Intermediate Inputs, External Rebalancing and Relative Price Adjustments*

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COMMENTS WELCOME

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Abstract

This paper proposes a methodology for tracing out the effect of intermediate inputs, including "processing trade", on the link between external rebalancing and relative price adjustments. We show that intermediate inputs affect the link through two opposing channels. Accounting for processing trade reduces economic openness, increases home bias in consumption and, consequently, *increases* the RER adjustment associated with a given external rebalancing. Accounting for domestic intermediate inputs reduces cross-sectoral asymmetries in openness and home bias, in essence because services are exported indirectly by being embodied in manufactures. The reduced cross-sectoral asymmetry dampens the *intra*national relative price adjustment and, consequently, *decreases* the RER adjustment associated with a given external rebalancing. Quantitative results show that the two opposing price effects are significant in economic terms and comparable in size.

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1 Introduction

This paper revisits the link between external sector rebalancing and the implied changes in relative prices. Conventional macroeconomic theory dictates that external rebalancing be accompanied by relative price adjustments – a depreciation of the real exchange rate (RER) in case of an external deficit and an appreciation in case of a surplus. The size of the required price adjustment is crucially linked to the degree of economic openness and, hence, also home bias in consumption, as measured by gross trade flows. With greater (lesser) openness, less (more) RER movement is required for a given rebalancing.

One criticism of this conventional approach is that trade in the model is restricted to domestic value added, thus implicitly equating trade in value added with gross trade flows. Data instead shows a significant presence of "processing trade", or re-exported imports, which drives a substantial wedge between trade in value added and gross terms.[1] This wedge mutes the response of trade to relative price adjustments, because import content in exports is not directly affected by the RER changes. Such criticism resonates in the economic policy debate. It is commonly argued that the effectiveness of exchange rate appreciation in China is hampered by China's role as a processing hub. Similarly, effectiveness of a devaluation in crisis-hit Latvia was criticized on the grounds that it would increase input costs for the export sector, muting the rebalancing effect of the price adjustment. Rephrased in model terms, this criticism states that by targeting gross trade rather than smaller value added trade flows, the conventional approach to modeling external rebalancing overstates openness and hence underestimates the implied adjustment in relative prices, and therefore requires a correction.

This paper demonstrates that such a correction is appropriate, but incomplete. We develop a methodology that allows one to assess the effect of all intermediate inputs, including but not limited to processing trade, on the link between the external rebalancing and the implied changes in relative prices.[2] We modify the conventional modeling framework to take into account cross-sectoral domestic and imported intermediate inputs in production. The modified framework allows for the fact that production of exported manufactured goods may draw on imported goods as intermediate inputs and thus lead to re-exported imports or processing

[1] Available empirical estimates put processing trade at approximately 1/4 of global trade.

[2] Throughout the paper the terminology used separates intermediate inputs by origin into domestic and imported. Following this terminology, processing trade is a subset of imported intermediate inputs that are re-exported, as opposed to absorbed at home.

trade. The framework also allows for the fact that there are domestic intermediate inputs, so that domestically-supplied services end up being embodied in exported manufacturing goods and manufacturing goods are embodied in services. It is crucial to consider both imported and domestic intermediate inputs, because either can affect the link between the external rebalancing and relative price adjustments. The modified framework offers a natural way to generate a wedge between the gross output and value added of a sector and to study relative price implications of the use of both imported and domestic intermediate inputs in production.

The implementation of the methodology follows several steps. First, building on Johnson and Noguera (2011), we construct a global input-output table. The table provides detailed data about the use of sectoral gross output by countries and sectors and differentiates between intermediate and final uses – for example, the extent to which manufacturing goods imported from Mexico into the U.S. are used to produce services that are consumed in the U.S. or exported to Canada. This data is used to decompose sectoral gross output and sectoral value added by destination to measure, for example, the extent to which value added of the manufacturing sector in Mexico is consumed domestically or exported, directly or indirectly, to Canada. Next, the derived value added flows are used to parametrize a conventional macro model. We highlight several dimensions along which the resulting parametrization deviates from the conventional approach in the literature. Most notably, the model is parametrized to match data on aggregate and sectoral trade in value added terms rather than gross terms. Finally, the parameterized model is subjected to an external rebalancing experiment a la Obstfeld and Rogoff (2005) – an exogenous change in the transfer term induces relative price adjustments – and results are contrasted with those from a benchmark parameterization. Comparing the results from the two parameterizations, we quantify and investigate the causes of systematic differences in the link between the external rebalancing and the implied changes in relative prices.

Our main finding is that, contrary to the common criticism, the conventional approach to rebalancing – one that ignores intermediate inputs – does not lead to a clear-cut bias in the estimated link between external rebalancing and relative price adjustments. We show that intermediate inputs affect the link through two opposing channels. On the one hand, accounting for processing trade – use of imported inputs – lowers the measured economic openness, increases home bias in consumption and, consequently, increases the RER adjustment associated with a given external rebalancing. This “processing trade“ effect implies that the conventional approach *under*estimates the link between external rebalancing and relative price adjustments. On the other hand, accounting for domestic intermediate inputs reduces cross-sectoral asymmetries in openness and home bias within economies. In essence, value added of the service sector is traded more than the gross output of the service sector, because services are used as intermediate inputs in manufacturing of goods that end up being traded. Conversely, value added of the manufacturing sector is traded less than the gross output of the sector, further contributing to the reduction of the asymmetries. The reduced cross-sectoral asymmetries dampen the *intra*national relative price adjustment and increase the adjustment of *inter*national relative prices, i.e., the terms of trade. Importantly, the former dominates the latter if the elasticity of substitution across sectors is lower than within sectors – a plausible and widely-held assumption. As a result, the RER adjustment in response to rebalancing is reduced. This "domestic intermediation input" effect implies that the conventional approach *over*estimates the link between the external rebalancing and relative price adjustments.

Quantitative results show that these two opposing effects on the RER adjustment are likely to be significant in economic terms and are comparable in magnitude. For example, accounting for processing trade significantly increases the RER response to external rebalancing in China by around 50%. For the U.S. the response increases by 20%, with the difference explained by the share of processing trade in gross trade flows. At the same time, domestic intermediate inputs significantly increase trade in services and decrease trade in manufactures. In case of the U.S., services represent 1/5 of gross trade, but 1/2 of value added trade. For China the same share increases from 1/10 to 1/3. In both cases the lowered sectoral asymmetries in openness and home bias and the resulting reduction in the RER adjustment broadly offset the increase induced by the presence of processing trade. Aggregate results for the U.S. show that accounting for all intermediate inputs reduces the RER adjustment by only about 10%, while in the China RER adjustment increases by 7%.

This study is related to an extensive literature that examines the external rebalancing and the implied changes in relative prices. Important contributions include Obstfeld and Rogoff (2004, 2005), who formulate the benchmark exercise to which our results are compared. Numerous subsequent papers examine alternative model specifications, including considerations such as intensive versus extensive trade margin, monetary policy response and flexibility in factor markets.[3] These

[3] See, e.g., Faruqee, Laxton, Muir and Pesenti, 2007; Dekle, Eaton and Kortum, 2008; Ferrero,

papers investigate how the relative price adjustment changes with the time horizon over which the external sector is rebalanced. Other papers explore the short run properties of the link between external rebalancing and relative price adjustments.[4] Our approach is distinct from the rest of the literature in that we refine the link between objects in the conventional model and data rather than modify the modeling framework or the shocks that define the rebalancing exercise. The paper's findings are equally applicable to the alternative specifications of the model and the rebalancing exercise, because non of them allow for the wedge between trade flows in value added and gross terms.[5] Our refinements can significantly alter the economic forces that drive the adjustment in relative prices. To our knowledge no previous paper has incorporated these considerations into a model-based assessment of external sector rebalancing.

Taken more broadly, this paper serves as an illustration of a more general issue with the way multi-sector macro models with value added production functions – the dominant approach to modeling the macro economy – are mapped into data. Parametrizing these models requires detailed data on sectoral value added flows. While on the supply side such data is widely available, sectoral demand data is reported exclusively in terms of expenditures on gross output of a sector rather than its value added. Faced with this problem, macroeconomists have reverted to simplifying assumptions, such as equating value added trade with gross trade flows. This paper explores the consequence of these assumptions for a particular macroeconomic application - external rebalancing. More general implications for macroeconomic models remain an open research question.

The next section examines the relationship between gross output and value added flows at the sectoral level. Disentangling the difference between the two types of flows is crucial for the results of this paper. We show how to implement a destination based decomposition of sectoral flows and contrast results with the conventional parameterization of multi-sector macro models. Section 3 presents the modeling framework that defines the link between the external rebalancing and the relative price adjustments. In Section 4 we present the results of the rebalancing exercise in a one-sector setting, which serves to illustrate the role of processing trade. Section 5 extends the exercise to a more general two-sector case

Gertler and Svensson, 2008 and Corsetti, Martin and Pesenti, 2009.

[4] See, e.g., Eichengreen and Rua, 2011 and Mejean, Rabanal and Sandri, 2011.

[5] Dekle, Eaton and Kortum (2008) is a notable exception that partially takes the wedge into account. They allow for intermediate use of services in the production of manufacturing goods, but not for intermediate use of manufactures in the production of services.

and analyzes the effect of domestic intermediate inputs on the link between the external rebalancing and the relative price adjustments. The final section contains concluding remarks.

2 Gross Output and Value Added Flows

There are two internally consistent ways to specify the supply and demand in a Macro model with multiple goods. The dominant approach is to model sectoral output in value added terms and correspondingly specify demand in terms of expenditures on the sectoral value added. We label this the '*value added*' approach. An alternative is to explicitly account for intermediate inputs in the production function. In this case supply is expressed in terms of gross output and demand needs to be specified in terms of expenditures on sectoral gross outputs. We label this the '*gross output*' approach. As should be clear, the difference between the two approaches is in the treatment of intermediate production inputs. When parameterized in a consistent way the two model specifications should generate identical model results. However, the interpretation of parameters, and hence their values, by the value added and gross output approaches differs.[6]

Unfortunately, available sectoral data, domestic as well as international, makes a consistent parameterization difficult. Data limitations are most binding on the demand side, because statistical offices report final demand in terms of expenditures on sectoral gross output, such as durables or services, but do not provide any data on demand for sectoral value added – a crucial input for parametrizing the sectoral demand function in the 'value added' model. In the absence of appropriate data, expenditures on sectoral gross output are commonly used as a proxy to parameterize sectoral demand in a 'value added' model. Whether this is a reasonable assumption depends on the application of the parametrized 'value added' model.

In this paper we focus on one particular application: the response of relative prices to an external rebalancing. This application by definition requires a Macro model with multiple goods and therefore faces the problems with the inconsistent parameterization of the supply and demand sides of the 'value added' model described above. A shortcut used by the conventional parameterization has been to

[6] For example, the share of manufacturing goods in consumption differs between the two approaches because the nature of the good – value added good versus gross output good – differs. The model with intermediates also requires a larger set of parameters to specify the production function.

equate gross trade flows with value added trade flows, which in a 'value added model overstates the weight of foreign goods in consumption.

Building on recent developments in the field of global input-output tables, this section presents a methodology that allows one to derive a consistent sectoral demand and supply for the 'value added' and 'gross output' approaches. In the subsequent sections we use this methodology to evaluate the appropriateness of the parameterization shortcuts in the literature.

We start with accounting identities that underlie the methodology and discuss the additional information that a global input-output table brings to the more familiar national accounts framework. Next, we describe the method for disentangling domestic and cross-border gross output flows into value added flows. Finally, the derived sectoral value added flows are compared with sectoral gross output flows, highlighting the implications for the parameterization of Macro models. Without loss of generality the discussion draws on a simple 2-country-2-goods framework.

2.1 The Global Input-Output Table

Increased availability of national input-output tables over the last two decades makes it possible to construct a global I-O table. In recent years there has been a proliferation of work on this topic involving a range of participants from academic economists to international organizations.[7] The methodology of this paper draws on these developments.

To convey the additional information provided by a global IO table, when compared to the more familiar national accounts data, this section presents a simplified global IO table. Consider a global economy consisting of two countries each producing a differentiated good. Global make and use identities describing the flow of expenditures for this case are summarized in **Figure 1**. The two row identities in the figure can be thought of as resource constraints for each country and good. Gross output of country 1, y_1, is used either as intermediate input in the production of the home good, m_{11}, or in the production abroad, m_{12}. Alternatively, it can be absorbed by final demand in one of the two countries, c_{11} or c_{12}. A symmetric use identity holds for country 2.

The two column identities in **Figure 1** show sectoral expenditures on production inputs. Gross output in country 1 is spent on factor inputs, f_1, own inter-

[7] See, e.g., Hummels et al. (2001), Johnson and Noguera (2010), Koopman et al. (2010), Erumban et al. (2011) and Inomata et al. (2011).

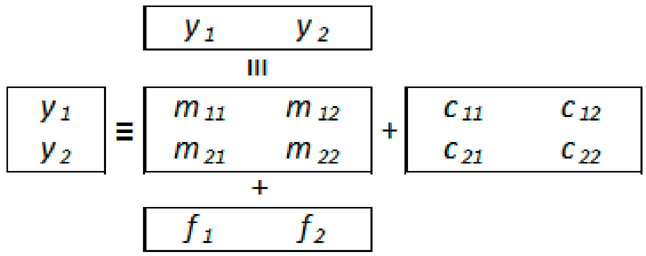

Figure 1: Make and use identities in the case of 2 countries and 2 goods

mediate production input, m_{11}, or intermediate production inputs from country 2, m_{21}. A symmetric identity holds for country 2. Column and row identities add up to the same gross output.

Identities in **Figure 1** contain all the information that economists routinely obtain from national accounts data. For example, final demand in country 1 is the sum of expenditures on domestic and foreign gross outputs, $c_{11} + c_{21}$. Gross exports for country 1 are the sum of exported intermediate production inputs and final goods, $m_{12} + c_{12}$. For imports the corresponding terms are $m_{21} + c_{21}$. Value added and GDP of country 1 equals gross output less intermediate inputs, $m_{11}+m_{12}+c_{11}+c_{12}-m_{11}-m_{21}$. A more detailed table would contain such data for sectors in addition to the aggregate economy.

As already noted, to parametrize a multi-sector macro model, such as the one used for external sector rebalancing, detailed national accounts data is not sufficient. For example, to parametrize the sectoral consumption weights in country 1 one would need final demand expenditures on the value added of the two sectors, rather than expenditures on sectoral gross outputs, c_{11} and c_{21}.The same also applies for country 2.

The contribution of the global IO table is to provide the additional information about the use of expenditures that is needed to disentangle sectoral gross output flows into value added flows. In particular, **Figure 1** distinguishes between intermediate and final uses. With multiple sectors the table provides further details about the destination sector for the intermediate use. These are the key ingredients needed to derive value added flows by destination sector.

2.2 Value Added Decomposition

This section summarizes the method for decomposing sectoral value added by destination, as proposed by Johnson and Noguera (2011). For a general N country and S sector exposition of the decomposition the reader is referred to the original paper. Here we apply it to the 2 countries and 2 goods case.

Rewrite the resource constraints for the two sectors in a matrix form as

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = A \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} + \begin{bmatrix} c_{11} \\ c_{21} \end{bmatrix} + \begin{bmatrix} c_{12} \\ c_{22} \end{bmatrix}, \tag{1}$$

where

$$A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} = \begin{bmatrix} \frac{m_{11}}{y_1} & \frac{m_{12}}{y_2} \\ \frac{m_{21}}{y_1} & \frac{m_{22}}{y_2} \end{bmatrix}. \tag{2}$$

is the requirement matrix for intermediate inputs. Sectoral gross output can then be decomposed by its final destination as

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = (I - A)^{-1} \left(\begin{bmatrix} c_{11} \\ c_{21} \end{bmatrix} + \begin{bmatrix} c_{12} \\ c_{22} \end{bmatrix} \right) = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix}, \tag{3}$$

where y_{ij} is gross output of country i used to produce final goods in country j. Sectoral value added can then be decomposed using the proportionality between gross output and value added

$$va_{ij} = (1 - a_{1j} - a_{2j})\, y_{ij}. \tag{4}$$

The decomposition transforms the global I-O table into a table of cross-sectoral destination-based value added flows, depicted in **Figure 2**. Intuitively, using the information provided by the global I-O table, the decomposition traces out the flow of value added from a particular sector through the global I-O table. Some of the sectoral value added is directly consumed in the country of origin. In this case the mapping into a final destination is straightforward. However, value added is also used as an intermediate input in the production of domestic or foreign goods. For example, value added of the U.S. manufacturing sector is an intermediate input in the production of manufacturing goods in Mexico. The output from Mexico can then be consumed in Mexico, sent back to the U.S., or sent to Canada. Under each scenario the sectoral output can again be used as an intermediate input in production or it can flow to final consumption. Such considerations generate complex

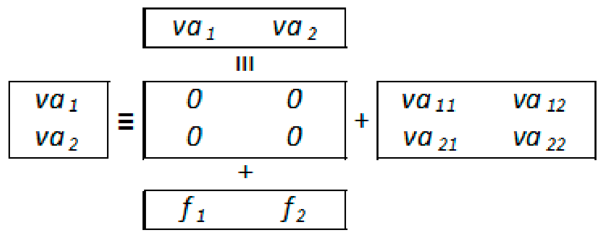

Figure 2: I/O-based decomposition of sectoral value added by destination in the case of 2 countries and 2 goods

value added linkages between sectors within and across countries, but can nevertheless be traced out using the information provided by the intermediate requirement matrix. In **equation 3** these linkages are captured by the term

$$(I - A)^{-1} = I + A + A^2 + ... \ . \tag{5}$$

Of particular interest for this paper are value added exports and imports, which in **Figure 2** are represented by the final demand for value added of country 2 in country 1, va_{21}, and final demand for value added of country 1 in country 2, va_{12}. One can show that the relationship between gross output based and value added based trade flows satisfies

$$(m_{21} + c_{21}) - va_{21} = (m_{12} + c_{12}) - va_{12} > 0 \tag{6}$$

In words, value added exports and imports are smaller than gross exports and imports. Also, the difference between the gross and value added trade flows is the same on the export and import sides, leaving net exports unaffected. This is the case because the derivation of the value added trade amounts to an identification of re-exported imports – a subset of trade flows that is by definition identical on the import and export side – and a subtraction of re-export imports from both gross imports and gross exports.

2.3 Benchmark Value Added Flows

To identify the contribution of this paper, we need a benchmark that reflects parameterization practices for models that study relative price implications of external rebalancing. In the absence of sectoral value added flow data, the literature derives

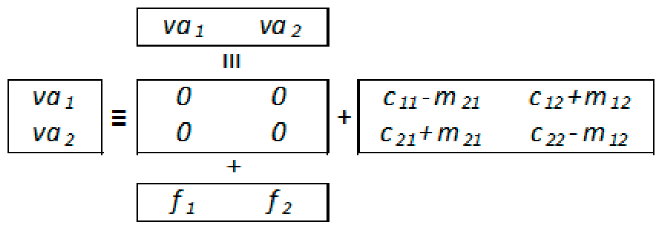

Figure 3: Benchmark decomposition of value added by destination in the case of 2 countries and 2 goods

the weights for sectoral final demand from sectoral expenditure data. For the case of two countries and two goods, the approach is summarized in **Figure 3**. The matrix for intermediate consumption is zeroed out by (i) transferring intermediate consumption of a sectoral output to final consumption in the same destination, e.g. $c_{21} + m_{21}$, and (ii) subtracting the same amount from the final consumption of the destination sector's output, e.g. $c_{11} - m_{21}$. The latter adjustment is crucial because it ensures that row and column equalities are preserved.

It is easy to verify that this transformation of **Figure 1** into **Figure 3** preserves for each country the value of GDP, final demand, net trade and in a more general multi-sector case also sectoral value added and sectoral domestic and cross-border expenditure flows. However, sectoral weights in final demand under this transformation differ from the weights derived with the value added decomposition of the previous section.

Intuitively, this method accounts only for the first order effect from the use of value added as an intermediate input in production. Thus, if the U.S. manufacturing output is used as an intermediate production input in Mexico, it is assumed that Mexico is the final destination of the value added. Whether this is a reasonable assumption depends on the specific research question as well as the structure of cross-sectoral intermediate inputs in production.

How is this benchmark parameterization done in the absence of the global I-O table? Sectoral consumption weights are derived by equating sectoral value added with the sectoral gross output. For example, in the case of 2 countries and 2 sectors in **Figure 3**, the relevant weights are derived by equating value added imports and exports to corresponding gross trade flows and backing out the domestic component of final demand in each country as a residual. With multiple sectors, sectoral value added components are derived from more detailed sectoral gross trade and final expenditure data, or by imposing assumptions such as no cross-border trade in services.

3 The Modeling Framework

The main analysis of the paper is carried out in a 'value added' modeling framework that specifies supply of sectoral output and demand for the output in value added terms, rather than gross output terms. The gist of the exercise is to compare the model's outcomes from a parameterization based on the benchmark data with a parameterization based on the I/O data. With this approach, implications of intermediate production inputs are reflected in the model parameterized to the I/O data and intermediates need not be modeled explicitly. Main results of the paper do not change if we instead compare outcomes from the parametrized benchmark 'value added' model with outcomes from a 'gross output' model that explicitly accounts for cross-sectoral intermediate production inputs and specifies demand over expenditures on sectoral outputs.

The 'value added' model is a version of Obstfeld and Rogoff (2004) static model that captures relative price implications of external rebalancing. Global economy consists of N countries and output in each country is partitioned into S sectors that supply differentiated goods, so that the total number of differentiated goods is SN. Sectoral output in each country is provided in the form of an endowment. Consumer utility is specified as a CES Armington (1969) system of goods differentiated by type and source country.

Consumer's problem in country n is

$$\max \left(\sum_{i=1}^{S} \phi_{i,n}^{\frac{1}{\gamma}} c_{i,n}^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}} \tag{7}$$

where

$$c_{i,n} = \left(\sum_{j=1}^{N} \phi_{ij,n}^{\frac{1}{\omega}} c_{ij,n}^{\frac{\omega-1}{\omega}} \right)^{\frac{\omega}{\omega-1}} \tag{8}$$

subject to a budget constraint

$$\sum_{i=1}^{S} \sum_{j=1}^{N} p_{ij} c_{ij,n} = \sum_{i=1}^{S} p_{in} y_{in} + T_n. \tag{9}$$

Here $c_{ij,n}$ stands for consumption of goods from sector i of country j in country n with the corresponding expenditure share captured by $\phi_{ij,n}$; p_{ij} is the price of the differentiated good from sector i of country j; y_{in} is endowment for sector i in country n; and T_n is a transfer term that allows a static model to capture a non-zero net trade for country n in data.

Notice that all SN differentiated goods can potentially be consumed in each country. A common practice in the literature is instead to label sectors as tradable or nontradable by restricting consumption to the domestic market. We do not follow this approach because in data all sectors have some traded output. Furthermore, allowing the tradability of sectoral output to be determined by data is a less favorable approach for the main results of this paper.

The model is closed with SN resource constraints $\sum_{n=1}^{N} c_{ij,n} = y_{ij}$ and a global adding up constraint for transfers, $\sum_{n=1}^{N} T_n = 0$. The model solution is then characterized by SN resource constraints, an adding up constraint and $N-1$ budget constraints as well as $2SN$ first order conditions with respect to consumption of the SN differentiated goods in N countries. For a given set of parameter values and endowments, the model is solved as a system of nonlinear equations.

The external rebalancing in this model is proxied by changes in the exogenous transfer term, T_n. With home bias in consumption, changes in the transfer redistribute income and demand for goods across countries and sectors and, in equilibrium, are accompanied by endogenous changes in relative prices. The price of primary interest is the RER, defined as the relative price of the aggregate consumption basket at home and abroad. The model implies that the price of the aggregate consumption basket in country n is a weighted average of the prices of differentiated goods

$$p_n = \left(\sum_{i=1}^{S} \phi_{i,n}^{\frac{1}{1-\gamma}} \left(\sum_{j=1}^{N} \phi_{ij,n}^{\frac{1}{1-\omega}} p_{ij}^{\frac{\omega}{\omega-1}} \right)^{\frac{\gamma(\omega-1)}{\omega(\gamma-1)}} \right)^{\frac{\gamma-1}{\gamma}} . \tag{10}$$

Then, for $N = 2$ RER is a ratio of home and foreign aggregate prices,

$$RER_n = p_n / p_{j \neq n} \tag{11}$$

For $N > 2$, the price in the denominator is a weighted average of foreign aggregate prices.

Another relative price of interest is the price of exports relative to the price of imports or the terms of trade. The model implies that the price of exports in country n is

$$p_n^x = \left(\sum_{i=1}^{S} \eta_{i,n}^{\frac{1}{1-\gamma}} p_{in}^{\frac{\gamma}{\gamma-1}} \right)^{\frac{\gamma-1}{\gamma}} . \tag{12}$$

In contrast to the price of the aggregate consumption basket, export prices include only prices of domestic products from each sector weighted by their shares in total exports, η.

The price of imports in country n is

$$p_n^m = \left(\sum_{i=1}^{S} \phi_{i,n}^{\frac{1}{1-\gamma}} \left(\sum_{j \neq n} \phi_{ij,n}^{\frac{1}{1-\omega}} p_{ij}^{\frac{\omega}{\omega-1}} \right)^{\frac{\gamma(\omega-1)}{\omega(\gamma-1)}} \right)^{\frac{\gamma-1}{\gamma}} . \tag{13}$$

Import prices mimic the expression for the price of the aggregate consumption basket. The only difference is that the price of the domestic product, $j = n$, in each sector is excluded from the import price index. The terms of trade are then defined as

$$TOT_n = p_n^x / p_n^m . \tag{14}$$

We treat the model presented in this section as a benchmark model for the study of relative price implications of external rebalancing. The contribution of our paper is to suggest a novel way to parametrize the model, which we now turn to.

4 External Rebalancing: One-Sector Economies

This section addresses the main question of the paper: how accounting for intermediate production inputs affects the model-based estimate of the link between relative prices and external rebalancing. We start by parameterizing the model to replicate aggregate and sectoral income flows in data, where the relevant data is derived using the benchmark and I/O-based approaches detailed in **Section 2**. Recall that the two approaches differ only in terms of sectoral weights in consumption. Aggregate income flows, including the size of the external imbalance, are identical.

The exercise is applied to two familiar constellations of external sector imbalances: U.S. versus the rest of the world and China versus the rest of the world.

The two cases are chosen because both exhibit large and persistent imbalances. Also, the two countries differ in terms of openness and the prevalence of processing trade. For each parameterization we derive the model response to a 1% of GDP reduction in the external imbalance, as captured by a reduction in the size of the exogenous transfer, $T_n / \sum_{i=1}^{S} p_{in} y_{in}$, and then compare the response of the RER in the benchmark and I/O-based model parameterizations.

We start with a setup that distinguished between 2 countries and 1 good per country. This setup does not allow for *intra*national relative price adjustments, which are arguably an important component of the adjustment in aggregate relative prices, as emphasized by Obstfeld and Rogoff (1996). Nevertheless, it is an instructive initial exercise because intermediate cross-sectoral production inputs are by construction limited to imports and there are no domestic cross-sectoral linkages, which we introduce in the next section. This model serves to highlight the effect of processing trade on the external rebalancing mechanism of the model.

4.1 Parameterization

Model parameterization follows a two-step procedure. The first step is to construct a global I/O table of the form described in **Section 2** and transform gross output flows in the table into value added flows using the two approaches outlined in **Sections 2.2 and 2.3**. The second step is to use the information from the two derived value added flow tables to construct two sets of model parameterizations.

The global IO table is constructed using a methodology developed in Johnson and Noguera (2011) and data from GTAP 7.1. Panel (a) in **Figure 4** presents an aggregated version of the table that is relevant for a model of this section, i.e., $S = 1$ and $N = 2$ with the world economy partitioned into the U.S. and the rest of the world. The structure of this table is identical to the one detail in **Section 2.1**.

Panels (b) and (c) in **Figure 4** show results of the transformation of gross output flows in panel (a) into value added flows. Panel (b) represents the benchmark transformation where sectoral allocations are based in sectoral gross output data. Panel (c) shows results for value added decomposition by destination.

In line with the criticism of the benchmark case, one can verify that panel (b) equates value added trade flows with gross trade flows in panel (a)[8], which captures the conventional approach to parameterization of open economy macro models. In contrast, value added trade in panel (c), derived using the value added

[8] I.e., $1.52 = 0.87 + 0.66$ and $1.05 = 0.40 + 0.65$.

(a) Global IO table

	usa	row	c_{usa}	c_{row}	Y
usa	8.07	0.65	10.97	0.40	20.09
row	0.87	27.96	0.66	26.18	55.66
rk+wl	11.15	27.05			
Y	20.09	55.66			

(b) Benchmark income flows

	usa	row	c_{usa}	c_{row}	Y
usa	0	0	10.11	1.05	11.15
row	0	0	1.52	25.53	27.05
rk+wl	11.15	27.05			
Y	11.15	27.05			

(c) IO-based income flows

	usa	row	c_{usa}	c_{row}	Y
usa	0	0	10.28	0.88	11.15
row	0	0	1.35	25.70	27.05
rk+wl	11.15	27.05			
Y	11.15	27.05			

Figure 4: Aggregate gross output and value added flows (USA and the rest of the world, 2004, trillion USD)

decomposition by destination, is smaller than gross trade flows in panel (a)[9]. Both exports and imports are smaller by 0.17, so that net trade remains identical in the three panels. The U.S. runs a trade deficit of 4.3% of GDP with a corresponding 1.8% of GDP surplus in the rest of the world.

The key implication from differences in panels (b) and (c) is that openness will be lower, and hence home bias in consumption larger, in the model that is parametrized to replicate allocations in panel (c). As a result, prices will respond differently to an external rebalancing in the two model parameterizations. It is worth stressing again that differences in panels (b) and (c) are limited to sectoral weights in final demand. Aggregate value added and final demand in the two countries are identical.

The second step of the parametrization procedure sets the model parameters so as to replicate allocations in panels (b) and (c). Parameters $\{\phi_{US,US}$, $\phi_{ROW,US}$, $\phi_{US,ROW}$, $\phi_{ROW,ROW}\}$ are set to replicate sectoral expenditure shares in consumption in each country. y_{US} and y_{ROW} represent factor incomes and are hence

[9] I.e., $1.35 < 1.52$ and $0.88 < 1.05$.

set equal to the sectoral value added, defined as both capital and labor incomes. Transfer terms, T_n and $-T_n$, are set to match the trade balance between the two countries. We also need to specify the elasticity of substitution between the two goods in consumption, ω. Since I/O data does not help to pin down this parameter and there is no agreement in the literature about its value, we report results for a broad range of values. The resulting two sets of parameterizations replicate the allocations in panels (b) and (c), with the only difference stemming from consumption weights, $\{\phi_{j,n}^{Benchmark}\}$ and $\{\phi_{j,n}^{I/O-based}\}$.

4.2 Results

The response of the RER, defined in **equations 10** and **11**, to a 1% of GDP reduction in the cross-country transfer, T_n, is reported in **Figure 5**, where y-axis shows the change in RER induced by the reduction in the transfer and x-axis shows how the price response varies with the elasticity of substitution between the two goods.

The economic intuition behind the price adjustment is a straightforward one. The parametrized model exhibits home bias in consumption, as implied by the I/O data. In the presence of a home bias, a reduction in the transfer that the US receives from the rest of the world decreases income and demand in the US. Because final demand falls disproportionately on the domestic good, in equilibrium the relative price of the good falls. Through an off-setting increase in income, a reinforcing price effect is at work in the rest of the world. In this case, income is increased and it falls disproportionately on the non-US good. The more substitutable the two goods are, the more of the rebalancing takes place through adjustments in quantities of the two goods consumed and the less the relative price needs to adjust.

In level terms, the RER adjustment in **Figure 5** varies in the -0.3 to 0 range. Thus, depending on the assumed value of the elasticity, the RER adjustment in the model can be interpreted as large or small in economic terms. This finding for both model parameterizations is consistent with the conclusions of the extensive literature on the topic, to which our paper provides no new insights.

The focus of this paper is instead on the differences in the RER response between the two parametrized models. The two parameterizations differ in terms of openness and hence also in terms of the degree of home bias in consumption, with the I/O-based parametrization exhibiting lower openness and larger home bias. Applying the intuition outlined above, a given external sector adjustment in

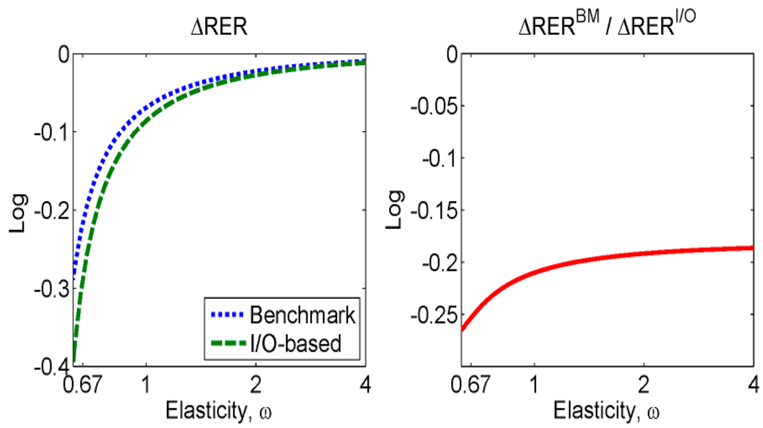

Figure 5: Response of the real exchange rate to a 1% of GDP reduction in the U.S. trade deficit (N=2, S=1)

equilibrium leads to a larger price response in the less open I/O based parametrization. This result holds regardless of the assumed elasticity of substitution. The right panel in **Figure 5** quantifies the *under*estimate of the RER response for the benchmark parameterization, which is the -0.25 to -0.20 range, depending on the assumed elasticity.

Figure 6 reports results of an identical rebalancing exercise for China. In this case, the two model parameterizations were based on the world partitioned into China and the rest of the world. We then reduce the trade surplus in China by 1% of GDP and compare model-implied RER adjustment for the two parameterizations. A reduction of the surplus increases income in China. Hence, the relative price appreciates rather than depreciates. Because China is more open and exhibits smaller home bias in consumption than the U.S., a 1% of GDP adjustment in the transfer generates a smaller price response. The size of the RER adjustment again depends crucially on the assumed elasticity of substitution between the two goods.

Differences in the price response between the two model parameterizations are qualitatively the same as in the U.S. However, in case of China, the heightened importance of processing trade implies a larger wedge between the gross and value added trade. As a result, the benchmark parameterization underestimates the size of the RER adjustment by a half or even more for the low range of elasticities.

Overall, results from the one-sector model are consistent with the intuitive no-

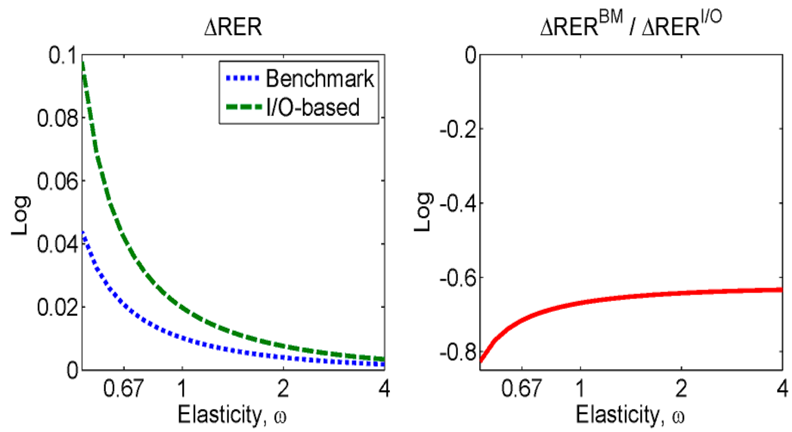

Figure 6: Response of the real exchange rate to a 1% of GDP reduction in China's trade surplus (N=2, S=1)

tion that processing trade decreases the price elasticity of the external balance. For countries with large processing trade, such as China, implications can be significant in economic terms regardless of the assumed elasticity of substitution in consumption. Even for the relatively closed U.S. economy our simple model finds a sizable difference in the RER response.

5 External Rebalancing: Two-Sector Economies

A quantitatively more realistic model is one that allows for the *intra*national price adjustment to be part of the rebalancing and for the elasticity to differ across and within sectors. In a sequence of influential papers Obstfeld and Rogoff (2000, 2004, 2005) argue that while terms of trade play a part in the external adjustment process, an equally significant adjustment takes place within the economies through the relative price of the tradable manufactures and nontradable services. In this section we repeat the rebalancing exercise in a setting where there are two sectors in each country, thus allowing for an intranational relative price adjustment.

For the purpose of this paper, the key addition from modeling multiple sectors is that intermediate cross-sectoral production inputs become predominantly domestic. Domestic services are used as intermediate inputs in manufacturing and vice versa. Imported inputs in a multi-sector setting represent only a fraction of intermediates. As a result, the research question needs to be broadened to include not only processing trade, but also domestic cross-sectoral trade in services and manufactures. Processing trade continues to drive a wedge between gross and value added trade flows for the aggregate economy, while domestic cross-sectoral intermediate inputs redistribute sectoral value added trade between services and manufactures. Both channels affect the link between the RER and external rebalancing. We show that this generalization has important implications for model results.

5.1 Parameterization

The parameterization procedure is identical to the one discussed in the previous section. The global I/O table is aggregated into 2 countries, the U.S. and the rest of the world, and 2 sectors in each country, services and manufacturing. The resulting table, presented in panel (a) of **Figure 7,** is consistent with the more aggregated version in **Figure 4**, but contains further sectoral detail. The table reveals that domestic cross-sectoral intermediate inputs in production are considerably larger than imported inputs. In case of the U.S., inputs from the domestic service sector account for 21% (1.2/5.8) of the manufacturing gross output. The same number for imports is 9%.

As before, the use of imports as intermediates implies that a fraction is re-exported and hence gross trade flows exceed value added trade flows. Cross-sectoral use of domestic intermediate inputs does not affect countries' aggregate trade flows, but redistributes trade across sectors, so that sectoral value added trade differs from the sectoral gross trade. Compare, for example, trade flows in the service sector between panels (b) and (c). In line with the discussion in **Section 2**, service trade flows in panel (b) equal sectoral gross flows in panel (a)[10]. In panel (c), by contrast, both service exports and service imports significantly exceed levels reported in panel (a). In value added terms (see panel (c)) services constitute 50% of the U.S. exports, while in gross terms (see panel (a)) services account for 28% of exports.

What explains such large differences in sectoral trade flows? While for the aggregate economy value added trade by definition is smaller than gross trade, the same does not have to hold at the sectoral level. Consider, for example, an extreme

[10] 0.2+0.1 in panel (a) and 0.3 in panel (b) for US exports of services and 0.1+0.1 in panel (a) and 0.2 in panel (b) for US imports of services.

(a) Global IO table

	S_{usa}	M_{usa}	S_{row}	M_{row}	c_{usa}	c_{row}	Y
S_{usa}	3.7	1.2	0.1	0.1	9.1	0.1	14.3
M_{usa}	1.3	1.9	0.1	0.4	1.9	0.3	5.8
S_{row}	0.1	0.0	9.2	4.3	0.1	19.4	33.1
M_{row}	0.2	0.5	4.4	10.1	0.6	6.8	22.6
rk+wl	8.9	2.2	19.2	7.8			
Y	14.3	5.8	33.1	22.6			

(b) Benchmark income flows

	S_{usa}	M_{usa}	S_{row}	M_{row}	c_{usa}	c_{row}	Y
S_{usa}	0	0	0	0	8.6	0.3	8.9
M_{usa}	0	0	0	0	1.5	0.8	2.2
S_{row}	0	0	0	0	0.2	19.0	19.2
M_{row}	0	0	0	0	1.3	6.6	7.8
rk+wl	8.9	2.2	19.2	7.8			
Y	8.9	2.2	19.2	7.8			

(c) IO-based income flows

	S_{usa}	M_{usa}	S_{row}	M_{row}	c_{usa}	c_{row}	Y
S_{usa}	0	0	0	0	8.5	0.4	8.9
M_{usa}	0	0	0	0	1.8	0.4	2.2
S_{row}	0	0	0	0	0.5	18.7	19.2
M_{row}	0	0	0	0	0.8	7.0	7.8
rk+wl	8.9	2.2	19.2	7.8			
Y	8.9	2.2	19.2	7.8			

Figure 7: Sectoral (manufacturing and services) gross output and value added flows (USA-ROW, 2004, trillion USD)

case where there is zero trade in the output of a sector, yet value added of the sector is exported indirectly, because it is used as an intermediate input in another export-generating sector. This is precisely what happens with services. Value added of the service sector is traded more than gross output of the sector, because services are used as intermediate inputs in manufacturing and hence exported indirectly.

For trade in value added of the manufacturing sector, relative to trade in the gross output of the sector, there is an off-setting large reduction driven by two factors. First, for the economy as a whole value added trade is smaller than gross trade. Second, in the service sector trade in value added exceeds trade in gross output. Comparison of manufacturing trade in panels (b) and (c) show a reduction in the U.S. value added exports of manufacturing from 1.3 to 0.8 and an even more drastic reduction in manufacturing value added imports from 0.8 to 0.4. Note, further, that sectoral trade deficits are redistributed. In value added terms the U.S. runs a trade deficit, rather than a surplus, in services coupled with a smaller deficit in manufacturing value added.

Replicating the procedure described in **Section 4.1**, data in panels (b) and (c) is used to obtain two sets of model parameters. The two parameterizations differ only in terms of sectoral weights in final demand. The model with multiple sectors differentiates elasticities between goods within sectors (e.g., manufactures from the U.S. and the rest of the world) , ω, and across sectors (e.g., services and manufactures), γ. In the absence of an agreement in the literature about the values of these elasticities, the only restriction we impose is that more similar products are better substitutes, i.e., $\gamma < \omega$, which is consistent with the available empirical evidence. Taking this restriction into account, we consider a range of values for both elasticities, centered around recent estimates from Feenstra, Obstfeld and Russ (2010), who argue that $\gamma = 0.5$ and $\omega = 1$.

5.2 Results

The 2-country, 2-sector model, parametrized to the U.S. and the rest of the world is subjected to the same 1% of GDP decrease in the U.S. trade deficit as in the previous section, with relevant results summarized in **Figure 8**. To limit the presentation of results to two-dimensional figures, top panels in **Figure 8** fix the intrasectoral elasticity, ω, while allowing the cross-sectoral elasticity, γ, to vary. Bottom panels examine a symmetric case that fixes γ and varies ω. Otherwise, the structure of the figure mimics the one-sector case, with panels on the left depicting the level response in the two model parameterizations and panels on the right summarizing the difference between the two RER responses.

As expected, RER responses in both model parameterizations are negatively related to elasticities and the size of the response depends crucially on the values of the two elasticities. These observations are in line with the results from the one-sector model and the rest of the literature.

This paper instead focuses on the difference in the response between the two parameterizations. In this respect, results in **Figure 8** reveal important differences with the one-sector case. Panels on the left reveal that when intra and inter sectoral elasticities are similar in size, the benchmark model underestimates the RER response. In this case, results are consistent with the one-sector model. However, as we move towards the empirically more relevant case of a relatively lower substitutability across sectors, the underestimate of the RER response by the benchmark model turns into an overestimate.

The reason is that in the two-sector model there are two opposing forces at work. On the one hand, the I/O-based parameterization exhibits lower aggregate openness and a larger home bias, which increase the RER response to a given

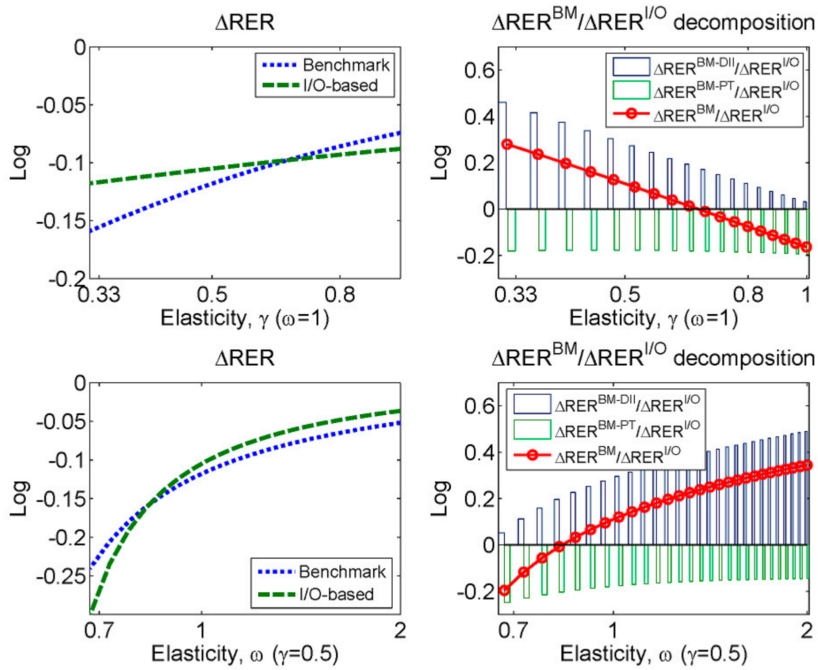

Figure 8: Response of the real exchange rate to a 1% of GDP reduction in the U.S. trade deficit and decomposition of the response difference into the "processing trade" and "domestic intermediate input" effects

external rebalancing. This "processing trade" (PT) effect is familiar from the one sector model. On the other hand, the I/O-based parameterization exhibits smaller cross-sectoral asymmetries in openness and home bias because of domestic cross-sectoral intermediate inputs. Although the service sector remains less open than the manufacturing sector, home bias is reduced in the service sector and increased in the manufacturing sector relative to the benchmark parameterization. Smaller cross-sectoral differences in home bias lead to a smaller relative price adjustment between domestic services and manufactures, which dampens the RER response to a given external rebalancing and thus counters the "processing trade" effect. The identification and analysis of this second effect, which we denote "domestic intermediate input" (DII) effect, is the main contribution of this paper.

Panels on the right in **Figure 8** decompose the difference in the RER response between the two model parameterizations into contributions from the "domestic intermediate input" and "processing trade" effects. The decomposition is based on

$$\ln\left(\frac{\Delta RER^{BM}}{\Delta RER^{I/O}}\right) = \ln\left(\frac{\Delta RER^{BM-DII}}{\Delta RER^{I/O}}\right) + \ln\left(\frac{\Delta RER^{BM-PT}}{\Delta RER^{I/O}}\right), \qquad (15)$$

where ΔRER^{BM-DII} is derived from a model parameterization that preserves the benchmark cross-sectoral asymmetry in home bias but sets the home bias for the aggregate economy equal to the one observed in the I/O-based parameterization.[11] Thus, for this modified benchmark parametrization any RER deviations from the I/O-based parameterization are exclusively due to sectoral asymmetries in home bias. The remaining term in **(15)**, ΔRER^{BM-PT}, is obtained as a residual and captures the effect from the aggregate home bias, which was the sole driver of the RER differences in the one-sector setting.

Two results from this decomposition are noteworthy. First, the RER deviation that is associated with the "processing trade" effect, $\frac{\Delta RER^{BM-PT}}{\Delta RER^{I/O}}$, is qualitatively and quantitatively similar to the one derived in the one-sector model and reported in the right hand side panel of **Figure 5**. Clearly, this component of the difference in the RER response is not contributing to the deviation in results between the one-sector and two-sector models. Second, bulk of the difference between the results in **Figures 5** and **8** is explained by the "domestic intermediate input" effect, which is captured by the $\frac{\Delta RER^{BM-DII}}{\Delta RER^{I/O}}$ term. When the two elasticities are similar in size, the contribution of this term is negligible and results in the two sector model are consistent with the one-sector case. However, as the elasticity difference between and within sectors widens, the contribution of the "domestic intermediate input" effect increases and has the opposite sign to the "processing trade" effect.

What economic forces explain the behavior of this "domestic intermediate in-

[11] Modify the final demand vectors of the benchmark economy as follows

$$\begin{bmatrix} c_{11}+\alpha_2 & c_{12}-\alpha_2 \\ c_{21}+\beta_2 & c_{22}-\beta_2 \\ c_{31}-\alpha_1 & c_{32}+\alpha_1 \\ c_{41}-\beta_1 & c_{42}+\beta_1 \end{bmatrix}$$

where

$$\begin{aligned} \alpha_1 &= c_{31}(1-(c_{31}+c_{41})/(c_{31}^{IO}+c_{41}^{IO})) \\ \beta_1 &= c_{41}(1-(c_{31}+c_{41})/(c_{31}^{IO}+c_{41}^{IO})) \\ \alpha_2 &= c_{21}(1-(c_{21}+c_{22})/(c_{21}^{IO}+c_{22}^{IO})) \\ \beta_2 &= c_{22}(1-(c_{21}+c_{22})/(c_{21}^{IO}+c_{22}^{IO})) \end{aligned}$$

and c_{ij}^{IO} are sectoral final demand components from the I/O-based VA flows.

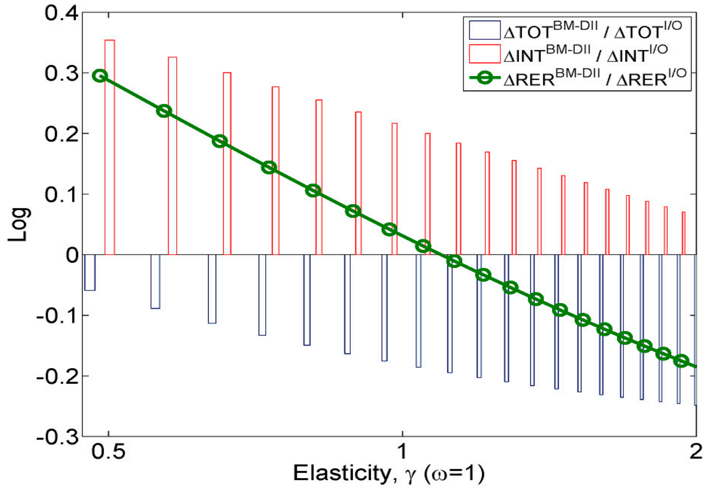

Figure 9: Response difference of the real exchange rate due to the "domestic intermediate input" effect and its decomposition into the terms of trade and internal RER components.

put" effect? One can gain further insight into the working of this effect by analyzing it in isolation. **Figure 9** zooms in on the RER response differences between the benchmark and I/O based parametrization that can be attributed to this effect. The solid line in the figure reproduces the relevant decomposition component, as depicted in the upper right panel of **Figure 8**. Note that **Figure 9** reports values of this component for a wider range of cross-sectoral elasticity, γ. This is done in order to illustrate the workings of this component for both cases, $\gamma < \omega$ as well as $\gamma > \omega$, even though the letter is of limited empirical relevance.

Figure 9 further reports a decomposition of the RER response differences into an external component, defined as the difference in the response of terms of trade between the benchmark parametrization without the PT effect and the I/O-based parameterization, and an internal component, defined as a residual. The exact derivation of this decomposition follows

$$\ln\left(\frac{\Delta RER^{BM-DII}}{\Delta RER^{I/O}}\right) = \ln\left(\frac{\Delta TOT^{BM-DII}}{\Delta TOT^{I/O}}\right) + \ln\left(\frac{\Delta INT^{BM-DII}}{\Delta INT^{I/O}}\right), \quad (16)$$

where the terms of trade is denoted by TOT^i and defined in **(12)** – **(14)**. The internal component of the RER is denoted by INT^i and captures the relative price adjustment between domestic services and manufactures.

The decomposition exercise in **Figure 9** illustrates two important results that together explain the main finding of this paper – a "domestic intermediate input" effect that counteracts the "processing trade" effect. The first intuitive result is that a reduction in the home bias in the service sector and a simultaneous increase in the home bias in the manufacturing sector redistribute the RER adjustment from the internal RER to the terms of trade. To see this result recall that any changes in relative prices in this modeling framework require home bias. The larger the bias, the larger the price adjustment. This holds for the aggregate economy as well as its subsectors. Hence, in **Figure 9** response differences in the internal RER, $\frac{\Delta INT^{BM-DII}}{\Delta INT^{I/O}}$, are positive, indicating an overestimate of this component by the benchmark parametrization, while response differences in the terms of trade, $\frac{\Delta TOT^{BM-DII}}{\Delta TOT^{I/O}}$, are negative, indicating an underestimate of this component by the benchmark parametrization.

The second finding is that response difference for the terms of trade increases with the relative cross-sectoral elasticity, γ/ω, while the response difference for the internal RER decreases. Intuitively, when the substitution across sectors is relatively less elastic, the cross-sectoral relative price, i.e., the internal RER, accounts for the bulk of the RER response differences. In contrast, when the substitution within sectors is relatively less elastic, the terms of trade accounts for the bulk of the RER response differences. As a result, in the empirically relevant case of a lower cross-sectoral elasticity, $\gamma < \omega$, the "domestic intermediate input" effect counteracts the "processing trade" effect and can lead the benchmark parameterization to *overestimate* the RER adjustment. Notice also that when the two elasticities are similar in magnitude, the differences in the internal RER and terms of trade broadly cancel out. In this case "domestic intermediate effect" does not contribute to the aggregate RER response differences and, hence, results in the two-sector model mimic the one-sector case.

Quantitatively, for reasonable values of elasticities, e.g., $\gamma = 0.5$ and $\omega = 1$, the smaller cross-sectoral asymmetries in home bias in the I/O-based parametrization lower the aggregate price response, relative to the benchmark model, in a way that broadly offsets the price increase from the lower aggregate openness. The net effect for the US, reported in **Figure 8,** is a 10% larger RER adjustment in the benchmark parameterization.

Is the large role played by the differences in cross-sectoral asymmetries in open-

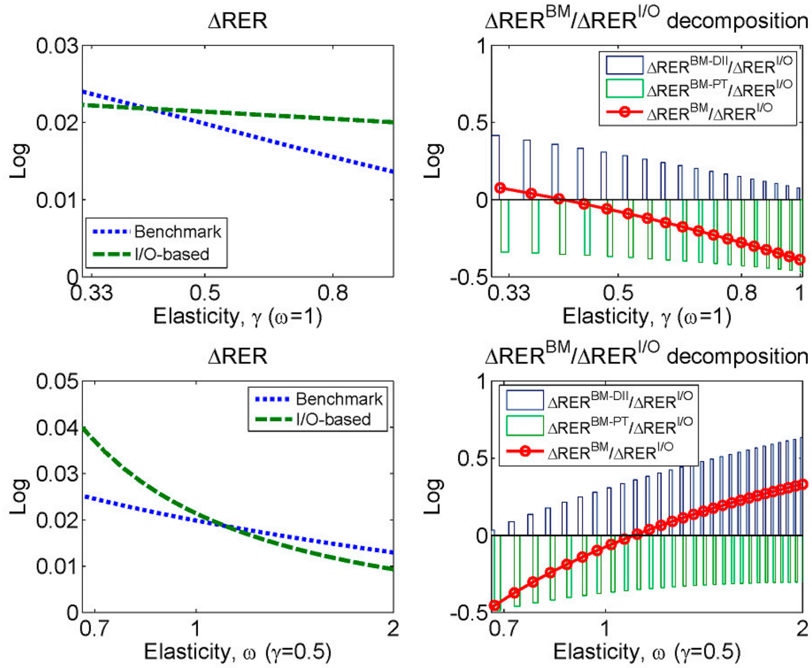

Figure 10: Response of the real exchange rate to a 1% of GDP reduction in China's trade surplus and decomposition of the response difference into the "processing trade" and "domestic intermediate input" effects

ness between the two parameterizations unique to the U.S. economy? Comparable results for China are presented in **Figure 10** and convey a similar picture. The benchmark model significantly underestimates the RER adjustment when the two elasticities are similar in size. However, for the more empirically relevant values of elasticities, i.e., $\gamma = 0.5$ and $\omega = 1$, the "domestic intermediate input" effect reduces the RER underestimate to mere 7%.

Overall, this section shows that taking domestic intermediate inputs into account leads to a significant redistribution of trade flows across sectors. For the RER adjustment there are two forces at work. The disentangling of gross trade flows into value added trade flows reduces openness and hence *increases* RER responses. In contrast, the accompanying reallocation of trade across sectors of the domestic economy, from manufactures to services, reduces cross sectoral asymmetries in openness and *decreases* the RER response to an external rebalancing. For the examined applications of the model, the two effects are comparable in magnitude, making the overall price response considerably smaller than implied by the one-sector model.

6 Conclusions

Starting from a conventional macro modeling framework, this paper proposes a methodology for tracing out the effect of intermediate inputs, including processing trade, on the link between external sector adjustment and relative price changes. We first recast a widely held view that by not taking processing trade into account, the conventional approach to rebalancing overstates economic openness and understates home bias in consumption. As a result, the conventional model *over*estimates the price elasticity of the external sector balance.

Next, we show that in a multi-sector setting, with tradable manufactures and nontradable services, domestic intermediate inputs have an additional effect on the link between the external rebalancing and relative price adjustments. Because services are used as intermediate inputs in manufacturing, they are more tradable than assumed by the conventional approach – one that ignores intermediate inputs. To put it differently, value added of the service sector is traded more than the gross output of the service sector At the same time, value added of the manufacturing sector is traded less than the gross output of the sector, further contributing to the reduction of cross-sectoral asymmetries in openness and home bias within economies. For the external sector rebalancing, this finding – a reduced cross sectoral asymmetry in openness and home bias – redistributes the RER adjustment between its internal and external components. There is an increase in the terms of trade adjustment and decrease in the relative price adjustment between domestic services and manufactures. Which of the two adjustments dominates depends on the assumed cross-sectoral and within-sector elasticities. When the cross-sectoral elasticity is lower than the elasticity between goods within sectors, which is a plausible and widely-held assumption in macroeconomics, the relative price adjustment between domestic services and manufactures dominates and leads to a reduction in the RER adjustment. Thus, in contrast to the "processing trade" effect above, the "domestic intermediate input" effect implies that the conventional approach may *under*estimate the price elasticity of the external sector balance.

Finally, model simulations for the US and China suggest that the opposing “processing trade“ and “domestic intermediate input“ effects are both economically significant and comparable in size. One implication of this quantitative finding is that although the conventional macro model ignores domestic intermediate inputs and processing trade, its resulting overestimate of the price elasticity of the external sector balance is much smaller than implied by the “processing trade“ effect alone. Indeed, we find that in the case of the US, the conventional framework without intermediate inputs underestimates, rather than overestimates the price elasticity.

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