015, after the second round of quantitative easing. By that time, all of the main cross-sectional effects had already set in: domestic revenues, employment, and stock prices were rising for nonexporting firms relative to exporters. Besides, it would be hard to envisage a theory for why lower interest rates would generate the observed patterns between exporters and nonexporters. Interest rate movements could therefore not have been the main explanatory factor behind the empirical regularities.

Lastly, potential confounding factors stemming from a revaluation of long-term debt are accounted for in the regression model—the inclusion of leverage as well as its interaction term with the time indicator allows for a heterogeneous response to the nominal devaluation across firms with varying degrees of exposure to long-term debt in both Russia and Japan.[26] Taken together,

[25] Appendix B sheds more light on the role of intermediate inputs as the driving force behind the results in Japan. A triple difference methodology is used and confirms the same transmission channel as for Russia.

[26] Another alternative story could stress currency mismatch and differential exposure to dollar borrowing across firms. This phenomenon is extremely rare in Japan, where only a tiny fraction of companies have ever issued a Eurobond. In Russia, only 66 foreign currency bonds were issued by non-financial and non-resource oriented companies in 2006–2014. See Bruno and Shin (2017) or, recently, Salomao and Varela (2018) for more detail on the foreign currency borrowing channel.

these findings inform a new theoretical paradigm that features a more realistic microstructure of the economy to understand the effects of monetary policy and competitive devaluations on firm dynamics. The model in section 4 embeds heterogeneous import intensities across firms as an ingredient for generating the observed cross-sectional patterns documented so far.

4 Model

This section develops a framework to help interpret the differential treatment effects between exporters and nonexporters in section 3.3 and uses it to understand the mechanism underlying the dynamic adjustment path of the economy.

There are two countries of equal size, home (H) and foreign (F). As in the models of Obstfeld and Rogoff (2000) and Obstfeld and Rogoff (1996), firms produce differentiated goods using heterogeneous labor inputs. Workers are subject to a Calvo friction when setting wages in home currency, but domestic prices are flexible and can be changed in response to market conditions. Home and foreign produce an array of tradable goods.[27]

Several ingredients from trade are ingrained into the framework. First, firms are treated as heterogeneous, choosing to sell products and to source intermediate inputs from abroad. The exchange rate enters via three potential channels: i) by changing the costs of imported inputs, ii) by potentially changing the export prices in local currency, and iii) by affecting the degree of import competition in the domestic market. Strategic complementarities in price setting improve the quantitative fit without changing the qualitative predictions of the model.

Second, the following international pricing structure is compared in turn: i) producer currency pricing (PCP), ii) local currency pricing (LCP), and iii) dollar currency pricing (DCP). The last is consistent with recent evidence on most trade being invoiced in U.S. dollars (Gopinath (2016)) and is critical in reproducing observed patterns in the data. The nominal exchange rate, ϵ, is expressed as home currency per unit of foreign currency. Going forward, the home currency can be thought of as *yen* and the foreign currency as *dollar*. Figure 5 provides a schematic representation of the benchmark model.[28]

[27] One might think that tradable goods are products of exporters whereas nontraded goods are produced by non-exporters. However, this would be inconsistent with the data and the model will account for the fact that all cross-sectional patterns are observed *within* rather than across industries.

[28] Exporting firms and their non-domestic operations are depicted in blue. The foreign market is also shown in a smaller size than the domestic market, which reflects trade stylized facts about exporting firms shipping a relatively small fraction of their total produce abroad (see, for example, Bernard, Jensen, Redding, and Schott (2007)).

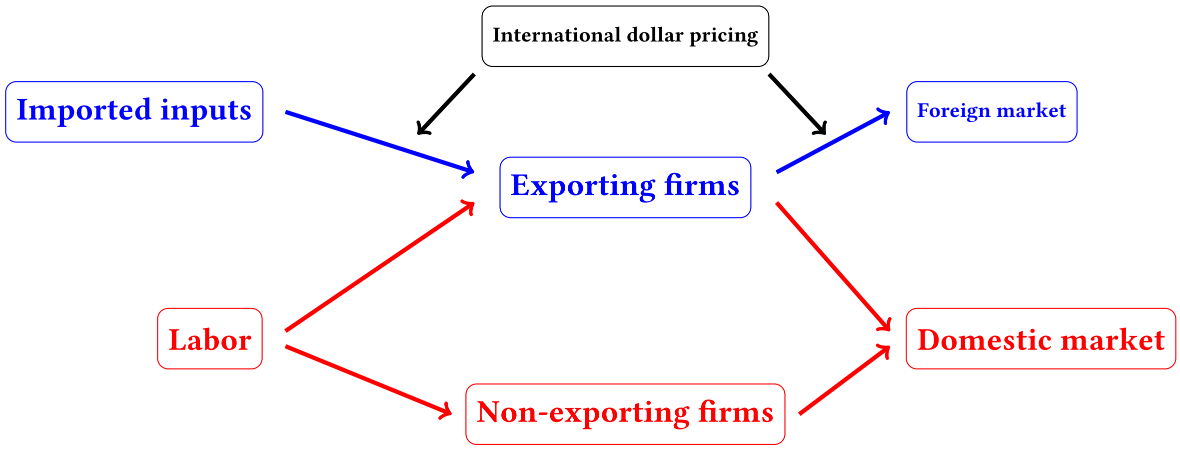


Figure 5: **Schematic representation of benchmark model**

Motivated by Bilbiie, Ghironi, and Melitz (2012) and unreported empirical facts showing that entry into foreign sales is a negligible portion of trade, the export/import status of a firm is assumed to be fixed.[29] The trade literature (e.g., Halpern, Koren, and Szeidl (2015), or Amiti, Itskhoki, and Konings (2014)) takes a detailed approach when thinking about firm import and export decisions and concludes that both are highly correlated in equilibrium as well as in the data. This implies that the majority of firms are either exporters or nonexporters, and so the present treatment focuses on those two types, thereby mimicking the empirical discussion.

4.1 Households

There is monopolistic competition in the labor market among households who set staggered nominal wage contracts. Individual household labor supply is differentiated and indexed by i on the unit interval. Household-level labor inputs, $\ell_{i,t}$, are aggregated to generate total labor supply, L_t, before this is supplied to firms. Specifically:

$$L_t = \left(\int_0^1 \ell_{i,t}^{\frac{\phi-1}{\phi}} \, \mathrm{d}i \right)^{\frac{\phi}{\phi-1}} \tag{2}$$

where $\phi > 1$ represents the elasticity of the relative wage. Standard CES aggregation results for the profit maximization problem generate formulas for the demand for each given variety

[29]New firms account for a very small share of overall production and employment, meaning that at first approximation one can ignore the extensive margin when studying aggregate outcomes.

of differentiated household labor supply and an aggregate wage index, which depend on the individual-specific wage for labor of type i, $W_{i,t}$, and the aggregate wage index W_t, at which the composite labor bundle is leased to firms:

$$\ell_{i,t} = \left(\frac{W_{i,t}}{W_t}\right)^{-\phi} L_t, \qquad W_t = \left(\int_0^1 W_{i,t}^{1-\phi}\, \mathrm{d}i\right)^{\frac{1}{1-\phi}} \tag{3}$$

Utility is derived from an aggregate index of final real goods consumption (discussed further below) and leisure, with preferences assumed to be separable. Households retain pricing power over their individual-specific nominal wages as they supply differentiated labor services.

Households face a cash-in-advance (CIA) constraint such that the nominal budget constraint for a household i at time period t is given by:

$$P_t c_{i,t} + B_{i,t} + M_{i,t} = W_{i,t}\ell_{i,t} + P_t\Gamma_t + (1+i_{t-1})B_{i,t-1} + M_{i,t-1} \tag{4}$$

where P_t is the aggregate price level, $c_{i,t}$ represents real consumption, $B_{i,t}$ are nominal bonds, $M_{i,t}$ represents nominal money holdings, $W_{i,t}$ is the nominal wage paid to household with individual-specific labor type i, $\ell_{i,t}$ is individual-specific labor supply, Γ_t are real lump-sum transfers paid to all households (which will include firm profits and government transfers), i_{t-1} is the nominal interest rate on bonds held between periods $t-1$ and t. Previous asset holdings are given as bonds, $B_{i,t-1}$, and nominal money, $M_{i,t-1}$. The cash-in-advance constraint specifies that households must finance consumption through monetary holdings ($P_t c_{i,t} \leq M_{i,t-1}$). Both constraints may be re-written in real terms to become:

$$c_{i,t} + b_{i,t} + m_{i,t} = w_{i,t}\ell_{i,t} + \Gamma_t + \frac{1+i_{t-1}}{1+\pi_t} b_{i,t-1} + \frac{m_{i,t-1}}{1+\pi_t} \tag{5}$$

$$(1+\pi_t)c_{i,t} \leq m_{i,t-1} \tag{6}$$

where real variables are defined as lower-case equivalents, $b_{i,t} \equiv B_{i,t}/P_t$, $m_{i,t} \equiv M_{i,t}/P_t$, $w_{i,t} \equiv W_{i,t}/P_t$ and $1+\pi_t \equiv P_t/P_{t-1}$ denotes the rate of inflation in the economy.

Households maximize utility by choosing real consumption, differentiated labor supply, real wages, real bond holdings and real money balances:

$$\max_{c_{i,t},\ell_{i,t},w_{i,t},b_{i,t},m_{i,t}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_{i,t}, l_{i,t}) \tag{7}$$

$$\text{where:} \qquad u(c_{i,t}, \ell_{i,t}) = \ln c_{i,t} - \kappa \frac{\ell_{i,t}^{1+\psi}}{1+\psi} \tag{8}$$

subject to the real budget constraints above, and the first order condition which links the individual-specific real wage and labor supply decisions. This first order condition may be used directly in the household problem to eliminate dependence on $\ell_{i,t}$ as a choice variable, and focus instead on $w_{i,t}$ as household i's objective in the labor market.[30]

Households are subject to a Calvo friction when setting wages. In any given period, they may adjust their wage with probability $1-\theta$ and maintain the previous-period nominal wage otherwise. The standard standard optimality condition for household who are able to update their real wage is given by:

$$w_t^{\#,1+\phi\psi} = \frac{\phi}{\phi-1} \frac{\mathbb{E}_t\left[\sum_{s=t}^{\infty}(\beta\theta)^{s-t}\kappa w_s^{\phi(1+\psi)} L_s^{\psi+1} \Pi_{t,s}^{\phi(\psi+1)}\right]}{\mathbb{E}_t\left[\sum_{s=t}^{\infty}(\beta\theta)^{s-t}\lambda_s w_s^{\phi} \Pi_{t,s}^{\phi-1} L_s\right]} \tag{12}$$

where $\Pi_{t,s} \equiv \prod_{m=1}^{s}(1+\pi_{t+s})$ denotes the product of a series of inflationary realizations, and due to symmetry of the problem across all households dependence on index i is removed. Intuitively, households set their wage equal to a constant markup over a weighted average of current and expected future marginal rates of substitution between labor and consumption.

The index of final real goods consumption, c_t, is taken as a CES aggregated index of home and foreign tradable goods:

$$c_t = \left[\alpha^{\frac{1}{\eta}} c_{H,t}^{\frac{\eta-1}{\eta}} + (1-\alpha)^{\frac{1}{\eta}} c_{F,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{1-\eta}} \tag{13}$$

where the basket of goods comprises of consumption by the home country of an index of home goods, $c_{H,t}$, and consumption by the home country of an index of foreign goods, $c_{F,t}$. The degree

[30]The three first order conditions for an optimal solution of the associated Lagrangian with respect to consumption, real bond holdings and real money balances are then as follows:

$$\frac{1}{c_{i,t}} = \lambda_{i,t} + \mu_{i,t}(1+\pi_t) \tag{9}$$

$$\lambda_{i,t} = \beta\mathbb{E}_t\left[\lambda_{i,t+1}\frac{1+i_t}{1+\pi_{t+1}}\right] \tag{10}$$

$$\lambda_{i,t} = \beta\mathbb{E}_t\left[\frac{\lambda_{i,t+1}}{1+\pi_{i,t+1}} + \mu_{i,t+1}\right] \tag{11}$$

where $\lambda_{i,t}$ denotes the Lagrange multiplier on the budget constraint and $\mu_{i,t}$ denotes the Lagrange multiplier on the cash-in-advance constraint.

of home bias is represented by $\alpha \in (0,1)$, and $\eta > 1$ is the elasticity of substitution between the home and foreign goods indexes. Home consumer demand functions resulting from the utility maximization yield the standard results:

$$c_{H,t} = \alpha \left(\frac{1+\pi_{H,t}}{1+\pi_t} \right)^{-\eta} c_t, \qquad \text{and} \qquad c_{F,t} = (1-\alpha) \left(\frac{1+\pi_{F,t}}{1+\pi_t} \right)^{-\eta} c_t \tag{14}$$

where $1 + \pi_{H,t} \equiv P_{H,t}/P_{t-1}$ and $1 + \pi_{F,t} \equiv P_{F,t}/P_{t-1}$ represent price inflation of the home and foreign goods indexes respectively. These are derived from home and foreign price indexes ($P_{H,t}$ and $P_{F,t}$) and denominated in home currency. The standard pricing aggregator for the home country allows inflation to be found as the combination of home and foreign goods:

$$1 + \pi_t = \left[\alpha (1+\pi_{H,t})^{1-\eta} + (1-\alpha)(1+\pi_{F,t})^{1-\eta} \right]^{\frac{1}{1-\eta}}, \tag{15}$$

which is home consumer price inflation (CPI). The relative demand for each good may be shown to depend on the home terms of trade:

$$\mathcal{T}_t \equiv \frac{P_{F,t}}{P_{H,t}}, \qquad \text{such that:} \qquad \frac{c_{H,t}}{c_{F,t}} = \frac{\alpha}{1-\alpha} \mathcal{T}_t^{\eta} \tag{16}$$

Consumption of the home and foreign goods indexes may be decomposed further. In particular, the home and foreign goods indexes are themselves an index of diversified varieties. For simplicity, it will be sufficient to consider the case of two distinct varieties, with $\omega \in \{N, E\}$ representing a grouping of nonexporting and exporting firms, such that:

$$c_{H,t} = \left(\int_0^1 c_{H,\omega,t}^{\frac{\nu-1}{\nu}} \mathrm{d}\omega \right)^{\frac{\nu}{\nu-1}} = \left(\Lambda_H^{\frac{1}{\nu}} c_{H,N,t}^{\frac{\nu-1}{\nu}} + (1-\Lambda_H)^{\frac{1}{\nu}} c_{H,E,t}^{\frac{\nu-1}{\nu}} \right)^{\frac{\nu}{\nu-1}} \tag{17}$$

with aggregation weight Λ_H (and Λ_F for the foreign country). Again, the home consumer demand functions resulting from the utility maximization will yield the standard CES results as:

$$c_{H,N,t} = \Lambda_H \left(\frac{1+\pi_{H,N,t}}{1+\pi_{H,t}} \right)^{-\nu} c_{H,t} \qquad \text{and} \qquad c_{H,E,t} = (1-\Lambda_H) \left(\frac{1+\pi_{H,E,t}}{1+\pi_{H,t}} \right)^{-\nu} c_{H,t} \tag{18}$$

where $1 + \pi_{H,\omega,t} \equiv P_{H,\omega,t}/P_{t-1}$ again represents price inflation in home currency terms. The standard pricing aggregator allows the home inflation index to be found as a combination of inflation indexes for N and E varieties:

$$1+\pi_{H,t}=\left[\Lambda_H(1+\pi_{H,N,t})^{1-\nu}+(1-\Lambda_H)(1+\pi_{H,E,t})^{1-\nu}\right]^{\frac{1}{1-\nu}} \tag{19}$$

where $1+\pi_{H,N,t}\equiv P_{H,N,t}/P_{t-1}$ and $1+\pi_{H,E,t}\equiv P_{H,E,t}/P_{t-1}$. Analogous expressions apply to the foreign country.

4.2 Firms

In this model, domestic prices are fully flexible, but the flexibility of internationally priced goods depends critically on the invoicing currency assumption. Firms have a Cobb-Douglas production function which uses labor and intermediate inputs to produce varieties of goods:

$$Y_{H,\omega,t}=A_\omega L_{\omega,t}^{1-\phi_\omega}x_\omega^{\phi_\omega} \tag{20}$$

where the technology parameter, A_ω, will differ across exporters and nonexporters, and the cost minimization problem results marginal costs of the following form:

$$mc_{\omega,t}=\frac{w_t^{1-\phi_\omega}p_{x,t}^{\phi_\omega}}{A_\omega(1-\phi_\omega)^{1-\phi_\omega}\phi_\omega^{\phi_\omega}} \tag{21}$$

The demand for factor inputs is:

$$p_{x,t}x_{\omega,t}=\phi_\omega mc_{\omega,t}Y_{H,\omega,t} \tag{22}$$

$$w_tL_{\omega,t}=(1-\phi_\omega)mc_{\omega,t}Y_{H,\omega,t} \tag{23}$$

with the real value of profits given by:

$$\begin{aligned}\Gamma_{\omega,t}=&\left(\frac{1+\pi_{H,\omega,t}}{1+\pi_t}-mc_{\omega,t}\right)c_{H,\omega,t}+\left(Q_t\frac{1+\pi^*_{H,\omega,t}}{1+\pi^*_t}-mc_{\omega,t}\right)c^*_{H,\omega,t}\\&+\left(Q_tp^*_x-mc_{\omega,t}\right)x^*_{H,\omega,t}\end{aligned} \tag{24}$$

4.2.1 Domestic pricing

Under the assumption of flexible domestic price setting, firms profit maximization problem generates a standard solution with a markup above marginal costs. This basic price setting paradigm can be adjusted to allow for variable markups and strategic complementarities. This will be particularly important in producing a better quantitative fit of the model in section 5. As in Itskhoki and Mukhin (2017), prices are set in real terms according to the following rule:

$$\frac{1+\pi_{H,\omega,t}}{1+\pi_t} = \frac{\nu}{\nu-1} mc_{t,\omega}^{1-\zeta} \tag{25}$$

Here, $\zeta \in [0, 1)$ is the strategic complementarity elasticity. Although ζ in equation 25 appears *ad hoc*, it can be made consistent with a large range of price setting models, such as both monopolistic and oligopolistic competition models under CES and non-CES demand.

4.2.2 International pricing

The international pricing block may then take one of three forms: producer currency pricing (PCP), local currency pricing (LCP) or dollar currency pricing (DCP).[31] With firm heterogeneity, only the most productive ($\omega = E$) will both export and import intermediate inputs. The international price of imported intermediates, p_X and p_X^*, are treated symmetrically with the consumption good. For simplicity, p_X^* is taken to be an exogenous parameter and therefore does not depend on the pricing structure.

Under producer currency pricing (PCP), international prices obey the law of one price and may be written as follows:

$$Q_t \frac{1+\pi^*_{H,E,t}}{1+\pi^*_t} = \frac{1+\pi_{H,E,t}}{1+\pi_t} \tag{26}$$

$$\frac{1+\pi_{F,E,t}}{Q_t(1+\pi_t)} = \frac{1+\pi^*_{F,E,t}}{1+\pi^*_t} \tag{27}$$

$$p_{x,t} = Q_t p_x^* \tag{28}$$

Under local currency pricing (LCP), exporters are assumed to permanently fix price inflation in the local currency terms, allowing deviations from the law of one price:

$$\frac{1+\pi^*_{H,E,t}}{1+\pi^*_t} = 1+\bar{\pi}^*_{H,E,t} = \frac{1+\pi_{H,E,t}}{Q_t(1+\pi_t)} \tag{29}$$

$$\frac{1+\pi_{F,E,t}}{1+\pi_t} = 1+\bar{\pi}_{F,E,t} = \frac{Q_t(1+\pi^*_{F,E,t})}{1+\pi^*_t} \tag{30}$$

$$p_{x,t} = \bar{p}_{x,t} = Q_t p_x^* \tag{31}$$

[31] Appendix C provides more detail on how to derive the pricing equations in this section.

Dollar currency pricing (DCP) is the hybrid case when international prices are set in dollars. This implies the following price setting equations:

$$\frac{1+\pi^*_{H,E,t}}{1+\pi^*_t} = 1+\bar{\pi}^*_{H,E,t} = \frac{1+\pi_{H,E,t}}{Q_t(1+\pi_t)}, \tag{32}$$

$$\frac{1+\pi_{F,E,t}}{Q_t(1+\pi_t)} = \frac{1+\pi^*_{F,E,t}}{1+\pi^*_t}, \tag{33}$$

$$p_{x,t} = Q_t p^*_x \tag{34}$$

For completeness, in the cases where firm heterogeneity is suppressed, domestic firms set international prices in precisely the same way as exporting firms, such that:

$$1+\pi^*_{H,N,t} = 1+\pi^*_{H,E,t} \qquad \text{and} \qquad 1+\pi_{F,N,t} = 1+\pi_{F,E,t} \tag{35}$$

4.2.3 Aggregation

The final set of equations for firms specify a series of aggregation conditions. The demand for factor inputs, the demand for each variety, and the total demand across goods are simply:

$$L_t = L_{N,t} + L_{E,t} \qquad \text{and} \qquad x_t = x_{N,t} + x_{E,t} \tag{36}$$

$$Y_{H,\omega,t} = c_{H,\omega,t} + c^*_{H,\omega,t} + x^*_{\omega,t} \tag{37}$$

$$Y_{H,t} = Y_{N,t} + Y_{E,t} \tag{38}$$

Two further aggregate conditions may also be defined here. First, lump sum transfers to household are given as:

$$\Gamma_t = \Gamma_{H,N,t} + \Gamma_{H,E,t} + m_t - \frac{m_{t-1}}{1+\pi_t} \tag{39}$$

where $\Gamma_{H,\omega,t}$ are the profits of each firm type and the remaining terms are a result of seigniorage revenue earned by the fiscal authority being returned to households. Second, the nominal value of net exports is given by:

$$NX_t = \varepsilon_t P^*_{H,t} c^*_{H,t} + \varepsilon_t P^*_t p^*_{x,t} x^*_t - P_{F,t} c_{F,t} - P_t p_{x,t} x_t \tag{40}$$

Denoting the real value of net exports by $nx_t \equiv NX_t/P_t$, they can be written as:

$$nx_t = Q_t \frac{1+\pi^*_{H,t}}{1+\pi^*_t} c^*_{H,t} + Q_t p^*_{x,t} x^*_t - \frac{1+\pi_{F,t}}{1+\pi_t} c_{F,t} - p_{x,t} x_t \tag{41}$$

4.3 Monetary policy

It is assumed that the central bank in each country sets the nominal quantity of money. More formally, an AR(1) process is assumed in the growth rate of money. For home, this implies:

$$\Delta \ln M_t = (1-\rho_m)\tilde{\pi} + \rho_m \Delta \ln M_{t-1} + \epsilon_{m,t} \tag{42}$$

where $\tilde{\pi}$ represents the home central bank's inflation target, which is achieved through the monetary growth rule. This equation embeds two attractive features. First, the impact of a one-period shock to the growth rate of the nominal money supply will dissipate over time. Second, the permanent impact of a one-period shock to the growth rate, compared to a baseline scenario without a shock, may be captured as:

$$\ln M^S_\infty - \ln M^{NS}_\infty = \frac{\epsilon_{m,t}}{1-\rho_m} \tag{43}$$

where M^S_∞ refers to the nominal money supply far in the future after a shock, and M^{NS}_∞ refers to the nominal money supply far in the future without a shock. For the model to be stationary, the exogenous transition equations are rewritten in real terms as:

$$\Delta \ln m_t = (1-\rho_m)\tilde{\pi} + \rho_m \Delta \ln m_{t-1} - \pi_t + \rho_m \pi_{t-1} + \epsilon_{m,t} \tag{44}$$

where the first-order approximation, $\pi_t \approx \ln P_t - \ln P_{t-1}$, has been used and $\Delta \ln m_t \equiv \ln m_t - \ln m_{t-1}$ is specified to remove dependence on lags of order above one.

4.4 Asset markets

The description above outlines the entire model up to the characterization of financial asset, which may be traded across countries in two ways described below.[32]

[32]Using the model's predictions, Appendix C builds intuition for how the relative allocations between exporters and nonexporters shift in the aftermath of a competitive devaluation.

4.4.1 Complete markets

Under complete asset markets, households are able to choose a value of $b_{t+1}(s_{t+1})$ for every possible realization of shocks tomorrow s_{t+1}. The first order conditions for real bonds are:

$$\lambda_t = \beta\lambda_{t+1}(s_{t+1})\frac{(1+i_t)\Pr[s_{t+1}|s_t]}{1+\pi_{t+1}(s_{t+1})}, \qquad \frac{\lambda_t^*}{\varepsilon_t} = \beta\frac{\lambda_{t+1}^*(s_{t+1})}{\varepsilon_{t+1}(s_{t+1})}\frac{(1+i_t)\Pr[s_{t+1}|s_t]}{1+\pi_{t+1}^*(s_{t+1})} \tag{45}$$

for the home and foreign country respectively, where $\Pr[s_{t+1}|s_t]$ denotes the probability of state s_{t+1}, given current state s_t. A no arbitrage condition has also been used between investment in home and foreign denominated financial assets. In the description above, those equations were only taken to hold on average across states. Taken together they imply:

$$Q_t = \kappa\frac{\lambda_t^*}{\lambda_t}, \tag{46}$$

where $\kappa \equiv Q_{t-1}\lambda_{t-1}^*/\lambda_{t-1}$. When the cash-in-advance constraint is not operating (such that $\mu_t = 0$), the above formulation becomes $Q_t = \lambda_t^*/\lambda_t = c_t/c_t^*$.

4.4.2 Incomplete markets

Next, consider the case of cross-boarder trade in a single one-period nominal discount bond, assumed to pay out in foreign currency (i.e., dollars). The first order conditions for the home and foreign country for real bond holdings become:

$$\varepsilon_t\lambda_t = \beta\mathbb{E}_t\left[\varepsilon_{t+1}\lambda_{t+1}\frac{(1+i_t^*)}{1+\pi_{t+1}^*}\right], \qquad \lambda_t^* = \beta\mathbb{E}_t\left[\lambda_{t+1}^*\frac{(1+i_t^*)}{1+\pi_{t+1}^*}\right] \tag{47}$$

Besides, one can deduce that:

$$1 = \beta\mathbb{E}_t\left[\frac{\lambda_{t+1}^*}{\lambda_t^*}\frac{Q_t}{Q_{t+1}}\frac{1+i_t}{1+\pi_{t+1}}\right] \tag{48}$$

The international risk sharing conditions for both countries become:

$$0 = \beta(1+i_t)\mathbb{E}_t\left[\frac{\lambda_{t+1}}{\lambda_t}\frac{1}{1+\pi_{t+1}} - \frac{\lambda_{t+1}^*}{\lambda_t^*}\frac{Q_t}{Q_{t+1}}\frac{1}{1+\pi_{t+1}}\right] \tag{49}$$

As discussed in Schmitt-Grohé and Uribe (2003), a further procedure is required to ensure stationary with incomplete international financial asset market. Specifically, the discount factor is replaced throughout with an *ad hoc* functional form as in Uzawa (1968):

$$\beta(c_t) = \omega_{SGU} c_t^{-\alpha_{SGU}}, \tag{50}$$

where the parameters ω_{SGU} and α_{SGU} are calibrated such that the endogenous discount factor matches the choice for the exogenous discount factor, β.[33] Households do not internalize the effect of their borrowing choice on the discount factor, which is assumed to respond to aggregate (or average) consumption choices, rather than to the choices of specific individuals.

5 Quantitative Results

This section numerically evaluates the impact of competitive devaluations on the relative performance of exporters versus nonexporters and discusses aggregate implications. Outcomes are judged against a pre-shock equilibrium for the three price setting scenarios and for varying degrees of intermediate import intensity. The two country framework developed in section 4 is used to understand how international shocks are transmitted into domestic prices and quantities in light of the firm-level reactions in section 3.2. To that end, a tightly calibrated quantitative model that captures the cross-sectional heterogeneity observed in Japan is employed to show how the interaction of dollar pricing and varying import intensities shapes the aggregate and firm-level response after a competitive devaluation as observed during Abenomics.

5.1 Parameter values

Consider a representative industry with nonexporting (N) and exporting (E) firms in both countries. The sector will be calibrated to one that is typical in Japan, focusing on the domestic market in which both local and foreign (U.S.) firms compete. The calibration can be split into three parts. First, around half of all parameters in the model are set to standard values from the literature. Second, a number of parameters are chosen to match empirically relevant features of the Japanese economy. The remaining parameters are chosen to target a set of moments specific to the setup of the benchmark model, with heterogeneous firms, strategic complementarities and imported intermediate inputs. The results of the calibration are given in Table 4, with individual parameter

[33] This approach is consistent with the literature, and analogous to that followed by Schmitt-Grohé and Uribe (2003) and Corsetti, Dedola, and Leduc (2008) among others.

Table 4: Calibration values

Parameter	Value	Description	Target
A: Literature			
β	0.98	Time discount factor	Standard value
η	2	Elasticity across H and F	Standard value
ν	6	Elasticity across N and E	Standard value
α_{SGU}	0.02	SGU parameter	Standard value
κ	1	Disutility of labour	Farhi et al. (2014)
ψ^{-1}	0.5	Frisch elasticity of labour supply	Farhi et al. (2014)
ϕ	2	Labour substitution elasticity	Standard value
$1+\tilde{\pi}$	1.005	Inflation target (Japan)	2% (annualized)
ζ	0.40	Strategic complementarity elasticity	IM (2016)
B: Empirical			
α	0.93	Home bias (Japan)	Japanese macro data
θ	0.90	Calvo prob. of wage stickiness	Standard value
ϕ_N	0	Exchange rate exposure (nonexporters)	Customs data & AIK (2014)
ϕ_E	0.4	Exchange rate exposure (exporters)	Customs data & AIK (2014)
C: Targetted			
ω_{SGU}	0.97	SGU parameter	$\beta = \beta(c_t)$
A_N	1.00	Productivity (nonexporters)	Normalization
A_E	2.35	Productivity (exporters)	Normalization
p_x^*	0.77	Cost-savings	20%, HKS (2015)
Λ_H	0.83	Weight on nonexporting firms	25% revenue share
Λ_F	0	Weight on nonexporting U.S. firms	Preferences
ρ_m	0.87	AR(1) component of monetary growth	1 year half-life
σ_m	0.06	S.D. of monetary growth shocks	50% change in level

Note: Parameters shown for the benchmark case with DCP pricing, firm heterogeniety, intermediate goods, strategic complemetarities and complete asset markets.

choices discussed next.

Most of the values taken from the literature are self-explanatory. The time period is a quarter. Anderson and Van Wincoop (2004) conclude that the elasticity of demand for imports at the sectoral level is in the range of 5 to 10. Even though the results are robust to a wide range of parameter choices, the elasticity of substitution across home and foreign goods is set to $\eta = 2$, and the elasticity of substitution between exporters and nonexporters is set to $\nu = 6$, a value near the middle of a relatively wide range of estimates found in much of the literature. The parameter α_{SGU} is chosen to ensure a slow convergence to a stationary equilibrium, matching the implementation in Schmitt-Grohé and Uribe (2003) and a variety of related work.[34] The literature

[34]Although $\alpha_{SGU} = 0.01$ could be used, with a 2% level of inflation the dynamics of nx are too slow compared

suggests a broad range of plausible values for the markup of real wages as a result of imperfect competition the in labor market, with Christiano, Eichenbaum, and Evans (2005) using a markup of 5% compared to a 50% markup used by Smets and Wouters (2003). Incomplete pass-through and variable markups are introduced as in Itskhoki and Mukhin (2017) and the same elasticity of strategic complementarities is used as in their benchmark case ($\zeta = 0.4$).

Empirical estimates are taken from the Japanese data. The Calvo parameter governing nominal wage rigidity, θ, is set to ensure slow nominal wage adjustments to shocks, which is a well-documented fact in Japan. The home bias parameter, α, is set to 0.93 in both countries to reflect the fact that Japan and the U.S. are relatively closed economies—exports and imports each represent about 14% of GDP for Japan and the U.S., which means that the foreign share is 7% as final consumption is half of total imports. The exchange rate exposure across firms, ϕ_N and ϕ_E, is calibrated using customs data and is consistent with Amiti, Itskhoki, and Konings (2014). For nonexporting firms, $\phi_N = 0$, whereas for continuing exporters, the import intensity is set to $\phi_E = 0.4$. This calibration is pivotal in matching domestic revenue and employment reallocations across both types of firms. Import intensities are taken as fixed, which is a good approximation over horizons of 3–5 years.[35]

The remaining parameters are set to target model moments. The incomplete markets parameter, ω_{SGU}, is used to calibrate the endogenous discount factor, in steady state, to be equal to the time-discount factor used in the complete asset market version of the model. As discussed in section 4, the permanent impact of a one-period shock to nominal money supply growth, compared to a baseline case with no shock, is given by $\epsilon_{m,t}/(1-\rho_m)$. This quantity is set at 0.5 to match the dynamics of quantitative easing in Japan. This calibration sets the size of the standard deviation of $\epsilon_{m,t}$ as $\sigma_{\epsilon_m} = 0.5(1-\rho_m)$, allowing the parameter ρ_m to control the speed of adjustment. Again, in the context of Japan's experience, this arises quickly. More precisely, to match the observed pace of monetary expansion, the value of ρ_m is determined by allowing 50% of the total impact to arise within the first year (four quarters). This implies:

$$\frac{\ln M_4^S - \ln M_4^{NS}}{\ln M_\infty^S - \ln M_\infty^{NS}} = \frac{(1+\rho_m+\rho_m^2+\rho_m^3)\epsilon_{m,t}}{\frac{\epsilon_{m,t}}{1-\rho_m}} = (1+\rho_m+\rho_m^2+\rho_m^3)(1-\rho_m) = 0.5$$

to those of prices, resulting in a divergent series for NX.

[35] The exchange rate exposure term, ϕ_E, is assumed to be firm-specific and constant over time. Amiti, Itskhoki, and Konings (2014) justify this assumption using Belgian customs data and show that firm import intensities are not sensitive to exchange rate fluctuations in the medium run.

and therefore $\rho_m = 0.87$. The total factor productivity parameters, A_N and A_E, alongside the cost-savings from imported intermediate goods, p_x^* are used to give exporting firms a 20% marginal cost advantage over purely domestic firms (as consistent with Halpern, Koren, and Szeidl (2015)). Initially, A_N is used to normalize the denominator of marginal costs, $mc_{t,N}$. Then, A_E is used to reduce the difference between firms in the denominator of the marginal cost to 20%, while p_x^* is used to calibrate the overall difference in marginal costs to 20%. This procedure achieves a dual objective of normalizing the cost-savings from importing intermediates to 20% of costs and simultaneously retaining positive profits in equilibrium across all model formulations. In this way, firms compare the fixed costs of becoming exporters with the added benefits from lower marginal costs. This moment is used to target the exogenous price of imported intermediate goods, p_x^*. The aggregation weight Λ_F is set to ensure only exporters supply to the foreign country, whereas Λ_H is used to calibrate the share of domestic revenue sold by exporting firms to 25%. This ensures a consistent comparison may be made between two firm types while maintaining their relative revenue shares in the economy.[36]

5.1.1 Benchmark model

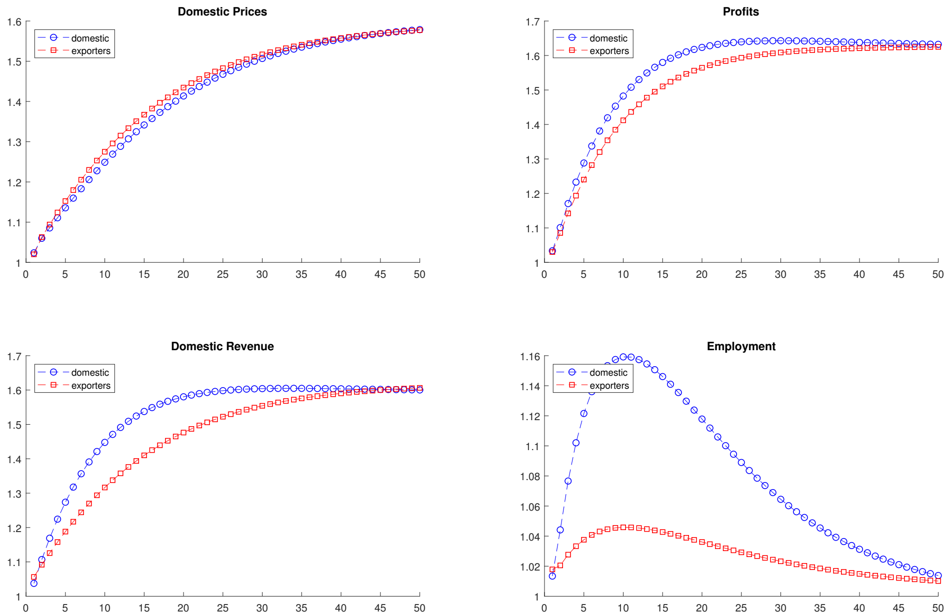
In the benchmark model, firms are heterogeneous, differing by productivity and their import intensity, prices are set in accordance with international dollar invoicing (DCP) with strategic complementarities, and asset markets are incomplete such that net exports are not simply pinned down by international risk sharing. All of the key parameter values used in the benchmark version of the model are summarized in Table 4.

Figure 6 shows the economy's adjustment path at the micro- and macro-levels for the benchmark model. Panel (A) shows the simulation results for both types of firms, solely domestic (in blue circles) and exporters (in red squares). A monetary shock relaxes the cash-in-advance constraint in the home country, leading to higher levels of income and consumer spending on all goods. Greater demand increases domestic prices, while the Calvo assumption implies that the nominal wage is sticky and labor is demand determined in the short-run. Additional labor is hence required to meet rising aggregate demand, generating a domestic boom.[37]

[36] As mentioned in section 3.1, exporters account for 22% of domestic revenue in Japan. At the same time, Bernard and Jensen (2004) report that the fraction of exporting plants was 21% and 30% in 1987 and 1992, respectively.

[37] Any framework with nominal rigidities produces a domestic boom after monetary expansions, which is not what happened in Japan, where real GDP growth was low around 2014. However, manufacturing output reacted a lot more to the nominal devaluation, rising by about 10% from early 2013 to mid 2014, and one could imagine a setup where the industrial sector is subject to a binding cash-in-advance constraint while the remaining industries operate

(A) Firm-level patterns



(B) Aggregate patterns

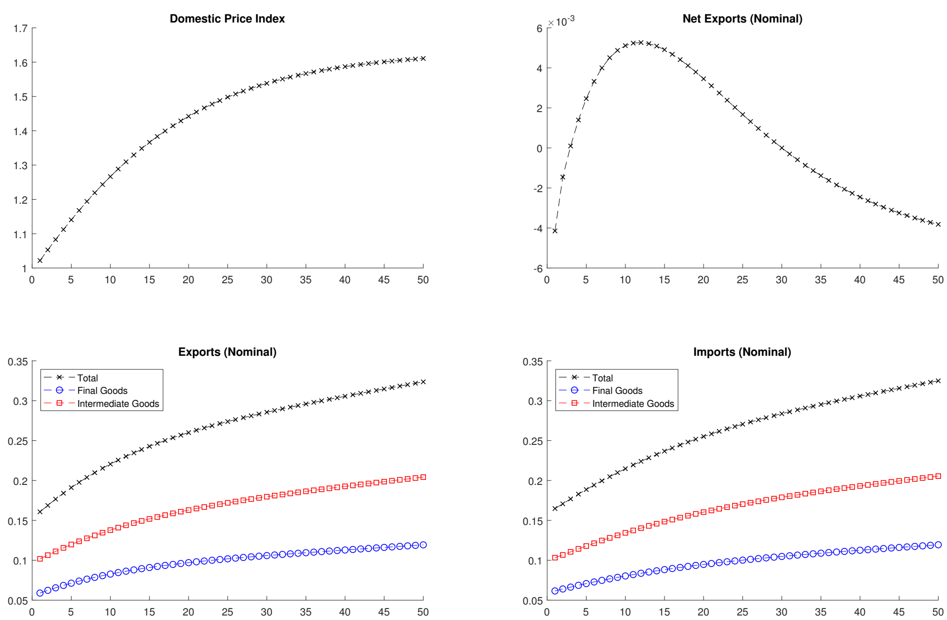


Figure 6: **Benchmark**

Note: Panel (A) displays firm-level impulse responses for nonexporters (blue circles) and exporters (in red squares) to a one standard deviation (50%) shock to the growth rate of the home country nominal money supply, M_t. Panel (B) shows the aggregate response. The time period is a quarter.

Table 5: Comparison of models

	Data	MF	Benchmark	M1	M2	M3	M4
Price setting		PCP	DCP	LCP	LCP	DCP	DCP
Firm heterogeneity		✗	✓	✗	✓	✓	✓
Imported intermediate inputs		✗	✓	✗	✓	✓	✓
Strategic complementarities		✗	✓	✗	✗	✗	✓
Incomplete markets		✗	✓	✗	✗	✗	✗
$Rev_{H,N}/Rev_{H,E}$	0.07	0	0.08	0	0	0.29	0.17
L_N/L_E	0.06	0	0.09	0	0.04	0.26	0.14
Γ_N/Γ_E	0.1	0	0.04	0	-0.3	-0.02	0.05
CPI	0.03	0.04	0.03	0.03	0.03	0.05	0.04
Y_H	0.01	0.13	0.08	0.11	0.09	0.04	0.07
NX	0	0.02	0	0	0.03	0.03	0.02
ϵ	0.25	0.28	0.21	0.28	0.28	0.28	0.28

Note: This table lists key moments (growth rates) in the data and compares them with simulations in different versions of the model. Key ingredients are added one-by-one. Each row shows the impulse response functions of endogenous variables after 1.5 years to a (persistent) one standard deviation (50%) shock to the level of the home country nominal money supply, M_t. Only CPI contains the instantaneous response of the price level to a monetary shock.

The monetary expansion generates a nominal (competitive) depreciation, and feeds through to home CPI inflation. At the micro-level, nonexporting firms expand proportionally more as they experience an increase in demand for all of their produce—given sticky international prices, exporting firms experience a relatively small increase in demand, while domestic revenue expands equally for both types of firms. Besides, the impact is compounded by a difference in marginal costs—exporting firms experience an increase in their nominal marginal costs as the home price of imported intermediate inputs rises substantially following the home currency depreciation. Due to these effects, both output and labor expand by more for nonexporting firms. Strategic complementarities in price setting contribute to matching the relative output and employment paths for both types of firms, and they are helpful in generating shrinking relative profits of exporting firms.[38]

At the aggregate level, displayed in Panel (B) of Figure 6, inflation increases both as a result

in a credit economy and are insensitive to monetary policy.

[38]Profits of exporters may increase by more as the markup on their exported intermediate inputs rises in domestic currency terms following the home currency depreciation. Strategic complementarities mute these valuation effects relative to the output expansion.

of the domestic boom and because imports become relatively more expensive. As in the data, net exports show almost no response to the depreciation since they are not determined by international risk sharing under incomplete markets. With complete markets, a domestic boom in Japan would require a transfer to the foreign economy.

Table 5 summarizes key moments for different versions of the model, and contains impulse responses of endogenous variables after 1.5 years to a one standard deviation (50%) shock to the level of the home nominal money supply, M_t. Only the CPI numbers contain the instantaneous response of the price level to a monetary shock. The Mundell-Fleming case is reported in the MF column while other ingredients are added one-by-one.[39] The basic Mundell-Fleming setup fails to explain the dynamic adjustment path of the economy at the micro and macro levels. Modifying the framework to account for local currency pricing (LCP) in column M1 does not improve the quantitative performance despite shutting down the expenditure switching channel and muting the response of net exports.[40]

Heterogeneous import intensities together with LCP (rather than DCP) are not enough to jointly match the cross-sectional and aggregate expansion paths either. This is can be seen in the M2 version of the model in Table 5. The reason is simply that nominal exchange rate movements would not influence exporting firms' marginal costs under LCP. It is only with international dollar invoicing that firms are negatively affected if they import and also do not get to reap the benefits from a relative reduction in their export prices abroad.

6 Conclusion

This paper uses novel microdata to investigate how firm heterogeneity and intermediate import intensities mediate the monetary transmission mechanism. Abenomics provides an innately suited natural experiment to isolate the effects of competitive devaluations not just on firm dynamics but also on aggregate outcomes. Empirical tests show that, contrary to standard theories, exporters shrink relative to nonexporters in terms of their employment, domestic revenue and

[39] See Appendix D for a more comprehensive discussion of the quantitative results in the Mundell-Fleming case.

[40] The real value of net exports depends on two factors—relative prices and quantities. Although the relative price of imports is left unchanged for the home country in model M1, a greater amount is demanded in real terms due to the domestic income effect. Imports in the home country therefore increase. For foreign consumers, the relative price of the home export good is also unchanged, and the quantity demanded is also unchanged. However, in home country terms, the value of these exports is now higher due to the depreciation, and thus real-valued exports increase. These effects offset one another and leave the real value of net exports unaltered.

profitability while the trade balance remains unaffected. Unique Russian customs data allows for a direct examination of the channel and confirm the same transmission as for Japan.

Conventional open economy macro models are too simplistic in their microstructure to explain these findings. This paper develops a theoretical framework to make sense of the empirical regularities and the mechanism of competitive devaluations. A New Keynesian two-country model that is augmented by three key ingredients from international trade—heterogeneous firms, varying imported input intensities, and international dollar pricing—is successful in matching the main cross-sectional patterns and the evolution of inflation and net exports. The quantitative fit is greatly improved by a fourth ingredient that has been prominent in studies of exchange rate pass-through—strategic complementarities in firm price setting.

This paper is the first to use microdata to study the transmission mechanisms of currency wars. The results suggest that such exchange rate policies work more through import substitution rather than the promotion of national export champions, thereby stimulating a different set of firms than suggested by conventional wisdom. With international dollar invoicing, the U.S. reaps additional benefits through its insulation from other countries' nominal devaluations, while expansionary monetary policy in the rest of the world shifts resources toward less productive nonexporting firms.

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Online Appendix: Not For Publication

A Data

This list includes the main variables used throughout the analysis. For Japan, all components are drawn from the merged Worldscope (WS), Capital IQ, and ORBIS annual and segment files. For Russia, all firm-level data comes from Amadeus and is merged with information on imports from the Federal Customs Service of Russia. Variables are listed in alphabetical order.

- $\mathbf{Age_{i,t}}$: Either as reported, or inferred from the date of incorporation.
- $\mathbf{Assets_{i,t}}$: Total assets, as reported in the respective data sets.
- $\mathbf{Cash/Assets_{i,t}}$: Cash and equivalents divided by assets.
- $\mathbf{Employment_{i,t}}$: The number of both full and part time workers.
- $\mathbf{IC_j}$: Import content of production for any given STAN industry j (OECD).
- $\mathbf{Impint_i}$: The share of imported intermediate inputs in total variable costs in 2013 (Russia).
- $\mathbf{Leverage_{i,t}}$: Total debt as a % of assets.
- $\mathbf{Market\ Capitalization_{i,t}}$: Market price at year end $\cdot$ common shares outstanding.
- $\mathbf{PB_{i,t}}$: Market-to-book ratio, calculated as: [market value of common equity $+$ assets $+$ book value of common equity)]$/$ assets.
- $\mathbf{Revenue_{i,t}}$: Total domestic revenues in either Japan or Russia.
- $\mathbf{ROA_{i,t}}$: Return on assets (profitability ratio), measured as: (net income / assets).
- $\mathbf{Size_{i,t}}$: Natural logarithm of assets.

A documented problem with ORBIS data is that variables, such as employment, are missing once the data are downloaded. There are many reasons for this. Employment, for instance, is not reported as a balance sheet item but in memo lines. Less often, there can be other missing variables such as capital or assets. Variables are not always reported consistently throughout time in a particular disk or in a web download, either from the BvD or the Wharton Research Data Services (WRDS) website. BvD has a policy by which firms that do not report during a certain period are automatically removed from later vintages, creating an artificial survivorship bias in the sample. An additional issue is that any online download (BvD or WRDS) will cap the number of firms that can be downloaded in a given period of time. This cap translates into missing observations in the actual download task rather than termination of the request.

I implement a comprehensive data collection procedure to address these problems and maximize the coverage of firms and variables for Japan over time.[41] The general strategy is to merge data for Japan by downloading them from the ORBIS interface in limited search requests and making sure no information on employment or assets is discarded throughout the process.

[41] Kalemli-Ozcan, Sorensen, Villegas-Sanchez, Volosovych, and Yesiltas (2015) offer a detailed analysis of how to construct representative firm-level data using the ORBIS data set.

B Reduced Form Evidence

B.0.1 Identification

Previous literature has established the centrality of imported intermediate inputs to the production processes of large exporting firms (Amiti, Itskhoki, and Konings (2014)). Despite the lack of access to Japan's firm-level customs data (as opposed to Russia), insights into the driving forces behind the growth (or contraction) of exporters relative to nonexporters following Abenomics can be gained with a triple difference identification strategy.

In particular, non-financial industries are heterogeneously reliant on imported intermediate inputs in production. As a result, one should expect to see more pronounced differences across continuing exporters and solely domestic firms in sectors that are more dependent on imported intermediate inputs than in industries, which are not. Since exporters are also the biggest importers (as seen in customs data), disparities between both groups of firms are bound to be particularly stark in sectors where exporters are most sensitive to changing imported input prices rather than in industries where almost all factors of production are obtained domestically. That reasoning motivates the following triple difference specification:

$$\begin{aligned}\log(Y_{i,t}) = \alpha_i + \alpha_1' X_{i,t} + \alpha_2'(X_{i,t} \cdot QE_t) + \beta_1(Treat_i \cdot QE_t) + \beta_2(IC_j \cdot QE_t) \\ + \gamma(Treat_i \cdot IC_j \cdot QE_t) + \nu_{i,t}\end{aligned} \tag{B.1}$$

where, as earlier, Y_{it} are either domestic revenue, employment, or profitability of company i in year t, α_i are firm fixed effects, $X_{i,t}$ is a matrix of controls, $Treat_i$ is an indicator variable equal to 1 whenever a firm is a Japanese exporter, QE_t is an indicator equal to zero in 2012 before Abenomics and unity after Abenomics in either 2014 or 2015, and IC_j is the import content of production across various industries based on Japan's 2011 input-output tables.[42] An attractive feature of this measure is that it allows one to compute the value of imported inputs used *indirectly* in production of a good. That is, imported inputs may be used in one sector, whose outputs are

[42] This number represents the degree of vertical specialization and measures the contribution that imports make in the production of goods in a certain industry. It is calculated as follows for country i:

$$IC_i = \frac{u' A_m (I - A_d)^{-1} q}{q_i},$$

where A_d and A_m are input-output coefficient matrices, q is the consumption vector for each sector, q_i is total consumption for country i, and u is a vector of ones. For sector j, the imported input share of gross output can be obtained from the individual columns of matrix $u' A_m (I - A_d)$.

employed in another sector, then a third, and eventually become embodied in a final good.[43] Note that the terms $Treat_i$, IC_j, and $Treat_i \cdot IC_j$ are not explicitly thrown into the regression because of the inclusion of firm fixed effects. All standard errors are clustered at the firm-level to allow for serial correlation across time.

The coefficient of interest is γ as it captures the percentage change in the respective outcome variable after Abenomics for exporting or nonexporting firms in import reliant versus less import dependent sectors. A positive coefficient would imply that, all else equal, Japan's competitive devaluation leads to a stronger expansion of exporters relative to nonexporters in sectors that are more exposed to importing.

This triple difference methodology is applied to the pooled sample of private and public firms, and it is further extended to emulate regression 1 in accounting for the timing of any effects. That is, the following fixed-effects equation is estimated to test whether the gaps between exporters and nonexporters widen *after* the introduction of Abenomics rather than before:

$$\begin{aligned} \log(Y_{i,t}) = \alpha_i + \theta' X_{i,t} + \sum_t \gamma_t \mathbf{D}_t + \sum_t \delta_t \left(\mathbf{D}_t \cdot X_{i,t}\right) + \sum_t \psi_t \left(\mathbf{D}_t \cdot Treat_i\right) \\ + \sum_t \lambda_t \left(\mathbf{D}_t \cdot IC_j\right) + \sum_t \zeta_t \left(\mathbf{D}_t \cdot Treat_i \cdot IC_j\right) + \epsilon_{i,t} \\ \forall i,\ \forall t \in \{2010, \ldots, 2015\} \setminus \{2012\} \end{aligned} \tag{B.2}$$

where all of the main variables and interaction terms are as before, and standard errors are clustered at the firm-level to allow for serial correlation across time. The only novelty is that now the parameters of interest are ζ_t, as they measure the difference between exporters and purely domestic firms over time in more versus less import reliant industries. This regression tests if the effects grow or fade, providing evidence of the validity of the parallel trends assumption.

B.0.2 Results

There is substantial heterogeneity across non-financial sectors in terms of their import reliance. Table 1 shows that the sectoral import content of production measure, IC, has a mean of 11.36% and a standard deviation of 4.61%. Given that exporters are also the biggest importers, one should expect to see larger differences across purely domestic firms (nonimporters) and continuing ex-

[43] The results are insensitive to using the direct or indirect measure of import dependence since the ranking between industries remains completely unaltered with either approach.

porters (importers) within industries that are more dependent on imported inputs.

Table B.1 presents the estimation results for regression model B.1 using the whole sample of public and private firms. The first two columns consider the treatment effect on employment, and the last two columns use domestic revenue as the outcome variable. Furthermore, regression results in columns (2) and (4) include all the main firm-level control variables as well as their interaction terms with the Abenomics indicator in the specifications. This tests whether any results can be attributed to a heterogeneous reaction across firms of a highly different nature to Japan's large monetary stimulus rather than the treatment allocation. Across all specifications, the estimated triple difference parameter, $\hat{\gamma}$, is negative and robustly statistically significant. The lack of explanatory power in firms' export treatment status beyond its interaction term with sectoral import dependence, as reflected by the statistical insignificance of the estimated β_1 coefficients, implies that all of the main results from before were driven by the variation in import intensities across exporting and nonexporting firms.

Table B.1: Mechanism

	$\log(employment)$		$\log($*domestic revenue*$)$	
	(1)	(2)	(3)	(4)
$Treat_i \cdot IC_j \cdot QE_t$	-0.004**	-0.004**	-0.004***	-0.004***
	[0.002]	[0.002]	[0.001]	[0.001]
$Treat_i \cdot QE_t$	0.020	0.025	-0.004	-0.009
	[0.035]	[0.035]	[0.030]	[0.030]
$IC_j \cdot QE_t$	-0.000	-0.000	0.000	0.000
	[0.000]	[0.000]	[0.000]	[0.000]
QE_t	✓	✓	✓	✓
$X_{i,t}$	✗	✓	✗	✓
$X_{i,t} \cdot QE_t$	✗	✓	✗	✓
Firm FE	✓	✓	✓	✓
Observations	61,832	61,832	61,832	61,832
Number of firms	30,916	30,916	30,916	30,916
R^2	0.074	0.076	0.529	0.535

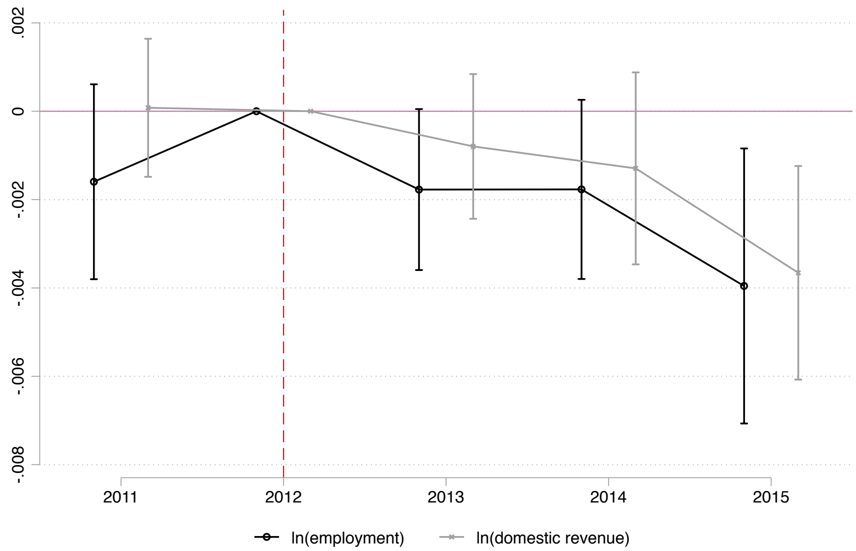
*Note: This table presents triple-difference estimates of the response of employment and domestic revenue for exporters versus nonexporters conditional on operating in differentially import reliant industries. The controls in $X_{i,t}$ include size (log total assets), leverage, and the cash-to-assets ratio. Those variables are also interacted with the Abenomics (QE_t) time indicator. Standard errors [in brackets] are clustered at the firm-level to allow for serial correlation across time. ***, **, * indicate significance at the 1%, 5% and 10% levels, respectively.*

Panel (A) of Figure B.1 extends this analysis of the mechanism by using repeated observations for the same company over time and shows the estimated coefficient plots for ζ_t in specification B.2. As before, this methodology scrutinizes the causal interpretation of the results. Consistent with the parallel trends assumption, the estimates show no robust differences between exporters and nonexporters in the years prior to Abenomics across industries sourcing intermediate inputs from abroad in varying degrees. After the policy, continuing exporters begin to shrink in terms of their domestic revenue and employment relative to nonexporting firms.[44] The magnitudes of the results are similar to the ones in Table B.1, and still manage to yield statistically significant results at the 10% level for both domestic revenue and employment by 2014.[45] Given the lack of firm-level customs data for Japan—which would make it possible to investigate the channel directly as for Russia—and because input-output measures for sectoral import reliance are noisy, the strength and robustness of those findings are remarkable.

[44] Analogous results can be obtained by defining a *discrete* measure of imported input reliance. Sectors belonging to the upper quintile of the import content of production distribution are then taken to be "import intensive", and industries in the lower quintile are "unintensive". By way of this approach, the gaps between nonexporters and exporters widen *only* in the import intensive industries.

[45] The results are statistically significant at the 5% level for both domestic revenue and employment in 2015.

(A) Triple Difference



(B) Interest Rates

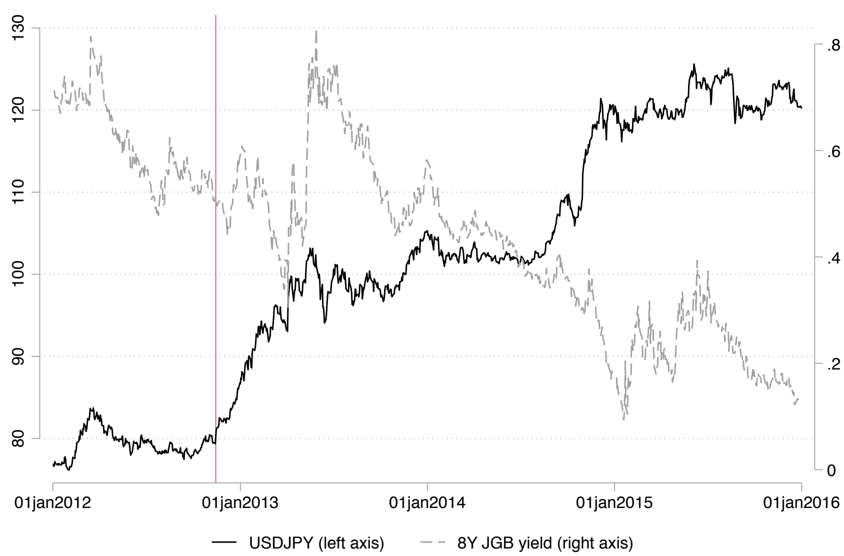


Figure B.1: **Mechanism**

Note: Panel (A) plots the estimated ζ_t coefficients of equation B.2 for employment and domestic revenue as outcome variables with 95% confidence intervals. Panel (B) shows the 8-year yield on JGBs—a heavily targeted security class during QE—alongside the USDJPY exchange rate. Time is yearly and the vertical red line marks the beginning of Abenomics.

C Model

This section first builds intuition for how the relative allocations between exporters and non-exporters shift in the aftermath of a competitive devaluation, focusing on the domestic revenue ratio of those firms. Details on the derivation of the pricing equations are also provided.

C.1 Relative expansion paths

After a shock, the relative response of marginal costs are key to determining the differing expansion paths. Specifically:

$$\frac{mc_{N,t}}{mc_{E,t}} = \Theta \left(\frac{w_t}{p_{x,t}} \right)^{\phi_E - \phi_N}$$

where $\Theta \equiv A_E(1-\phi_E)^{(1-\phi_E)}\phi_E^{\phi_E}/A_N(1-\phi_N)^{(1-\phi_N)}\phi_N^{\phi_N}$ is a constant depending on relative productivities. The relative expansion path for prices may then be found as:

$$\frac{P_{H,N,t}}{P_{H,E,t}} = \left(\frac{mc_{N,t}}{mc_{E,t}} \right)^{1-\tau} = \Theta^{1-\tau} \left(\frac{w_t}{p_{x,t}} \right)^{(\phi_E-\phi_N)(1-\tau)}$$

which, in turn, may be used to determine the relative expansion path for domestic revenue:

$$\frac{P_{H,N,t}c_{H,N,t}}{P_{H,E,t}c_{H,E,t}} = \frac{\Lambda_H}{1-\Lambda_H} \left(\frac{P_{H,N,t}}{P_{H,E,t}} \right)^{1-\nu} = \frac{\Lambda_H}{1-\Lambda_H} \Theta^{(1-\tau)(1-\nu)} \left(\frac{w_t}{p_{x,t}} \right)^{(\phi_E-\phi_N)(1-\tau)(1-\nu)}$$

where the term $\Lambda_H/(1-\Lambda_H)$ is a normalization within each sector to average firm size. Defining the log ratio of revenues as:

$$\Delta_{Rev,t} \equiv \ln \left(\frac{P_{H,N,t}c_{H,N,t}}{P_{H,E,t}c_{H,E,t}} \right) \qquad \text{and} \qquad \tilde{\Theta} = \ln \left(\frac{\Lambda_H}{1-\Lambda_H} \Theta^{(1-\tau)(1-\nu)} \right)$$

one can obtain:

$$\frac{\partial \Delta_{Rev,t}}{\partial \ln \varepsilon_t} = (\phi_E - \phi_N)(1-\tau)(1-\nu)\tilde{\Theta} \left[\frac{\partial \ln W_t}{\partial \ln \varepsilon_t} - \frac{\partial \ln P_{x,t}}{\partial \ln \varepsilon_t} \right]$$

Together, the first terms are clearly negative as $\tilde{\Theta} > 0$, $\phi_E > \phi_N$ and $\tau < 1$, and $\nu > 1$ is assumed. The sign of this expression is then determined by the relative balance between (sticky) nominal wages and the price of intermediate goods, which depends on the international pricing scheme.

In an environment with dollar currency pricing (DCP), $\partial \ln P_{x,t}/\partial \ln \varepsilon_t = 1$ as the nominal price of intermediate goods is set in the foreign country terms. Then, given sufficiently sticky nominal wages, one can be assured that:

$$\frac{\partial \Delta_{Rev,t}}{\partial \ln \varepsilon_t} < 0$$

such that a competitive devaluation leads to a relative expansion of the (less productive) nonexporting firms. Nominal wages are deemed sufficiently sticky if $\partial \ln W_t/\partial \ln \varepsilon_t < 1$, such that the exchange rate moves by more.

C.2 Pricing equations

This section provides an example of the derivation of the pricing equations. The exposition begins with a standard equation for the reset price:[46]

$$\begin{aligned}
\mathbb{E}_t \sum_{s=t}^{\infty} \vartheta^{s-t} \left(\frac{P_t C_t}{P_s C_s}\right) P_{H,s}^{\nu}(C_{H,s} + C_{H,s}^{*}) \left[\bar{P}_{H,t} - \frac{\nu}{\nu-1} MC_s\right] &= 0 \\
\bar{P}_{H,t} &= \frac{\nu}{\nu-1} \frac{\mathbb{E}_t \left[\sum_{s=t}^{\infty} \vartheta^{s-t}\beta^{s-t} \left(\frac{P_t C_t}{P_s C_s}\right) P_{H,s}^{\nu}(C_{H,s} + C_{H,s}^{*}) MC_s\right]}{\mathbb{E}_t \left[\sum_{s=t}^{\infty} \vartheta^{s-t}\beta^{s-t} \left(\frac{P_t C_t}{P_s C_s}\right) P_{H,s}^{\nu}(C_{H,s} + C_{H,s}^{*})\right]} \\
\bar{P}_{H,t} &= \frac{\nu}{\nu-1} \frac{J_{1,H,t}}{J_{2,H,t}} \\
J_{1,H,t} &= P_{H,t}^{\nu}(C_{H,t} + C_{H,t}^{*}) MC_t + \vartheta\beta E_t \left[\frac{P_t C_t}{P_{t+1} C_{t+1}} J_{1,H,t+1}\right] \\
J_{2,H,t} &= P_{H,t}^{\nu}(C_{H,t} + C_{H,t}^{*}) + \vartheta\beta E_t \left[\frac{P_t C_t}{P_{t+1} C_{t+1}} J_{2,H,t+1}\right] \\
\frac{\bar{P}_{H,t}}{P_{t-1}} &= \frac{\nu}{\nu-1} \frac{J_{1,H,t}/P_{t-1}^{\nu+1}}{J_{2,H,t}/P_{t-1}^{\nu}} \\
\frac{J_{1,H,t}}{P_{t-1}^{\nu+1}} &= \left(\frac{P_{H,t}}{P_{t-1}}\right)^{\nu} (C_{H,t} + C_{H,t}^{*}) \frac{MC_t}{P_{t-1}} + \vartheta\beta E_t \left[\frac{P_t C_t}{P_{t+1} C_{t+1}} \frac{P_t^{\nu+1}}{P_{t-1}^{\nu+1}} \frac{J_{1,H,t+1}}{P_t^{\nu+1}}\right] \\
\frac{J_{2,H,t}}{P_{t-1}^{\nu}} &= \left(\frac{P_{H,t}}{P_{t-1}}\right)^{\nu} (C_{H,t} + C_{H,t}^{*}) + \vartheta\beta E_t \left[\frac{P_t C_t}{P_{t+1} C_{t+1}} \frac{P_t^{\nu}}{P_{t-1}^{\nu}} \frac{J_{2,H,t+1}}{P_t^{\nu}}\right] \\
1 + \bar{\pi}_{H,t} &= \frac{\nu}{\nu-1} \frac{j_{1,H,t}}{j_{2,H,t}} \\
j_{1,H,t} &= (1+\pi_{H,t})^{\nu}(C_{H,t} + C_{H,t}^{*}) mc_t + \vartheta\beta E_t \left[\frac{(1+\pi_t)^{\nu+1} C_t}{(1+\pi_{t+1}) C_{t+1}} j_{1,H,t+1}\right]
\end{aligned}$$

[46]See, for example, equation 13 in Farhi, Gopinath, and Itskhoki (2014)

$$j_{2,H,t} = (1+\pi_{H,t})^{\nu}(C_{H,t} + C^{*}_{H,t}) + \vartheta\beta E_t\left[\frac{(1+\pi_t)^{\nu}C_t}{(1+\pi_{t+1})C_{t+1}} j_{2,H,t+1}\right]$$

Simplifying:

$$\begin{aligned}
& P_{H,t}(i) = \frac{\nu}{\nu-1} MC_t(i) \\
\rightarrow \quad & \frac{P_{H,t}(i)}{P_t}\frac{P_{t-1}}{P_{t-1}} = \frac{\nu}{\nu-1}\frac{MC_t(i)}{P_t} \rightarrow \frac{1+\pi_{H,t}(i)}{1+\pi_t} = \frac{\nu}{\nu-1} mc_t(i) \\
& \varepsilon_t P^{*}_{H,t}(i) = \frac{\nu}{\nu-1} MC_t(i) \\
\rightarrow \quad & \frac{\varepsilon_t P^{*}_{H,t}(i)}{P_t}\frac{P^{*}_t}{P^{*}_t}\frac{P^{*}_{t-1}}{P^{*}_{t-1}} = \frac{\nu}{\nu-1}\frac{MC_t(i)}{P_t} \rightarrow Q_t\frac{1+\pi^{*}_{H,t}(i)}{1+\pi^{*}_t} = \frac{\nu}{\nu-1} mc_t(i)
\end{aligned}$$

Also:

$$\begin{aligned}
P_{H,t}(i) &= \frac{\nu}{\nu-1} MC_t(i) = \varepsilon_t P^{*}_{H,t} \\
\frac{1+\pi_{H,t}(i)}{1+\pi_t} &= \frac{\nu}{\nu-1} mc_t(i) = Q_t\frac{1+\pi^{*}_{H,t}(i)}{1+\pi^{*}_t}
\end{aligned}$$

D Quantitative Results

D.1 Mundell–Fleming environment

To study competitive devaluations in the Mundell–Fleming (or Obstfeld–Rogoff) environment, the following parameter values are imposed: all firms are homogeneous and participate in exporting ($\Lambda_H = \Lambda_F = \Lambda_H^* = \Lambda_F^* = 0.5$; $\phi_N = \phi_E$), there are no imported intermediate inputs in production ($\phi_N = \phi_E = 0$), and price setting conforms to the standard PCP constant markup version of the model with no strategic complementarities ($\zeta = 0$).

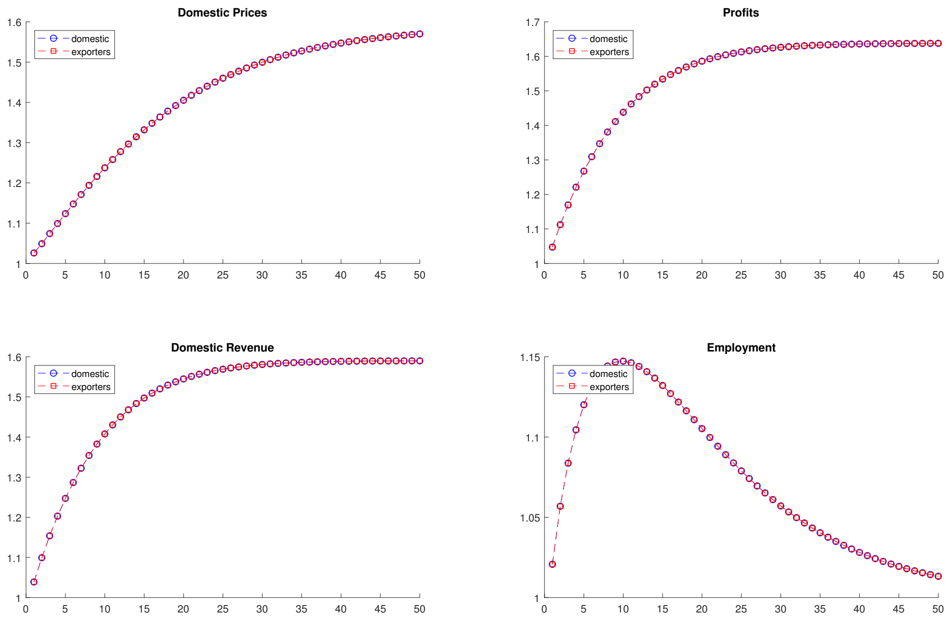
Figure D.1 plots the economy's firm-level and aggregate response to a one standard deviation (50%) shock to the growth rate of the home country nominal money supply, M_t, as observed in Japan from late 2012 until 2015.[47]

The initial monetary shock again translates into a nominal depreciation. Under PCP with flexible domestic prices, imports become relatively more expensive while exports become relatively cheap. This causes expenditure switching for consumers in both countries. Overall, there is greater demand for home products and the demand for labor increases further. Inflation in the home country increases as both π_H and π_F rise. The real wage falls, as inflation increases faster than the impact from π_H alone (which is itself comprised of only the impact from nominal wage adjustments), which means a reduction in marginal costs and rising profits.

The real value of net exports depends on two factors—relative prices and quantities. For the home country, the positive income effect which increases home consumption of foreign goods, C_F, is outweighed by the negative substitution effect from the large real depreciation. As such, home consumption of foreign goods, C_F, falls. For foreign consumers, the price of the home export goods falls and so more of C_H^* is demanded. Home exports therefore increase and this leads to an overall increase in the trade balance.

[47] In this version of the model, there are no differences between exporters and nonexporters and hence the impulse response functions for both types of firms are exactly on top of each other in Panel (A).

(A) Firm-level patterns



(B) Aggregate patterns

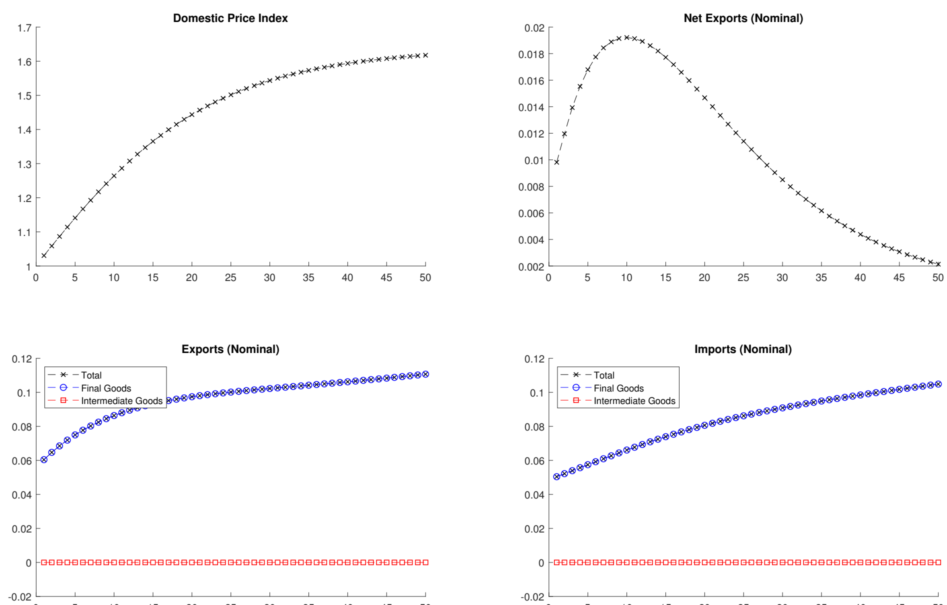


Figure D.1: **Mundell–Fleming**
Note: Panel (A) displays firm-level impulse responses to a one standard deviation (50%) shock to the growth rate of the home country nominal money supply, M_t*. Panel (B) shows the aggregate price and trade balance response. The time period is a quarter.*