(Un)Competitive Devaluations and Firm Dynamics*

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Abstract

This paper studies the impact of exchange rate shocks on firm dynamics 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 adjustment patterns. I propose a New Keynesian general equilibrium model with firm heterogeneity, varying intermediate import intensities, and international dollar pricing to explain the findings. The addition of strategic complementarities improves the quantitative performance of the model, but does not affect its qualitative properties. The new paradigm is successful in matching key firm-level moments as well as the evolution of inflation and net exports. The model is calibrated to evaluate monetary policy transmission under heterogeneous firm import intensity regimes.

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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, their usually assumed transmission mechanism seems to be at odds with microdata as well as the evolution of inflation and net exports.

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 begins by empirically dissecting the mechanisms of two recent devaluation episodes and moves on to develop a theoretical framework to analyze the effects of monetary policy on firm dynamics. 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 had, arguably, been driven by purely monetary factors. More precisely, to raise inflation, stimulate growth, and weaken the currency following years of relatively timid monetary interventions, the new prime minister, Abe, proposed three *arrows* of what has come to be known as Abenomics: monetary stimulus, fiscal flexibility, and structural reform.

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 policy 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.

As opposed 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 about 70%. Even though this happened without the use of monetary policy 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 that allow one to compute import intensities for each company with a cross-sectional identification strategy that differences out aggregate shocks to the economy, as well as a focus on non-financial and non-resource sectors, provides for relevant external validity and confirms the same micro-transmission channel as for Japan.

In sharp contrast 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 in Japan, output and consumption reacted sluggishly to the monetary stimulus and subsequent currency depreciation while the trade balance even deteriorated. 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 passthrough into prices (Amiti et al. (2014)), exporters tend to simultaneously be the largest importers and thus their expansion may be hampered by offsetting exchange rate movements on the marginal cost side. Despite the contrasting macroeconomic environment, direct cross-sectional examination of the mechanism with unique Russian firm-level customs data yields exactly the same findings.

Motivated by these empirical results, the 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 channel driving the main reallocation patterns and analyze the effects of monetary policy in open economies. Households derive utility from a composite consumption good and leisure, and are also specialized in one type of labor, which they supply monopolistically. Workers set next period's nominal wages (in their domestic currency) in advance of production and consumption. 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 et al. (2015)), and international dollar pricing (Gopinath et al. (2010) and Gopinath (2016)) to analyze the effects of competitive devaluations on firm dynamics. 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, and simulations are run to evaluate quantitatively the combined impact of firm heterogeneity and dollar pricing relative to standard models that assume away these channels. The effects of a competitive devaluation on firms' relative profitability, consumption, and employment allocations are considered 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 being the central mechanism generating a muted response of exports. Furthermore, 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 much improved via the addition of strategic complementarities in firm price setting.

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 to pre-shock GDP and inflation should increase by around 4% and 1%, respectively, the benchmark model matches these aggregate moments with much greater success, suggesting a fall in the trade balance to pre-shock GDP ratio of about 1% and an increase in CPI of 3%. Counterfactual simulations suggest vastly heterogeneous aggregate consequences depending on a country's prevalent import intensity distribution, and they underscore how the U.S. benefits from the international role of the dollar not just through its own monetary policy spillovers but also as a result of greater insulation from nominal devaluations undertaken abroad. Contrary to much conventional wisdom, the paradigm devised in this paper highlights the role of import substitution—rather than the development of national export champions—as the key transmission mechanism in the wake of competitive devaluations.

1.1 Relation to the Literature

This research builds on the new open economy macroeconomics literature. The first generation of contributions to this field emphasized welfare and policy implications of monopoly distortions in production, extending to an open-economy setting key conclusions of influential closed-economy models such as Blanchard and Kiyotaki (1987) and Ball and Romer (1990). In those models wages and prices are suboptimally high while output and consumption are low. Obstfeld and Rogoff (1995) then developed a two-country model to think about global macroeconomic dynamics in an environment with monopolistic competition and sticky nominal prices. The model developed in this paper is close in spirit to the Obstfeld and Rogoff (2000) framework based on sticky nominal wages. Corsetti et al. (2000) develop a general equilibrium model with monopolistic competition and 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 et al. (2010) study optimal monetary stabilization policy in interdependent open economies by proposing a unified analytical framework that systematizes the existing literature. Even if the mechanisms under consideration are completely distinct, the results in the present study are similar in spirit to Corsetti and Pesenti (2001), who 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 et al. (2010), Gopinath (2016) and contemporaneously modeled in Casas et al. (2017).[1] Cravino (2017) uses

[1] Casas et al. (2017) is contemporaneous work that proposes the dollar invoicing paradigm as a better alternative to PCP or LCP. In contract, the focus in the present paper is on another important dimension, which has so far been left out in new open economy macro—firm heterogeneity. This is crucial for the

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 et al. (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 et al. (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 appreciation; Itskhoki and Moll (2015) study active development, exchange rate and industrial 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 et al. (2015) explore the source and aggregate consequences of the gradual export expansion in emerging markets following large devaluations; Burstein et al. (2005) argue that the primary force behind large drops in real exchange rates occurring after large devaluations is the slow adjustment in the price of nontradable goods and services. 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

mechanism and findings besides DCP and imported inputs as it would otherwise be puzzling how little exporting companies grow after devaluations. In other words, firm heterogeneity is key because import intensity is correlated with exporting. Besides, the analysis in this paper centers on the domestic market rather than international markets to discipline the micro-transmission channel and uses aggregate shocks together with a cross-sectional identification strategy for causal inference.

competition and variable markups to explain the main features of fluctuations in international relative prices. Auer et al. (2017) study pass-through of the sudden Swiss franc appreciation to consumer prices after the removal of the euro peg in early 2015. Berman et al. (2012) find that higher performance firms absorb exchange rate movements in their markups so that their export volumes are less sensitive. Similar to the mechanism in this paper, Mendoza and Yue (2012) show that imported inputs require working-capital financing and that efficiency losses result when those inputs are replaced by imperfect substitutes. Halpern et al. (2015) estimate a model of importers in Hungarian microdata and find large effects from imported inputs on firm productivity. Amiti et al. (2014) show that large exporters are simultaneously large importers, and they stress the importance of this fact for understanding low aggregate exchange rate pass-through, whereas Amiti et al. (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 et al. (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 and equipped with customs data, Gopinath and Neiman (2014) find that import demand is non-homothetic and the implications for productivity depend on the details of individual firm adjustments that cannot be summarized by changes in the aggregate import share.

Lastly, a range of studies links firm profits to devaluations by combining tools from macroeconomics and finance. Gorodnichenko and Weber (2016) show that in the aftermath of monetary shocks, the conditional volatility of stock market returns rises more for companies with stickier prices than for firms with more flexible price setting rules. Griffin and Stulz (2001) explore the presence of economically significant competitive effects of exchange rate shocks on firms' stock prices. Aguiar (2005) shows that firms with heavy exposure to short-term foreign currency debt before the Mexican devaluation in 1994 experienced relatively low levels of post-devaluation investment. Cravino and Levchenko (2017b) demonstrate how multinational firms contribute to the transmission of shocks across countries using the same firm-level operating data set as in the present paper. Desai et al. (2008) find that U.S. multinational companies increase revenues, assets, and investment significantly more than local firms following depreciations. Hofmann et al. (2016) explore sovereign yields and the risk-taking channel of currency appreciation. Hau et al. (2017) study firm-level input substitution toward capital following shocks to the cost of labor. Some of the empirical methods in this paper as well as the focus on firm-level revenues (or market shares) and profitability measures are in the spirit of previous finance work that studied product market outcomes across industries (Giroud and Mueller (2011), Fresard (2010)).

The structure of this paper is as follows. Section 2 begins with a chronology of the main events around both episodes and lays out relevant institutional details for Japan and Russia. Next, section 3 describes the data sources, presents the identification strategy, and walks through the central empirical results. Section 4 develops a theoretical framework to analyze 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 institutional background leading up to the nominal devaluations in Japan and Russia, highlighting important commonalities as well as 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.

2.1 Japan: Abenomics

Having fought deflation for more than two decades after 1991, 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 figures remain subdued until today. It is against that backdrop of perpetual malaise that shortly after taking office in December 2012, Japan's new prime minister, Shinzo Abe, announced ambitious plans for a novel array of unorthodox policies aimed at breaking through Japan's seemingly unending 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 also meant to improve the country's economic performance by increasing competition, overhauling corporate governance, and making labor markets more flexible.

The first, and central, arrow 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 of so-called *quantitative and qualitative monetary easing* (QQE) meant that the monetary base would increase at an annual pace of about 60-70 trillion yen. 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. In this process, 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 Japan's real estate investment trusts (J-REITs) on a much smaller scale, with annual paces of 1 trillion yen and 30 billion yen, respectively.

Yet, because Japan's 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 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 heavy and lasting 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 employed in this paper, it has recently been argued that Japanese growth has been disappointing due to the missing second and third arrows. In fact, the IMF estimates that overall fiscal policy has actually gotten tighter due to the described consumption-tax increase (Krugman (2016)).

Abe's efforts at structural reforms failed to deliver any substantial breakthroughs that could spur economic growth. The few adopted policies obliged shareholders to be more assertive and introduced new codes on corporate governance 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 devaluation 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 much less opaque multinationals, which indicates that the main estimates are likely to be lower bounds on the effects of the devaluation. 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)).

2.2 Russia: 2014 Devaluation

In contrast to Japan, the nominal devaluation of the Russian ruble in late 2014 was the result of exogenous shocks to the economy rather than a consequence of monetary policy. First and foremost, crude oil prices, a major export of Russia, declined by nearly 50% between their yearly high in June 2014 and December 2014. Secondly, there was an abrupt worsening in the general macroeconomic environment that was linked to regional political developments. In particular, sanctions were imposed on Russia following its annexation of Crimea and a military intervention in Ukraine. Those sanctions were implemented during the course of 2014 and they included travel bans and asset freezes against individuals and groups supporting the separation of Crimea from Ukraine. As the War in Donbass escalated, major energy firms and government-owned banks were further hit with transaction bans. Russian defense contractors and arms manufacturers underwent embargos while restrictions on the oil industry and the issuance of certain bonds were introduced.

Crucially, this partial cutoff from western sources of financing is unlikely to have exerted a differential influence on importers versus purely domestic firms in Russia, and while it could affect profits, it can certainly not explain the observed domestic revenue and employment relocations in favor of smaller, more financially constrained nonimporting companies after the devaluation. Furthermore, the main 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 and industry groups engaged in support activities for mining, as well as oil and gas. Excluding those resource sectors from the analysis is important because they suffered from a direct negative shock to their revenue stream 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.[2] Finally, given the size of the baseline sample for Russia and a regression model that allows for a differential reaction to the devaluation by firms with varying debt levels, the result are highly 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 transmission channel through direct examination.

2.3 Aggregate patterns

Panel (A) of Figure 1 displays the Japanese nominal exchange rate against the U.S. dollar as well as the 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 QQE further depreciated the yen and appeared to put a dent into the growth of imports. Exports, however, still failed to increase, as would be suggested by commonly accepted macroeconomic theory and intuition. Notably, the initial deterioration of the trade balance, which started to improve only around 2015 is not simply the J-curve effect: even though a low substitutability between domestic and imported intermediate inputs made Japanese firms

[2] 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.

reluctant to decrease their imports for a very long time, classic open economy reasoning would dictate that the trade balance should eventually improve due to rising exports. But the competitive devaluation in Japan paints a starkly different picture: exports remained almost completely insensitive to the relative price of domestic currency, and even fell gradually in dollar terms. Moreover, those patterns are at odds with the well-known local currency pricing (LCP) paradigm because one would not expect dollar imports to remain as insensitive to a devaluation of such magnitude under that particular form of 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.

[Insert Figures 1 and 2 here]

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 would be true 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. 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. An important source of much of the observed price rigidity is nominal wage stickiness.[3]

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]In fact, according to the Japanese Ministry of Health, Labor and Welfare, nominal wages were perfectly sticky over this time period: the real wage index declined by exactly the same amount as overall inflation increased while nominal wages remained completely unchanged throughout 2012–2015. Those patterns imply that both sticky wages and international dollar pricing are key features of the macroeconomic environment in Japan—an observation that informs modeling choices in section 4.

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 primarily 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 Federal 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 files allow one to construct the import intensity for 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. Product markets (industries) can be 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 database, 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 more complete 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, but the country is known to have one of the highest percentages of publicly listed firms relative to GDP even when compared against other developed nations.[4] In fact, the main results in this paper remain unchanged whenever the analysis is exclusively 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 (Takeo and Nakamura (2016)). And given that the largest exporters are usually also the biggest importers (Amiti et al. (2014)), this preliminary evidence lends support to the intermediate inputs channel stressed in the paper.[5]

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

[4]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%.

[5]For Japan, the analysis relies on a company's segment files to identify exporters. In principle, foreign sales combine exports together with total revenues generated in other countries. However, extant trade research points to most international commerce as being carried out by multinational firms 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, reassuringly, confirm the baseline results for Japan.

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.[6] 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.

[Insert Tables 1 and 2 here]

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 a relatively aggregated 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 firms that are relatively exposed versus unexposed to both devaluations. Methods for gauging the importance of different mechanisms are discussed.

At the macro level, the central identification challenge with estimating the impact of devaluations on firm dynamics is the endogeneity of nominal exchange rate movements.

[6]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 et al. (2007)).

Many countries have experienced periods of large real exchange rate devaluations, and in general many factors have the potential to fuel such currency fluctuations. 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.

Meanwhile, 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 just two years. Attributing any aggregate reaction to a competitive devaluation would be complicated if, for example, adverse productivity shocks were the true underlying force instead.

At the micro level, the paper looks at both the experiences of Japan and Russia using novel microdata along with unique Russian firm-level customs data to investigate the response of firms that vary in their exposures to exchange rate fluctuations while stripping out aggregate shocks to the economy.

3.2.1 Cross-sectional evidence

Much of the evidence relies on the nominal exchange rate affecting nonexporting/nonimporting companies differentially compared with Japanese and Russian multinationals. 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 yen devaluation on domestic revenue, employment, and profitability via a difference-in-differences (DinD) 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 finance literature. All standard errors are clustered at the firm-level to allow for serial correlation across time.[7]

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

[7] Implementing the same regression framework on the merged Russian customs and firm-level data when testing the imported inputs channel directly implies that $Treat_i$ becomes a firm's import intensity, defined as the share of imported intermediate inputs from outside of Russia in total variable costs of a firm in 2013 (right-winsorized at the 99.5 percentile), and 2014 becomes the omitted year category.

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.

3.2.2 Mechanisms

Previous literature has established the centrality of imported intermediate inputs to the production processes of large exporting firms (Amiti et al. (2014)). Despite the lack of access to Japan's firm-level customs data, which would permit the exploration of the importance of this channel directly, insights into the driving forces behind the growth (or contraction) of exporters relative to nonexporters following Abenomics can be gained with a triple difference (DDD) identification strategy.

In particular, manufacturing and non-financial industries are known to be heterogeneously reliant on imported intermediate inputs in their 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 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:

$$\begin{aligned}\log(Y_{i,t}) = \alpha_i + \alpha_1' X_{i,t} + \alpha_2'(X_{i,t} \cdot QE_t) + \beta_1(Treat_i \cdot QE_t) + \beta_2(IC_j \cdot QE_t) \\ + \gamma(Treat_i \cdot IC_j \cdot QE_t) + \nu_{i,t}\end{aligned} \quad (2)$$

where, as earlier, 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, $X_{i,t}$ is a matrix of control variables that includes size, leverage, as well as cash-to-assets, $Treat_i$ is an indicator variable equal to 1 whenever a firm is a Japanese exporter and 0 when the firm is a domestic nonexporter, 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.[8] An attractive feature of this input-output table 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 employed in another sector, then a third, and eventually become embodied in a final good.[9] 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

[8] 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 $u' A_m (I - A_d)$.

[9] In the end, the core results are insensitive to using the direct or indirect measure of import dependence since the ranking between industries remains completely unaltered with either approach.

versus less import dependent sectors. A positive coefficient would imply that, ceteris paribus, 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:

$$\begin{aligned} \log(Y_{i,t}) = \alpha_i + \theta' X_{i,t} + \sum_t \gamma_t \mathbf{D}_t + \sum_t \delta_t \left(\mathbf{D}_t \cdot X_{i,t}\right) + \sum_t \psi_t \left(\mathbf{D}_t \cdot Treat_i\right) \\ + \sum_t \lambda_t \left(\mathbf{D}_t \cdot IC_j\right) + \sum_t \zeta_t \left(\mathbf{D}_t \cdot Treat_i \cdot IC_j\right) + \epsilon_{i,t} \\ \forall i,\ \forall t \in \{2010, \ldots, 2015\} \setminus \{2012\} \end{aligned} \tag{3}$$

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, and provides evidence of the validity of the critical parallel trends assumption.

3.3 Empirical results

This section presents the main cross-sectional findings on the relative expansion paths of exporters/importers versus nonexporters/nonimporters in Japan and Russia following each devaluation, delving into the evidence on the potential mechanism underlying all results. Heterogeneous import intensities are explored as the key driving forces behind the nonuniform 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). In particular, and as confirmed in previous trade studies (e.g., Bilbiie et al. (2012)), this extensive margin is inconsequential in terms of overall volume. The distinction between new exporters and purely domestic nonexporting firms is thus also immaterial to the subsequent analysis—attention will be devoted to purely domestic firms and continuing exporters in evaluating the cross-sectional impact of both devaluation episodes.[10]

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.

[Insert Table 3 here]

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 among companies, such as size and other balance sheet items that have been widely used in the finance literature and are pertinent

[10] Even though Japan experienced a feeble aggregate reaction of export volumes (as shown in Figure 1), the weaker yen appears to have induced a higher level of participation in foreign sales across companies at the micro-level. 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 in the sample. Indeed, newcomers turn out to resemble purely domestic firms more closely than continuing exporters in terms of size and other pertinent operating characteristics.

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.

[Insert Figure 3]

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.[11] As would be consistent with the parallel trends assumption, the estimates in Figure 3 show no robust differences between exporters and nonexporting firms in the years prior to the onset of Japan's quantitative easing policy: 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.[12]

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. Importantly, 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 puz-

[11] 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 the outcome variable.

[12] 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.

zling 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.

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 firms equally. As mentioned in section 3.1, identification is further bolstered through the exclusive focus on non-financial and non-resource oriented industries to provide external validity.

[Insert Figure 4]

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 critical 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 the imported intermediate inputs transmission channel.

To shed more light on the role of intermediate inputs as the driving force behind the results in Japan, this section also exploits disparities in the import content of production across industries by using Japan's input-output tables in 2011. As it turns out, there is substantial heterogeneity across non-financial sectors in terms of their import reliance. The summary statistics in Table 1 show that the sectoral import content of production measure, IC, has a mean of 11.36% and a standard deviation of 4.61% in the baseline sample. Given that exporters are also the biggest importers (as documented in the data and previous work), one should expect to see larger differences across purely domestic firms (nonimporters) and continuing exporters (importers) within industries that are more dependent on imported inputs. Essentially, this is tantamount to a triple difference methodology, where the above cross-sectional comparisons between nonexporters and exporters are also made conditional on these firms operating in relatively import-reliant versus -unreliant sectors.

[Insert Table 4 here]

Table 4 presents the estimation results for regression model 2 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 facilitates verification of 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. Notably, 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.

[Insert Figure 5 here]

Panel (A) of Figure 5 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 3. As before, this methodology scrutinizes the causal interpretation of the results. Again, 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.[13] The magnitudes of the results are similar to the ones in Table 4, and still manage to yield statistically significant results at the 10% level for both domestic revenue and employment by 2014.[14] Given the lack of firm-level customs data for Japan—which would make it possible to investigate the channel directly as for Russia—and since input-output measures for sectoral import reliance are noisy, the strength and robustness of the findings are remarkable.

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 hence led to the trends observed following both devaluation episodes. Another prominent hypothesis might highlight simultaneous 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 5, 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 and after the second round of quantitative easing. Yet, 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 explaining why lower interest

[13] 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.

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

rates would generate the observed cross-sectional patterns between exporters and domestic nonexporters. Interest rate movements are, therefore, very unlikely to have been the main explanatory factor behind the presented empirical results. Lastly, potential confounding factors stemming from a revaluation of long-term debt are accounted for by the inclusion of leverage as well as its interaction term with the time indicator, allowing for a heterogeneous response to the nominal devaluation across firms with varying degrees of exposure to long-term debt in both Russia and Japan.[15]

Taken together, 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 thus embeds heterogeneous import intensities across firms as a key ingredient for generating the observed cross-sectional patterns documented so far.

4 Model

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

The proposed static open economy consists of two countries of equal size, home (H) and foreign (F), which means that time subscripts can be avoided while the consumption and labor reallocation channels are elucidated in the most tractable fashion. As in the models of Obstfeld and Rogoff (2000) and Obstfeld and Rogoff (1996), firms produce differentiated goods using heterogeneous labor inputs indexed by [0,1]. One may think of each worker as a monopolistic supplier of a distinctive variety of labor services. Workers are assumed to set next period's nominal wages in their domestic currency in

[15] Yet another alternative story could stress a potential currency mismatch and differential exposure to dollar borrowing across firms. This phenomenon is extremely rare in Japan, with only a tiny fraction of companies ever having issued a Eurobond. See Bruno and Shin (2017) for more detail. In Russia, only 66 foreign currency bonds were issued by non-financial and non-resource oriented companies in 2006–2014.

advance of production and consumption. All labor is then supplied to firms in light of subsequently realized economic shocks, where the main focus will be on monetary shocks. Although wages are preset, domestic prices are completely flexible and can be changed in response to market conditions.

Home and foreign produce an array of differentiated tradable goods. Even though tradable goods could be thought of as products of exporters, with each country also manufacturing an array of differentiated nontraded goods that would then be seen as output of nonexporters, the framework will develop a more realistic version of the model accounting for the fact that all cross-sectional patterns are observed *within* rather than across industries.

Several key ingredients from international trade are incorporated and applied to the analysis of monetary policy in open economies. Firstly, strategic complementarities and variable markups are combined with a firm's choice to import intermediate inputs. That is, firms will be heterogeneous, choosing to sell products as well as to source intermediate inputs from abroad. The exchange rate will influence revenue and employment via three potential channels: 1) by changing the costs of imported inputs, 2) by changing the export prices in local currency (depending on pricing assumption), and 3) by affecting the degree of import competition in the domestic market. While being less important qualitatively, incorporating strategic complementarities is useful for improving the quantitative fit of the model.

Secondly, the following international pricing scenarios will be compared in turn: 1) producer currency pricing (PCP), 2) local currency pricing (LCP), and 3) dollar currency pricing (DCP). The last would be consistent with recent evidence suggesting that most trade around the world is invoiced in U.S. dollars (Gopinath (2016)) and is critical in reproducing the patterns observed in section 3.3. The nominal exchange rate denoted 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*.

Motivated by Bilbiie et al. (2012) as well as by unreported empirical results in section 3.3 showing that entry into foreign sales is a negligible portion of the total volume, the export and import status of a firm are assumed to be fixed.[16] The trade literature (e.g., Halpern et al. (2015), or Amiti et al. (2014)) takes a detailed approach to separately modeling firm import and export decisions and finds that both are highly correlated in equilibrium as well as in the data. This implies that the majority of all firms are either exporters or nonexporters, and so the model will focus on these two types and thereby also mimic the main empirical discussion. A schematic representation of benchmark model is provided in Figure 6.

4.1 Households

A consumer of type i maximizes utility derived from goods and minimizes disutility from labor. For simplicity of exposition separable constant-elasticity preferences over consumption and leisure are adopted. More precisely, the utility of a home representative household is given by:

$$U_i = \log C_i - \frac{\kappa L_i^{1+\psi}}{1+\psi} \tag{4}$$

where L_i is the labor supply and C_i is the consumption aggregator for any person i. The home consumption index depends on home and foreign tradables, and it can be written in the following form:

$$C = \left[\alpha^{1/\eta} C_H^{\frac{\eta-1}{\eta}} + (1-\alpha)^{\frac{1}{\eta}} C_F^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{5}$$

where C_H is the home consumption of domestic tradable goods, and C_F is home consumption of foreign tradables. The foreign country has a parallel indexes, but with a weight of $\alpha^\star > 1/2$ on consumption of its own export good. These assumptions generate

[16] Besides, new firms account for a very small share of overall production and employment, meaning that it would also be safe to ignore the extensive margin for aggregate outcomes.

home bias in consumption within the category of tradable goods and can be thought of as a substitute of explicit trade costs for tradable goods.

The η parameter is the constant elasticity of substitution between domestically produced and imported tradables, and it underlies the magnitude of price responses to quantity adjustments. A lower substitution elasticity implies that sharper prices changes are required to accommodate a given adjustment to quantities consumed.

The domestic consumer price index (CPI) corresponding to the consumption index C, measured in units of domestic currency, depends on the local prices of home and foreign produced tradables, P_H and P_F, according to the formula:

$$P = \left[\alpha P_H^{1-\eta} + (1-\alpha) P_F^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{6}$$

In the foreign country, there is an isomorphic index of tradable prices and nominal CPI with weight $\alpha^{\star}$ attached to foreign exportable goods. The home demand functions resulting from utility maximization are:

$$C_H = \alpha \left(\frac{P_H}{P_T}\right)^{-\eta} C, \qquad C_F = (1-\alpha)\left(\frac{P_F}{P_T}\right)^{-\eta} C \tag{7}$$

4.1.1 Differentiated goods

Consumers in each market are assumed to have a nested CES demand over varieties of goods. In other words, the tradable sector consists of domestic and foreign goods, where both C_H and C_F are indexes of the consumption of domestic and foreign goods given by the constant elasticity of substitution functions:

$$C_H = \left(\int_0^1 C_H(\omega)^{\frac{\rho-1}{\rho}}\,\mathrm{d}\omega\right)^{\frac{\rho}{\rho-1}}, \qquad C_F = \left(\int_0^1 C_F(\omega)^{\frac{\rho-1}{\rho}}\,\mathrm{d}\omega\right)^{\frac{\rho}{\rho-1}} \tag{8}$$

where $\omega \in [0,1]$ denotes the good variety, and each country produces a continuum of differentiated goods on the unit interval. The elasticity of substitution across the varieties within a sector is ρ, while the elasticity of substitution between domestic and foreign goods is η. Varieties within an index are assumed to be more substitutable than the home and foreign goods: $\rho > \eta \geq 1$.

Consumers maximize utility, given by equation 4, subject to their budget and cash-in-advance constraints. A firm producing a differentiated good ω and supplying it to destination market $k \in \{H, F\}$ will face a demand function given by:

$$C_k(\omega) = \left(\frac{P_k(\omega)}{P_k}\right)^{-\rho} C_k \tag{9}$$

where, for $k \in \{H, F\}$, $P_k = \left(\int_0^1 P_k(\omega)^{1-\rho}\, \mathrm{d}\omega\right)^{1/(1-\rho)}$ is either the index of prices of domestically or foreign produced goods. Combining the above optimality conditions in equation 9 with the definitions of the price and quantity indexes, P_k and C_k, yields $\int_0^1 P_k(\omega) C_k(\omega)\, \mathrm{d}\omega = P_k C_k$. Lastly, the optimal allocation of expenditures between domestic (H) and imported (F) goods is given by:

$$C_H = \alpha \left(\frac{P_H}{P}\right)^{-\eta} C, \qquad C_F = (1-\alpha)\left(\frac{P_F}{P}\right)^{-\eta} C \tag{10}$$

where $P = \left[\alpha P_H^{1-\eta} + (1-\alpha) P_F^{1-\eta}\right]^{1/(1-\eta)}$ is the CPI, and total consumption expenditures by domestic households are $P_H C_H + P_F C_F = PC$.

4.2 Firms

There are two types of firms operating in the tradable sectors of both the home and foreign economies: purely domestic (D) and exporters (E).[17] In general, firms in the tradable sector use labor, $L(\omega)$, and imported intermediate inputs, $X(\omega)$, to produce a

[17] As in much of the trade literature (e.g., Melitz (2003)), the former can be thought of as less productive companies that are unable to recoup the fixed costs of exporting, and the latter as more productive companies, catering to both domestic and foreign markets.

unique variety ω. The production function is:

$$Y_H(\omega) = A_\omega L(\omega)^{1-\varphi_\omega} X(\omega)^{\varphi_\omega} \tag{11}$$

where A_ω captures firm productivity, $X(\omega)$ is a bundle of diverse intermediate inputs produced aboard, and the labor input, $L(\omega)$, is a CES aggregator of the individual labor varieties supplied by each household:

$$L(\omega) = \left[\int L(i,\omega)^{\frac{\phi-1}{\phi}} \,\mathrm{d}i\right]^{\frac{\phi}{\phi-1}}, \qquad \phi > 1 \tag{12}$$

Here, $L(i,\omega)$ is the demand for labor input i by producer ω. Letting W_i stand for the nominal wage of worker i, the price index for labor inputs, W, is given by:

$$W = \left[\int W_i^{1-\phi} \,\mathrm{d}i\right]^{\frac{1}{1-\phi}} \tag{13}$$

There are parallel production functions with the same substitution elasticity, ϕ, for foreign-produced tradables, $Y_F(i)$. Splitting output between the home and foreign markets, $Y = Y_H + Y_H^\star$, the firm's per-period profits (distributed to domestic households) are given by:

$$\begin{aligned}\Pi(\omega) &= \Pi_H(\omega) + \Pi_H^\star(\omega) \\ &= (P_H(\omega) - MC(\omega))Y_H(\omega) + (P_H^\star(\omega)\epsilon - MC(\omega))Y_H^\star(\omega)\end{aligned} \tag{14}$$

Marginal costs are then:

$$MC(\omega) = \frac{W^{1-\varphi_\omega} P_X^{\varphi_\omega}(\omega)}{\widetilde{A}_\omega} \tag{15}$$

where W is taken as given (from equation 13) and does not vary across firms, while the imported inputs price index is equal to: $P_X(\omega) = \epsilon P_X^\star(\omega)$ and varies across firms to the extent that they import different measures of intermediate input varieties.

Holding everything else constant, the larger the measure of imported varieties used, the lower the intermediate input cost index. Also, $P_X^\star$ is the cost index of imported intermediate inputs in foreign currency, ϵ is the nominal exchange rate, φ_ω is the firm's import intensity, and $\widetilde{A}_\omega$ is the company's productivity term.

A microfoundation for this type of cost structure, where the import intensity, φ_ω, and the set of imported intermediate inputs are endogenously determined by firms facing fixed costs of importing, F, is provided in the trade literature (Amiti et al. (2016), Halpern et al. (2015)). The optimality conditions for hiring labor are given by:

$$L(\omega) = \frac{(1-\varphi_\omega)MC(\omega)Y(\omega)}{W}, \qquad L(i,\omega) = \left[\frac{W_i}{W}\right]^{-\phi} L(\omega) \tag{16}$$

And the optimality condition for intermediate inputs is:

$$X(\omega) = \frac{\varphi_\omega MC(\omega)Y(\omega)}{P_X} \tag{17}$$

4.3 Asset markets and budget constraints

There are complete markets, so agents can trade state-contingent securities in complete set of financial markets before the realization of the state of the world $s \in S$, with density $\pi(s)$. All agents own an equal share of domestic firms and of an initial stock of the domestic currency. There is no ex-ante trade in equity between countries. Money is introduced into the model by means of a cash-in-advance constraint:

$$P(s)C_i(s) \leq M_i(s) \tag{18}$$

while a typical individual i in the home country maximizes the expectation of equation 4 subject to the following two budget constraints:

$$\int D_i(s)Q(s)\pi(s)\,\mathrm{d}s = 0 \tag{19}$$

$$P(s)C_i(s) + M_i(s) \leq W_i L_i(s) + \int [\Pi_H(j,s) + \Pi_N(j,s)]\, \mathrm{d}j + T_i(s) + D_i(s) \tag{20}$$

where $Q(s)$ is the price of one unit of domestic currency in state s, normalized by the probability of state s, $W_i L_i(s)$ is labor income, where the wage is preset and does not depend on s, $T_i(s)$ is a lump-sum transfer, $D_i(s)$ are state-contingent net foreign assets denoted in home currency held by the domestic household i, and the integral in the second constraint aggregates profits of all domestic firms. Individuals take firm behavior as given. The home government budget constraint is given by:

$$M = T \tag{21}$$

So the government is assumed to rebate all lump-sum transfers in the form of money.[18]

4.4 Wage setting

Using the individual's budget constraint (equation 20) to eliminate C_i in the utility function, the first order condition for the optimal preset nominal wage, W_i, is:

$$W_i = \left(\frac{\phi}{\phi - 1}\right) \frac{\mathbb{E}\left[\kappa L_i^{\psi+1}\right]}{\mathbb{E}\left[L_i / PC_i\right]} \tag{22}$$

Here, the expectation operator in equation 22 reflects the monetary uncertainty faced by households. At an optimum, this wage-setting formula requires the expected marginal revenue (in marginal utility of consumption) from raising the wage a little bit to be equal to the expected marginal utility from the fewer hours worked as a result. Without monetary or exchange rate uncertainty, the relationship would simply give the marginal utility of the real wage as a fixed markup over the marginal disutility of labor, as is

[18] It is also assumed that the government buys back the whole outstanding money supply at the end of the period, financing the operation with lump sum taxes imposed on the consumption good. By doing that, the government effectively has the freedom to choose the price level and thereby ensures a *monetary* equilibrium. In particular, because the government is choosing how many consumption goods will pay for M, it can set M/p and implement $M/p > 0$.

standard for a monopolist facing a constant elasticity of demand.

4.5 Price setting

This section assumes constant markups and the use of domestic currency for pricing at home. Monopolistically competitive firms may set their domestic prices at whatever levels they choose. However, since individuals have constant elasticity of demand preferences, revenue maximizing firms in the singe sector economy will choose prices for goods that are a constant markup over their marginal costs.

Outcomes under three alternative pricing assumptions in international markets are contrasted: producer currency pricing (PCP), local currency pricing (LCP), and dollar currency pricing (DCP). Throughout, firms choose prices domestically and abroad to maximize their profits, $\Pi(\omega) = \Pi_H(\omega) + \Pi_H^\star(\omega)$.

4.5.1 Dollar currency pricing

When home prices are set in domestic currency and international prices are set in dollars, profit maximization at home (w.r.t. $P_H(\omega)$) and abroad (w.r.t. $P_H^\star(\omega)$) implies:

$$\overline{P}_H(\omega) = \left(\frac{\rho}{\rho - 1}\right) MC(\omega), \qquad \overline{P}_H^\star(\omega) = \frac{1}{\bar{\epsilon}} \left(\frac{\rho}{\rho - 1}\right) MC(\omega) \tag{23}$$

As usual, when firms compete in prices, they set a multiplicative markup $\rho/(\rho - 1)$ over their costs. Any ex-post fluctuations in the nominal exchange rate, ϵ, will affect repatriated profits, $\Pi_H^\star(\omega)$, but will not influence the pre-set dollar price. Meanwhile, imported intermediate input prices are also set in dollars, $P_X^\star$, and the price of imported consumption goods is given by:

$$P_F = \epsilon \overline{P}_F^\star = \epsilon \left(\frac{\rho}{\rho - 1}\right) MC(\omega)^\star \tag{24}$$

Under this form of price stickiness, nominal exchange rate changes lead to proportional short-run deviations from the law of one price. With import prices preset in the importer's rather than the exporter's currency, the short-run degree of exchange rate pass-through to import prices is exactly zero.

4.5.2 Producer currency pricing

When home and international prices are set in producer currency, profit maximization at home and abroad (w.r.t. $P_H(\omega)$) implies the same relationships as in 23, but nominal exchange rate movements will now lead to fluctuations in the foreign currency prices of exports. Accordingly:

$$\overline{P}_H(\omega) = \left(\frac{\rho}{\rho-1}\right) MC(\omega), \qquad P_H^{\star}(\omega) = \frac{1}{\epsilon}\overline{P}_H = \frac{1}{\epsilon}\left(\frac{\rho}{\rho-1}\right) MC(\omega) \tag{25}$$

Similarly, imports will be priced in producer currency, as in equation 24.

4.5.3 Local currency pricing

Now consider the alternative case of local currency pricing. The mechanism of a nominal exchange rate devaluation under LCP is somewhat different from before. Under PCP, a currency depreciation affects international relative consumer prices, whereas under LCP, profit margins are affected while prices stay unchanged.

The local currency pricing case is almost identical to dollar currency pricing, except that import prices are now also set in local currency rather than dollars. Hence equations 23 will still hold for the home good, intermediate input prices will not be sensitive to exchange rate fluctuations but fixed at $\overline{P}_X$, and imported goods prices will be predetermined in the home currency:

$$\overline{P}_F = \overline{\epsilon} P_F^{\star} = \overline{\epsilon}\left(\frac{\rho}{\rho-1}\right) MC(\omega)^{\star} \tag{26}$$

4.5.4 Strategic complementarities

The above price setting assumptions can be tweaked 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 (2016), price setting of domestic firms is assumed to take the following form under DCP:

$$P_H(\omega) = \frac{\rho}{\rho - 1} \left(MC(\omega)\right)^{1-\zeta} \cdot P^{\zeta} \tag{27}$$

$$P_H^{\star}(\omega) = \frac{\rho}{\rho - 1} \left(MC(\omega)/\epsilon\right)^{1-\zeta} \cdot (P^{\star})^{\zeta} \tag{28}$$

Here, $\zeta \in [0, 1)$ is the strategic complementarity elasticity. Equations 27 are *ad hoc* but 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.

Strategic complementarities in price setting, when $\zeta > 0$, reflect the tendency of companies to set prices closer to their local competitors, a pattern which is both pronounced in the data and emerges in a variety of models (as in Amiti et al. (2016)). Since these price setting assumptions are consistent with a version of Kimball (1995) demand, they are referred to as such in the quantitative section.

4.6 Market clearing

The home market for tradable goods clears when domestic demand equals domestic supply (the foreign country faces a parallel condition):

$$Y_H = C_H + C_H^{\star} = \alpha \left(\frac{P_H}{P}\right)^{-\eta} C + (1 - \alpha^{\star}) \left(\frac{P_H/\epsilon}{P^{\star}}\right)^{-\eta} C^{\star} \tag{29}$$

Domestic net exports measured in home currency are defined as:

$$NX = \epsilon P_H^{\star} C_H^{\star} - P_F C_F \tag{30}$$

4.7 Competitive devaluations

Having fully described the static complete markets DCP, PCP or LCP economy, the last remaining block needs to specify nominal exchange rate determination. The utility function in equation 4 together with the cash-in-advance (CIA) constraint and complete markets imply the following simple relationship:[19]

$$\epsilon = \frac{M}{M^{\star}} \tag{31}$$

4.8 Equilibrium

Solving for the *competitive equilibrium* of the DCP, PCP and LCP models entails the following conditions to hold:

1) Household optimization, firm optimization, and either DCP (equations 23 and 24), or PCP (equations 25), or LCP (equations 23 and 26).

2) Markets clear such that: $Y_H = C_H + C_H^{\star}$, and $Y_F^{\star} = C_F + C_F^{\star}$.

3) The monetary block is described by equation 31, and money demand is given by the cash-in-advance constraint in equation 18.

This completes the description of the modeling environment. The next sections present analytical results for intuition and turn to a numerical analysis that contrasts outcomes following a competitive devaluation under the three pricing regimes.

4.9 Comparative statics

In order to build some intuition for how the relative allocations between productive exporters and unproductive nonexporters shift in the aftermath of a competitive devaluation, consider the consumption ratio of two distinct firms. The objective is to compare

[19] The same condition is derived in Kehoe and Midrigan (2007).

what happens to the ratio of $C_H(\omega)$ to $C_H(\tilde{\omega})$, where the initial firm is an exporter and the latter is not, i.e. with $\varphi_\omega > \varphi_{\tilde{\omega}}$, following a nominal devaluation under the dollar currency pricing (DCP) regime. Define:

$$\begin{aligned}\Delta_C &\equiv \ln\left(\frac{C_H(\omega)}{C_H(\tilde{\omega})}\right) \\ &= \rho\left(\ln P_H(\tilde{\omega}) - \ln P_H(\omega)\right) \\ &= \rho\left(\ln MC(\tilde{\omega}) - \ln MC(\omega)\right)\end{aligned}$$

And now consider how Δ_C changes with the nominal exchange rate:

$$\begin{aligned}\frac{\partial \Delta_C}{\partial \ln \epsilon} &= \rho\left(\varphi_{\tilde{\omega}}\frac{\partial \ln P_X(\tilde{\omega})}{\partial \ln \epsilon} - \varphi_\omega \frac{\partial \ln P_X(\omega)}{\partial \ln \epsilon}\right) \\ &= \rho\left(\varphi_{\tilde{\omega}} - \varphi_\omega\right) < 0 \quad \text{since: } \varphi_\omega > \varphi_{\tilde{\omega}}\end{aligned}$$

As long as higher productivity firms have a larger import intensity than lower productivity firms do, the elasticity of $C_H(\omega)/C_H(\tilde{\omega})$ with respect to the nominal exchange rate is negative. This means that a competitive devaluation should lead to a relative expansion of less productive domestic firms at home.

A similar relationship holds for relative employment across the two types of firms. The only difference is the presence of slightly offsetting effects due to the increasing marginal cost side and the decreasing amount of output that results from the fall in demand following higher prices. The analogous expressions becomes:

$$\begin{aligned}\Delta_L &\equiv \ln\left(\frac{L_H(\omega)}{L_H(\tilde{\omega})}\right) \\ \frac{\partial \Delta_L}{\partial \ln \epsilon} &= (\rho - 1)\left(\varphi_{\tilde{\omega}} - \varphi_\omega\right) < 0\end{aligned}$$

Overall, employment shrinks at the more productive firms relative to the less productive nonexporters, albeit at a smaller rate than the ratios of consumption.

The predictions of the baseline model for relative consumption and employment growth as well as for the response of prices and net exports are then inconsistent with the data. At the same time, those moments characterize the dynamic adjustment path of an economy, and conventional wisdom often stresses the importance of nurturing national export champions that can spur economic growth following efforts to weaken the currency. Any coherent theory of competitive devaluations should, therefore, be expected to match those moments more successfully.

5 Quantitative Results

This section numerically evaluates the impact of competitive devaluations on firms' relative profitability, consumption, and employment allocations. Nominal exchange rate devaluations of diverse intensity are considered and 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 economy framework developed in section 4 is used for delving into the mechanisms by which international shocks are transmitted into domestic prices and quantities in light of the firm-level empirical findings of section 3.2. To that end, a tightly calibrated quantitative model that captures the cross-sectional heterogeneity observed in Japan's manufacturing industries is employed to show how the interaction of dollar currency pricing and import intensities shapes aggregate and firm-level reactions following a competitive devaluation as observed during Abenomics.

5.1 Parameter values

Consider a representative industry with domestic nonexporting (D) as well as exporting (E) firms in both countries. The representative sector will be calibrated to one that is typical in the Japanese data, focusing on the domestic market in which both domestic and foreign (say, US) firms compete. In a given Japanese industry, three types of firms are operating: N_E home exporters (serving both domestic consumers and the foreign market), N_D solely domestic firms, and N_F foreign firms. To approximate one of the features of the Japanese domestic market, the number of firms is calibrated to match an average SIC industry. In particular, the industry is taken to be composed of 300 firms (N) in both countries, and firms in each economy are born with an idiosyncratic marginal cost draw from the distribution $G(A)$. The entry decision into the domestic market happens automatically and is not modeled for simplicity. Meanwhile, the total number of firms headquartered at home and abroad that sell positive amounts of their goods in *each* country (exporters) is determined endogenously in equilibrium. In other words, firms will simultaneously choose to export and import intermediate inputs if such a decision yields additional profit for them.

The fraction of Japanese (and U.S.) manufacturing firms that export and import is set to be the most productive 10% of companies in the industry. That said, the key outcomes of the model are insensitive to specifying a smaller competitive fringe with a larger percentage of firms participating in international trade.[20] The marginal cost of a firm is modeled just like in section 4.2, more precisely:

$$MC(\omega) = \frac{W^{1-\varphi_\omega} \left[\epsilon P_X^\star(\omega)\right]^{\varphi_\omega}}{A_\omega} \tag{32}$$

where W is the price of labor (or domestic inputs), $P_X^\star(\omega)$ is the foreign-currency price index of foreign (imported) inputs, ϵ is the nominal exchange rate, and A_ω is the effective idiosyncratic productivity of the firm. In general, imported intermediate input prices do not have to depend on ω, because the formulation would still capture the idiosyncratic heterogeneity in input prices from before through the effective idiosyncratic productivity term A_ω. As in the recent trade literature, the exchange rate exposure term, φ_ω, is assumed to be firm-specific and constant over time. Amiti et al. (2014) show this assumption to be justified using Belgian trade data, with firm-level import intensities not being sensitive to exchange rate movements over a horizon over 3–5 years. Using

[20] Bernard and Jensen (2004) report the fraction of exporters in total plants to be 21% in 1987 and 30% in 1992. The baseline calibration in this paper will specify a larger competitive fringe, with many small firms capturing minuscule portions of the overall industry production volume.

that formulation, $P_X^{\star}(\omega)$ will be lower for exporters (that are also importers) than for nonexporters, and the price of intermediates is assumed *not* to move with the exchange rate, which is consistent with pass-through into import prices being slow and incomplete. Following Halpern et al. (2015), the cost-savings from importing are calibrated to be equal to 20% of production costs, meaning that firms compare the fixed costs of becoming exporters with the added benefits from lower marginal costs.

[Insert Table 6 here]

The initial value of the nominal exchange rate is set equal to one, and allocation outcomes are compared across a range of domestic monetary expansions that lead to varyingly large devaluations of the yen. Reflecting the industry-equilibrium focus of the numerical exercise as well as for simplicity and consistency with the nominal wage rigidity assumption of the model, the following normalizations are imposed: $W = 1$, $[P_X^{\star}]^D = 1$ for nonexporters, which means $[P_X^{\star}]^E = 0.8$ for exporters. Initial firm productivities are drawn from a log-normal distribution, $A_{\omega}^{-1} \sim \ln \mathcal{N}\left(\mu_A, \sigma_A^2\right)$, where μ_A is the location, and σ_A the scale parameters of the distribution. In the calibration, $\sigma_A = 0.1$, $\mu_A = 1$. Exporting firms draw their costs from the same distribution but end up being the most productive 10%. Given the other parameters of the model (including the demand elasticity ρ), this allows one to match the cross-sectional differences in profits, sales and employment patterns following a nominal devaluation.

The home bias parameter, α, is set to 0.93 in both countries, reflecting the fact that both Japan and the U.S. are relatively closed economies. Exports as well as imports are separately equal to about 14% of GDP for both Japan and the US, and given that final consumption is about half of total imports, with the rest capturing intermediate inputs, this ends up producing a 7% foreign share parameter. The exchange rate exposure across firms, $\varphi(\omega)$, is calibrated to reproduce the sales allocations across different types of companies in the data. For domestic nonexporting firms, $\varphi(\omega)^D = 0$, whereas for all-time exporters, this import intensity measure is set to $\varphi(\omega)^E = 0.4$. Because the information on import intensities is not directly observable in the data, this calibration enables the differential home sales and employment trends to be matched across both groups of companies. In addition, these parameter values help replicating the muted net exports reaction. As shown in Amiti et al. (2014), exporters are more import intensive than exclusively domestic firms are, and that feature is captured in the calibration. As mentioned, import intensities are also assumed to remain fixed independent of exchange fluctuations, which is a good approximation over horizons of 3–5 years.

Having specified the distribution of costs (or productivities) for both types of firms, $\{MC(\omega)\}$, equilibrium prices are firstly calculated assuming constant markups and CES demand—that is, according to equations 23, which then allows one to solve for industry and aggregate prices as well as the remaining allocations. Anderson and Van Wincoop (2004) survey the evidence on the elasticity of demand for imports at the sectoral level and conclude that this elasticity is likely to be in the range of 5 to 10. Even though the results in this paper 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 varieties within home or foreign goods is chosen to be $\rho = 6$, a value near the middle of a relatively wide range of estimates found in much of the literature. To better match the quantitative predictions of the model, the second approach to solve for prices is via a Kimball demand specification, as in equation 27. The parameter ζ is set to 0.7, which is somewhat larger than estimated by Amiti et al. (2016) but still in line with much of the markup and pass-through literature, especially given the low price reactions to exchange rates documented in Japan.

5.2 Model fit

Before turning to counterfactuals and policy implications, the calibrated model is verified to reproduce the key empirical mechanism of section 3.3. This is shown by rerunning specification 2 on data simulated from the model, where the results are reported in Table 5. In parallel to the empirical mechanism in Table 4, a firm's employment and domestic sales (in columns (1) and (2)) are regressed on a set of firm fixed effects, the

QE_t dummy, as well as the following interaction terms: $(Treat_i \cdot QE_t)$, $(IC_j \cdot QE_t)$, and $(Treat_i \cdot IC_j \cdot QE_t)$. As before, $Treat_i$ is an indicator variable equal to 1 whenever a firm is an exporter and 0 when the firm is entirely domestic, and IC_j equals 1 when exporters in the industry have an import intensity of 40% (i.e., $\varphi_\omega = 0.4$), whereas IC_j takes on the value of 0 if exporters, just like purely domestic firms, do not source any intermediate inputs from abroad (i.e., $\varphi_\omega = 0$). In addition, the natural logarithm of model generated prices is now also included as one of the outcome variables in column (3) of Table 5. The estimated coefficients show that, following a 30% nominal devaluation, the model nails the analog of γ in specification 2 of section 3.2. In other words, the model predicts that exporters will shrink relative to nonexporters only in import reliant sectors, as observed in real world data. Indeed, the results in column (3) of Table 5 suggest that exporters in such industries will be forced to increase prices more than their nonexporting peers, which leads them to lose market share as a result.

[Insert Table 5 here]

This analysis confirms that the calibrated model delivers on salient features of firm behavior in the data, and can be used for counterfactual analysis. Primarily, though, the framework is utilized to help interpret the main empirical patterns of quantity adjustment and price setting by Japanese companies following Abenomics. Using the calibrated model, simulations of the industry are run for various levels of domestic monetary stimuli and for nominal devaluations reaching 50% relative the pre-shock equilibrium. Given the calibrated exogenous marginal cost process in equation 32, the model is used to solve for firm- and sector-level prices and allocations. Comparing domestic nonexporters with all-time exporters in Japan, the focus is on the response of domestic prices, total profits, home sales, and employment. Furthermore, aggregate domestic output, the price index, and the evolution of net exports are studied following the interventions. To understand the mechanisms behind the empirical findings, successively more realistic versions of the model are compared.

[Insert Table 7 here]

Ultimately, the model reveals that the seemingly puzzling cross-sectional phenomena can be rationalized in a framework with three key ingredients: firm heterogeneity, heterogeneous import intensities and dollar currency pricing. The addition of strategic complementarities in price setting is useful for improving the quantitative fit but unimportant for the main qualitative predictions. Because all of the main empirical patterns hold *within* rather than across industries, the discussion going forward will limit itself to the case of a one-sector economy, dispensing with nontradable goods all together as in the main model developed in section 4. All key empirical moments are summarized in Table 7 together with a comparison of the benchmark model's performance along with more rudimentary versions of the framework, adding the necessary ingredients step-by-step. The mechanisms by which each additional feature improves the qualitative and quantitative predictions of the model are discussed next.

5.2.1 Mundell–Fleming environment

To study the implications of competitive devaluations in a one-sector version of the model that would correspond to the classic Obstfeld–Rogoff (or Mundell–Fleming) framework, the following parameter values are also imposed: firstly, the dispersion of firms' productivity draws is set to equal zero, $\sigma_A = 0$.[21] This effectively shuts down any type of firm heterogeneity and disables all barriers to trade, meaning that all firms choose participate in exporting. Secondly, the price setting assumptions conform to the standard PCP constant markup version of the model presented in section 4.5.2.

[Insert Figure 7 here]

Figure 7 plots the economy's response to monetary infusions (and hence competitive devaluations) of varying strength. Throughout the exercise, foreign money supply is normalized at unity, and domestic money supply is perturbed upwards. The magnitudes of the nominal devaluation are chosen to mimic the ones observed in Japan from late 2012 until 2015, although the baseline comparison will be to look at a 30% devalua-

[21] If there were fixed costs of exporting (as well as importing), these would also be set to zero.

tion and compare it with the empirical patterns seen in Japan around 2014. As expected from the theory, both the firm-level reactions in Panel (a) as well as the macroeconomic response in Panel (b) fail to even remotely match the data. Because all firms are homogeneous, do not source intermediate inputs from abroad, and set prices according to a constant markup over marginal costs, companies are not induced to adjust on any margin following the devaluation. Meanwhile, profits, sales and employment shoot up almost linearly along with the nominal depreciation as products supplied by import competition become relatively more expensive and consumers substitute toward domestically produced goods. Also, firms benefit from expenditure switching in the foreign market as their goods become relatively more competitive abroad.

The performance of the standard PCP framework in predicting aggregate adjustments is just as poor. The price index is almost completely unresponsive and rises only by about 1% as a result of imported inflation. Net exports to pre-shock GDP increases by about 4–5% following a 30% nominal devaluation, as would be consistent with standard intuition and the expenditure switching mechanism. A more fundamental deficiency of the present framework, which will not be fully resolved throughout the model, is that any New Keynesian setup with nominal rigidities produces a large domestic stimulus, which is counterfactual in the case of Japan, where real GDP growth was slow and barely positive around 2014.[22] A likely reason for such an extremely weak reaction of GDP could be the rising consumption tax (from 5% to 8%), the expectation and announcement of further consumption tax hikes, and the overall contractionary fiscal policy environment referred to in the empirical section.

Table 7 summarizes the key numerical predictions of the Mundell–Fleming model in the MF column. Taken together, this basic setup fails to reproduce the empirically observed dynamic adjustment path of the economy along every dimension and consequently yields an erroneous prediction for key outcome variables that any coherent

[22]It should be noted, however, that manufacturing output *did* react a lot more strongly to the nominal devaluation, rising by about 10% from early 2013 to mid 2014. It is possible, therefore, to imagine a setup where the industrial sector is subject to a binding cash-in-advance constraint while the remaining industries operate in a credit economy and remain insensitive to the monetary expansion.

theory of competitive devaluations should match with greater success. Modifying this framework along the well-known local currency pricing (LCP) paradigm does not provide a satisfactory solution despite managing to shut down the expenditure switching channel and thereby muting the trade balance reaction. As can be gauged from the results in the first M1 column of Table 7, none of the firm-level micro adjustment patterns are reproduced by simply modifying that price setting assumption.

5.2.2 Dollar currency pricing with heterogeneous firms

In order to make progress in matching the firm-level transmission channels, a number of ingredients from the international trade and macro literatures are introduced. By construction, firm heterogeneity is the first essential component to talk meaningfully about differential effects on various types of companies. This means that the dispersion of productivity draws will be set to positive levels and the top 10% most productive companies will be simultaneously exporting and importing, as discussed in section 5.1. All of the key parameter values used in the present version of the model are summarized in Table 6. Firm heterogeneity is far from being enough, though, because some other force is required to constrain exporters in their domestic expansion following nominal devaluations. Consistent with the empirical results of section 3.2, heterogeneous import intensities for intermediate inputs and dollar currency pricing turn out to be the two missing components. Notably, heterogeneous import intensities together with local (rather than dollar) currency pricing are not enough because in that case, nominal exchange rate movements still would not influence firms' marginal costs (see the M2 version of the model in Table 7). It is only with dollar currency pricing that firms are negatively affected if they import (and export) and also fail to reap the benefits from a relative reduction in their export price levels abroad.

[Insert Figure 8 here]

Figure 8 shows how the economy reacts to monetary infusions of varying strength at both micro- and macro-levels. Now, simulation results for both types of firms, solely domestic (in blue circles) and exporters (in red squares), are shown in Panel (a). Due to their higher reliance on imported intermediate inputs and international dollar invoicing, all-time exporters are now forced to increase their domestic prices a lot more than domestic nonexporters are. These movements in turn translate into lower profits and expenditure switching toward varieties produced by purely domestic companies. As a result, domestic sales and employment follow vastly different expansion paths for these two types of firms after the interventions. Even though the general micro patterns now point in the right direction, as shown in the M3 column of Table 7, the relative expansion of nonexporters is now much higher than observed in the data.

[Insert Figure 9 here]

However, the quantitative fit of the model is much improved with the addition of a fourth ingredient: strategic complementarities in price setting (see Amiti et al. (2016)), as described in section 4.5.4. Interestingly, with this form of variable markups, both exporters and nonexporters now optimally choose to increase their prices following the competitive devaluation, as can be discerned from Figure 9. The Benchmark column of Table 7 shows that this version of the model is vastly more successful in matching the relative percentage increase in the sales ratio gap between solely domestic and exporting firms, and similarly for the remaining firm-level moments. The aggregate patterns continue to suffer from a larger than observed output reaction, yet manage to display inflation and trade balance patterns that are much closer to the ones observed in the Japan following Abenomics.

5.3 Counterfactuals and policy implications

5.3.1 Alternative price setting

Consider first an economy with the identical level of firm heterogeneity and the same intermediate import intensities as in the benchmark model, but with a different price setting regime. In particular, take a world of exclusively producer currency pricing

(PCP). This can be thought of as a counterfactual scenario in which the U.S. dollar does not have its special role, or a case in which the use of producer currency for international transactions is promoted by regulation.[23]

Compared with the case of international dollar currency pricing, Japanese exporters would now gain competitiveness abroad, as in the standard Mundell–Fleming paradigm, yet they would still be hurt by rising imported intermediate input costs. Meanwhile, the U.S. economy will be less insulated than under DCP, with expenditure switching toward increasingly cheaper Japanese final goods and with rising imported input costs (now invoiced in yen) forcing U.S. firms to increase prices more. A counterfactual simulation reveals that Japan's trade balance is virtually unaffected by a 30% yen devaluation. Also, due to the gains in competitiveness experienced by Japanese exporters abroad, the gap between labor and profit growth for nonexporters relative to exports is now only 5%. These counter-factual scenarios point to the fact that the U.S. benefits from the international role of the dollar not just through its own monetary policy spillovers but also as a result of greater *insulation* from nominal devaluations undertaken abroad.

5.3.2 Alternative import intensities

The second counterfactual world considered in this discussion keeps the dollar currency pricing paradigm intact but assumes an alternative dispersion of firm import intensities. This scenario is useful for evaluating the channels of monetary policy transmission in open economies with varying dependencies on intermediate imported inputs.[24]

A simulation that sets the import intensity of exporters, φ_ω, equal to 0.7 and leaves all other parameters unchanged reveals that CPI inflation would rise by 6% and the trade balance to pre-shock GDP ratio would fall by 3.5%. The prior differences between do-

[23] Certain emerging economies have resorted to policies that target firms currency choices in the past. Even though trade was exempt, Indonesia made its currency mandatory for most transactions as of July 1, 2015. Another example is the Bank of Korea's providing importers with loans in South Korean won through local banks in order to promote local currency invoicing and settlement.

[24] Countries often wish to diminish their reliance on imports of certain commodities and introduce tariffs as part of an "import substitution" agenda. The US, for example, has declared the reduction of its dependence on foreign oil a "strategy to increase economic growth and reduce vulnerability."

mestic nonexporters and multinationals would naturally increase as well. Those results provide a word of caution against the use of unconventional monetary policy or competitive devaluations in countries with high degrees of vertical specialization forming a part of global value chains. By contrast, setting $\varphi_\omega = 0.1$ shrinks the gap between the expansion paths of nonexporters and exporters and, more importantly, yields aggregate inflation of about 1.5% while keeping the trade balance almost constant. Competitive devaluations have, therefore, vastly heterogeneous aggregate effects depending on a country's prevalent import intensity regime, with more vertical specialization decidedly influencing the transmission mechanisms of monetary policy in open economies.

6 Conclusion

This paper investigates the micro-transmission mechanisms of two recent devaluation episodes in Japan and Russia. I use the fact that Abenomics constituted a novel policy response to persistent economics problems together with heterogeneity in import intensities and differential exposure to exchange rate movements across firms for identification. Empirical tests show that exporters *shrink* relative to nonexporters in terms of their employment, domestic revenue and profitability. Unique firm-level customs data from Russia allows one to test the channel directly, whereas the results are particularly strong when comparing the two types of firms within industries that rely more heavily on imported intermediate inputs in 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 transmission 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 qualitatively successful in matching the main cross-sectional patterns and the evolution of net exports as well as CPI. 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 for studying the transmission mechanisms of competitive devaluations, or currency wars. Contrary to conventional wisdom, the results suggest that such exchange rate policies end up working through "import substitution" rather than "export-led" expansions or the promotion of national export champions, thereby helping a very different set of firms than suggested by traditional open economy macro models. While the U.S. reaps additional benefits through its insulation from other countries' nominal devaluations in a world of international dollar invoicing, expansionary monetary policy in other open economies effectively reallocates resources toward less productive nonexporting companies.

A Appendix

I. Variable definitions

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.

- $\textbf{Age}_{\mathbf{i,t}}$: Either as reported, or inferred from the date of incorporation.
- $\textbf{Assets}_{\mathbf{i,t}}$: Total assets, as reported in the respective data sets.
- $\textbf{Cash/Assets}_{\mathbf{i,t}}$: Cash and equivalents divided by assets.
- $\textbf{Employment}_{\mathbf{i,t}}$: The number of both full and part time workers.
- $\textbf{IC}_{\mathbf{j}}$: Import content of production for any given STAN industry j (OECD).
- $\textbf{Import Intensity}_{\mathbf{i}}$: defined for Russian firms only, as the share of imported intermediate inputs in total variable costs in 2013.
- $\textbf{Leverage}_{\mathbf{i,t}}$: Total debt as a % of assets.
- $\textbf{Market Capitalization}_{\mathbf{i,t}}$: Market price at year end $*$ common shares outstanding.
- $\textbf{PB}_{\mathbf{i,t}}$: Market-to-book ratio, calculated as: [market value of common equity + assets + book value of common equity)]/ assets.
- $\textbf{Revenue}_{\mathbf{i,t}}$: Total domestic revenues in either Japan or Russia.
- $\textbf{ROA}_{\mathbf{i,t}}$: Return on assets (profitability ratio), measured as: (net income / assets).
- $\textbf{Size}_{\mathbf{i,t}}$: Natural logarithm of assets.

A documented problem with ORBIS data is that key 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.[25] 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.

[25]Kalemli-Ozcan et al. (2015) offer a detailed analysis of how to construct representative firm-level data using the ORBIS data set.

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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

Notes: 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.

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%

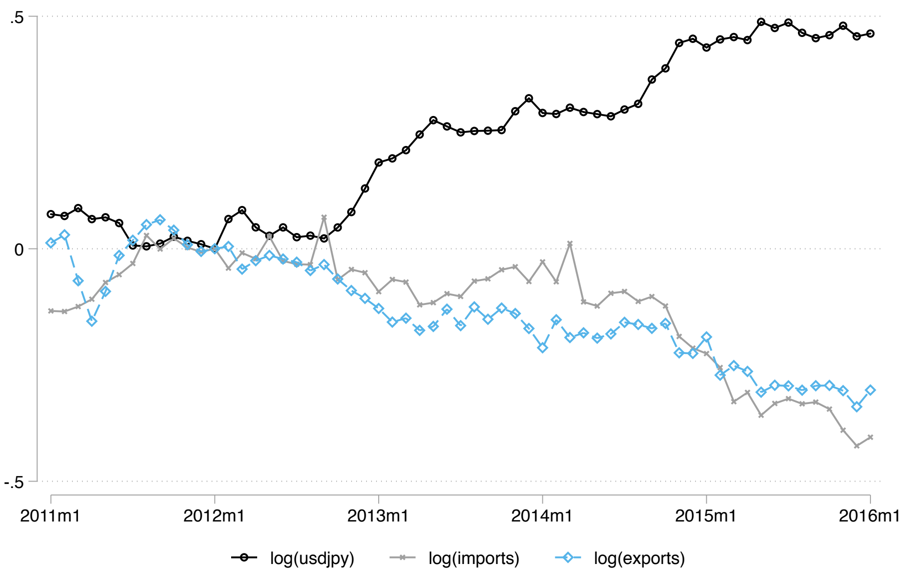
Notes: This table shows the distribution of import intensity among Russian non-financial companies for 2013*. Import intensity, φ_i, is defined for each firm as the share of imported intermediate inputs from outside of Russia in total variable costs.*

Table 3: **Correlates of import intensity or 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

Notes: 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.*

(A) Japan



(B) Russia

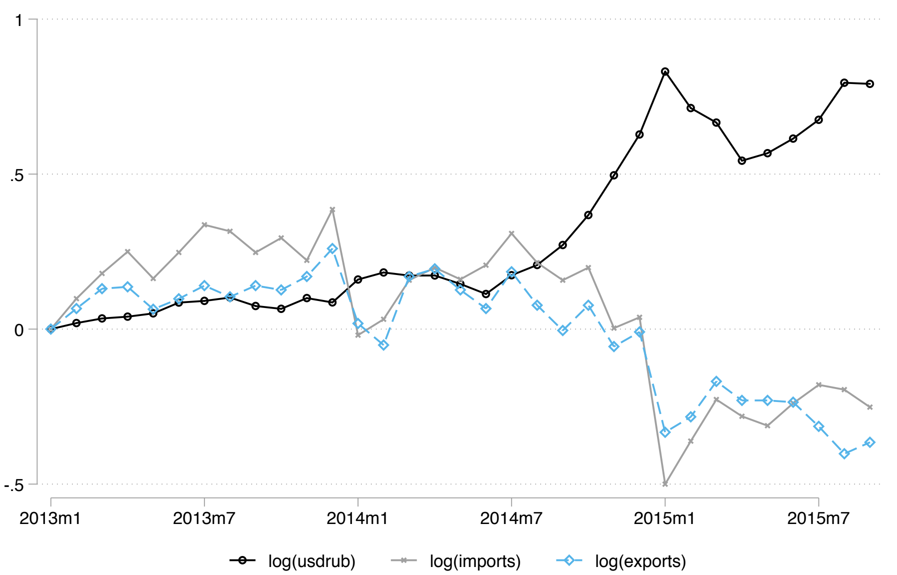
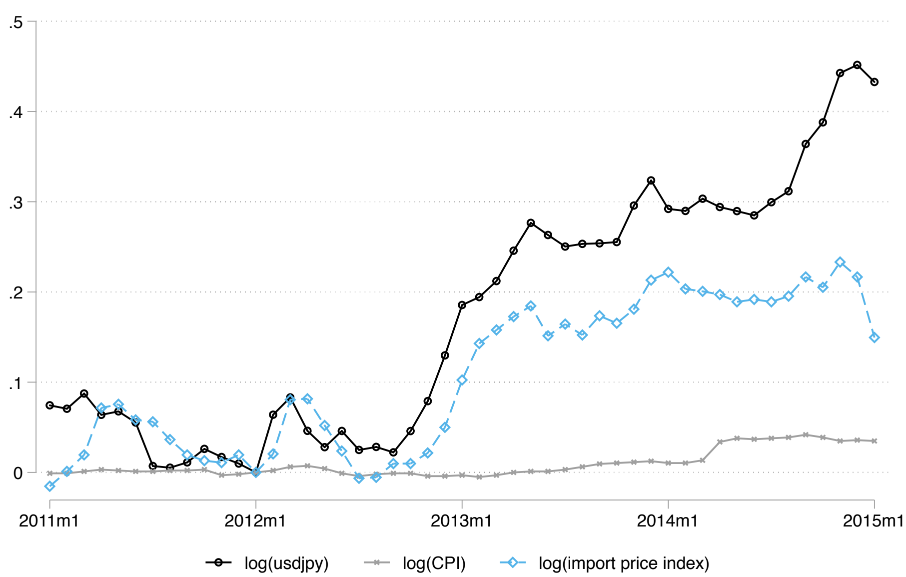


Figure 1: **Exchange rates and trade balances**

Notes: 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

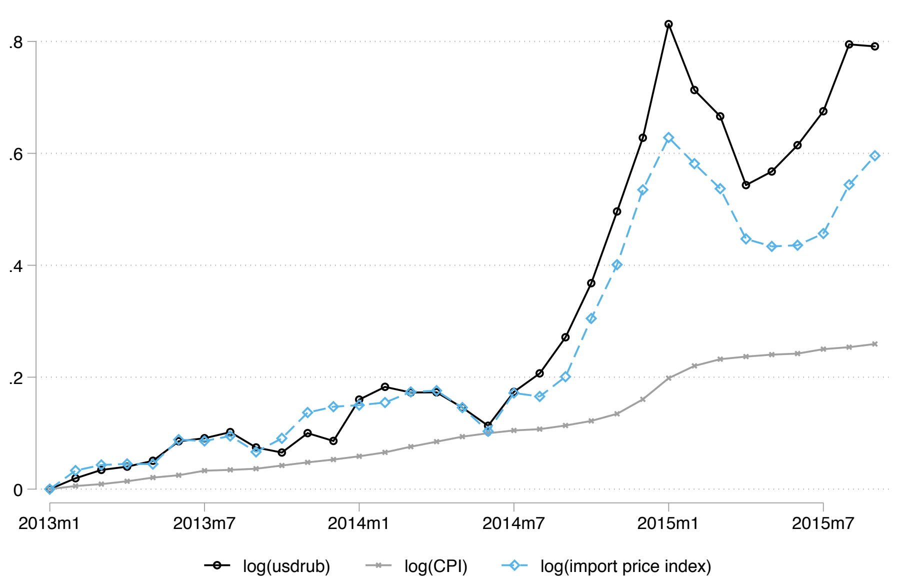
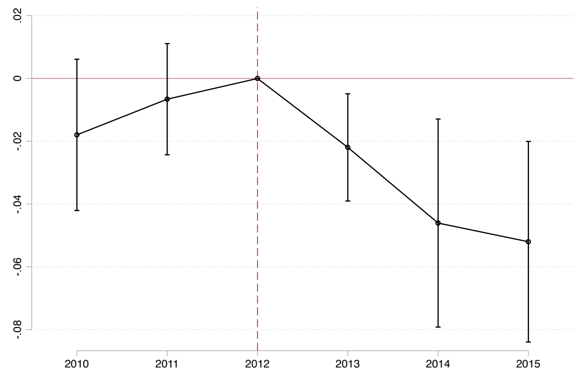


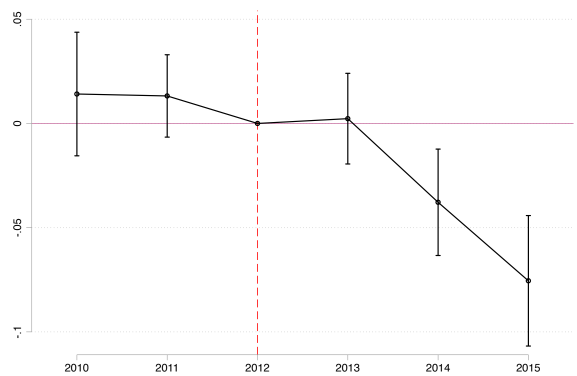
Figure 2: **Price Indexes**

Notes: 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.

(A) Employment



(B) Domestic revenue



(C) Market Capitalization

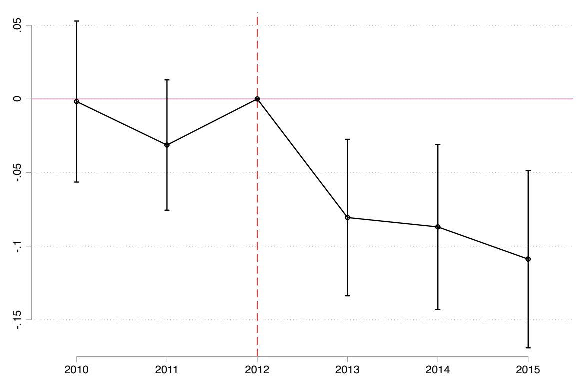


Figure 3: **Coefficient plots for Japanese firms**

Notes: 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.*

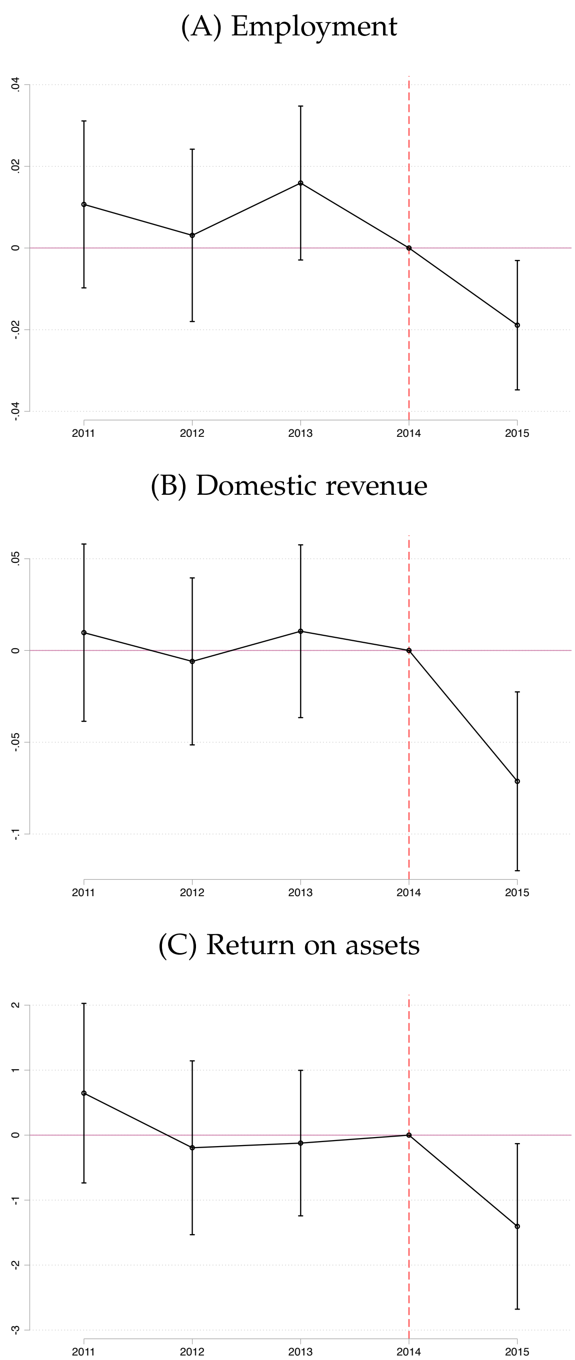


Figure 4: **Coefficient plots for Russian firms**

Notes: 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.*

Table 4: **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

*Notes: 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.*

Table 5: **Mechanism**

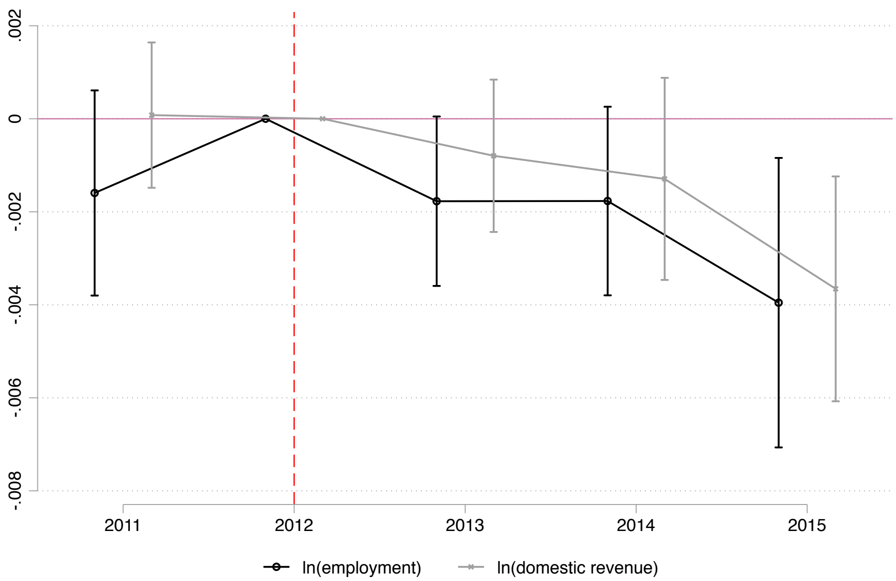
	$\log(labor)$	$\log(revenue)$	$\log(prices)$
	(1)	(2)	(3)
$Treat_i \cdot IC_j \cdot QE_t$	-0.039***	-0.146***	0.029***
	[0.000]	[0.000]	[0.000]
$Treat_i \cdot QE_t$	-0.036***	0.043***	-0.009***
	[0.005]	[0.011]	[0.002]
$IC_j \cdot QE_t$	0.011***	0.026***	0.015***
	[0.000]	[0.000]	[0.000]
QE_t	✓	✓	✓
Firm FE	✓	✓	✓
Observations	1,200	1,200	1,200
Number of firms	600	600	600
R^2	0.998	0.987	0.979

*Notes: This table presents model based triple-difference estimates of the response of employment, domestic sales, and prices for exporters versus nonexporters conditional on operating in relatively import intensive or unintensive industries following a 30% yen devaluation. 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.*

Table 6: **Calibration Values**

	Parameter	Value
number of firms	N_{JP}, N_{US}	300
elasticity across H and F	η	2
elasticity across varieties	ρ	6
strategic complementarity	ζ	0.7
home bias	α, $\alpha^\star$	0.93
mean costs	μ_A	1
cost dispersion	σ_A	0.1
wages	W, $W^\star$	1
cost-savings	$[P_X^\star]^E$	0.8
exchange rate exposure (N)	φ^N	0
exchange rate exposure (E)	φ^E	0.4

(A) Triple Difference



(B) Interest Rates

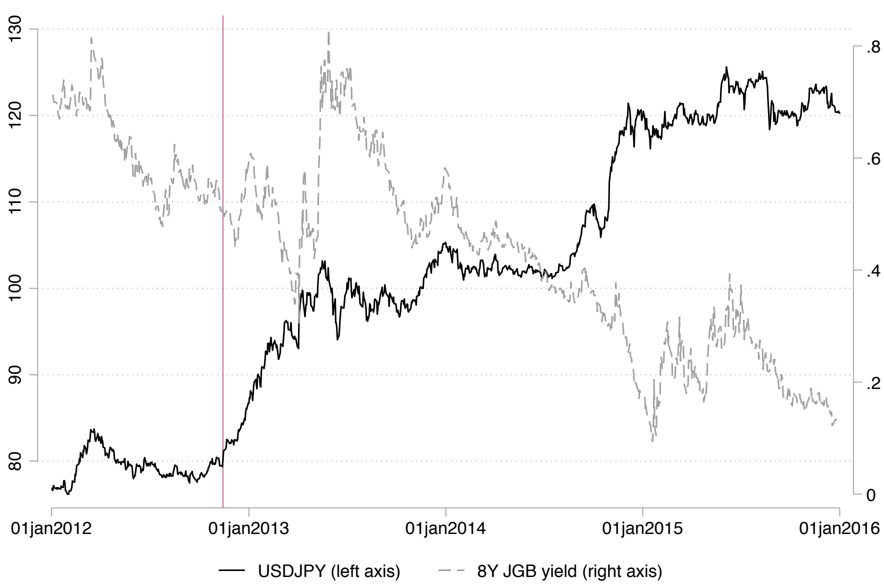


Figure 5: **Mechanism**

Notes: Panel (A) plots the estimated ζ_t coefficients of equation 3 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 the QE measures—alongside the USDJPY exchange rate. Time is yearly and the vertical red line marks the beginning of Abenomics.

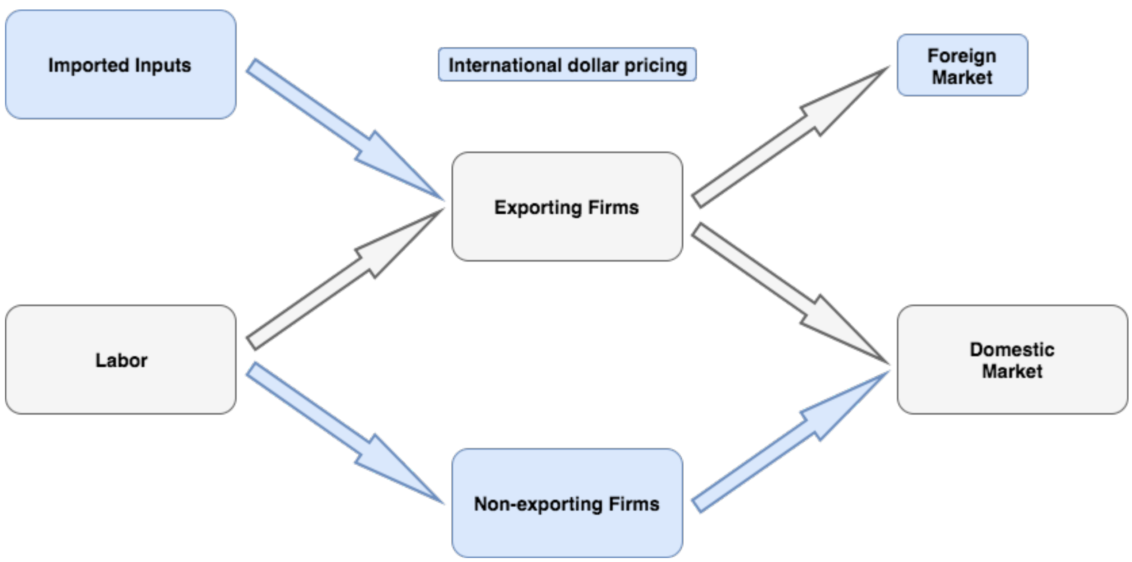


Figure 6: **Schematic representation of benchmark model**

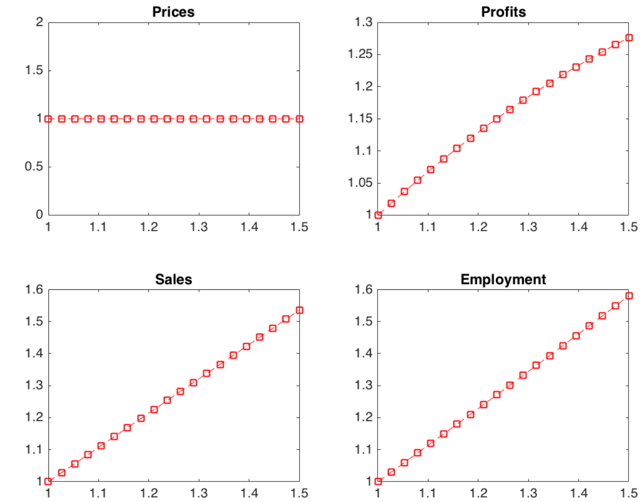
Table 7: **Comparison of Models**

	Data	MF	Benchmark	M1	M2	M3
firm price setting		PCP	DCP	LCP	LCP	DCP
firm heterogeneity		✗	✓	✗	✓	✓
imported intermediate inputs		✗	✓	✗	✓	✓
strategic complementarities		✗	✓	✗	✗	✗
C_N/C_E	0.15	0	0.14	0	0	0.66
L_N/L_E	0.06	0	0.09	0	0.02	0.68
Π_N/Π_E	0.10	0	0.09	0	-0.10	0.49
GDP	0.01	0.33	0.25	0.27	0.27	0.23
CPI	0.03	0.01	0.03	0	0	0.08
$NX/\overline{GDP}$	-0.01	0.04	-0.01	0	0	-0.01

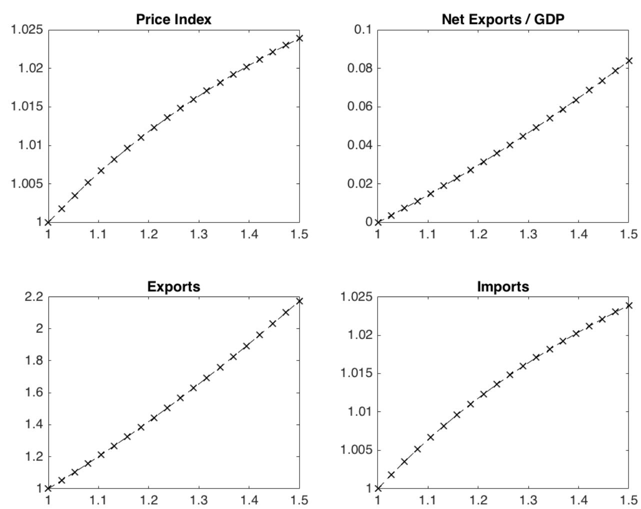
Notes: This table lists key moments (growth rates) in the data and compares them with simulations in different versions of the model, starting from the Mundell–Fleming producer currency pricing case with no firm heterogeneity or intermediate imported inputs. Key ingredients are then added one-by-one. The numerical results assume a 30% nominal devaluation, which corresponds to the general patterns observed in Japan by 2014.

Figure 7: **Mundell–Fleming**

(a) Firm-Level Patterns



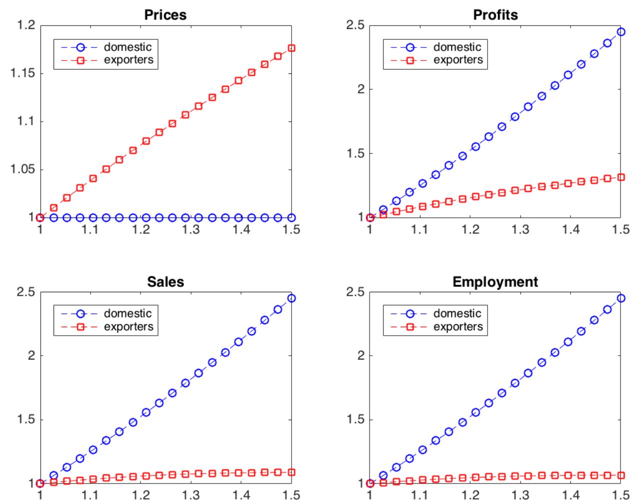
(b) Aggregate Patterns



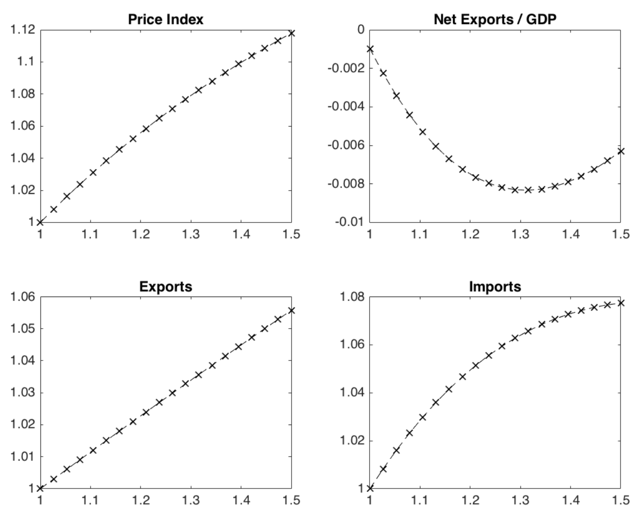
Note: Panel (a) displays micro firm-level reactions for prices, profits, sales and employment (in red squares). The nominal devaluation (from 0% to 50%) is displayed on each horizontal axis; the percentage change of each outcome variable relative to its normalized starting point is shown on the vertical axes. Panel (b) shows aggregate reactions for the price index (CPI), the trade balance to pre-shock GDP, exports in yen, and imports in yen (in black crosses). Again, the percentage nominal devaluation is measured on the horizontal axis in each graph.

Figure 8: **DCP with Heterogeneous Firms**

(a) Firm-Level Patterns



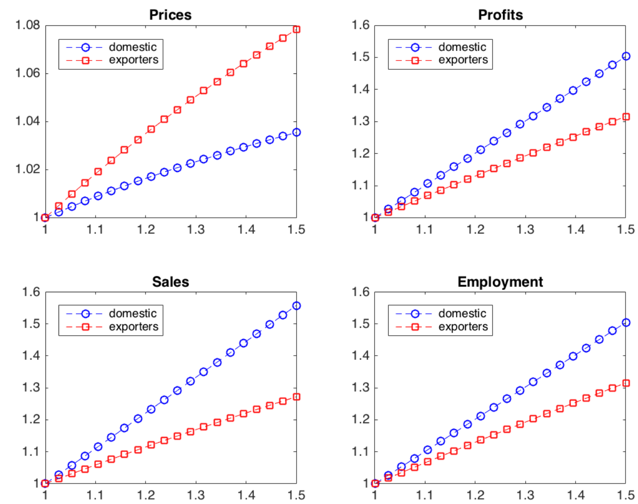
(b) Aggregate Patterns



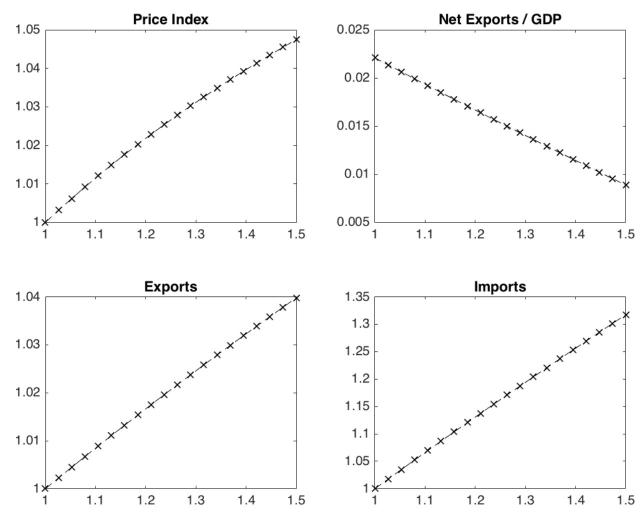
Note: Panel (a) displays micro firm-level reactions for prices, profits, sales and employment for nonexporters (blue circles) and exporting firms (in red squares). The nominal devaluation (from 0% to 50%) is displayed on each horizontal axis; the percentage change of each outcome variable relative to its normalized starting point is shown on the vertical axes. Panel (b) shows aggregate reactions for the price index (CPI), the trade balance to pre-shock GDP, exports in yen, and imports in yen (in black crosses).

Figure 9: **Kimball with Heterogeneous Firms**

(a) Firm-Level Patterns



(b) Aggregate Patterns



Note: Panel (a) displays micro firm-level reactions for prices, profits, sales and employment for nonexporters (blue circles) and exporting firms (in red squares). The nominal devaluation (from 0% to 50%) is displayed on each horizontal axis; the percentage change of each outcome variable relative to its normalized starting point is shown on the vertical axes. Panel (b) shows aggregate reactions for the price index (CPI), the trade balance to pre-shock GDP, exports in yen, and imports in yen (in black crosses).