External Rebalancing, Structural Adjustment, and Real Exchange Rates in Developing Asia*

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Abstract

This paper evaluates the impact of global external rebalancing on Developing Asia and the rest of the world using a multi-country multi-sector quantitative model of production and trade. Developing Asia countries currently running a trade surplus (such as People's Republic of China or Malaysia) see a substantial rise in relative wages and an appreciation in the real exchange rate. They also see an increase in the size of the non-traded sector and an increase in welfare. Deficit countries in Developing Asia (such as India or Viet Nam) see a depreciation in the trade-weighted real exchange rate of a few percent, a shrinking of the non-traded sector, and a fall in welfare.

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1 Introduction

The Developing Asia region has been the fastest-growing region in the world in recent decades. As is common for fast-growing countries, the region's growth has been export-led, and many of the countries in the region have been running trade surpluses. As these countries develop, sustained economic growth will require a rebalancing from reliance on exports and towards greater domestic demand.

What will be the consequences of that rebalancing process, for the Developing Asia countries themselves and for the rest of the world? A country running a trade surplus is spending less than the value of its output. Rebalancing – an elimination of the trade surplus – then by construction increases the country's total spending. If the country is small (i.e., does not affect the world goods prices) and all goods are freely traded, rebalancing directly increases nominal spending, but has no effect on the real exchange rate, factor prices, or the sectoral allocation of employment. A small country model with non-tradeable goods, sometimes called the "dependent economy" or the Salter-Swan model (Salter 1959, Swan 1960) predicts that a rise in domestic spending due to the elimination of the trade surplus will increase demand for non-tradeables and their prices, thereby moving factors of production into non-tradeables and appreciating the country's real exchange rate. The dependent economy model assumes a small country and a single exportable good, and thus it makes no prediction on how the patterns of international specialization or relative factor prices will change in response to rebalancing. In the two-country Ricardian model with a continuum of goods, Dornbusch, Fischer and Samuelson (1977) show that an elimination of the trade surplus in a country will raise both its relative and real wage, and reduce the set of goods that it exports. In summary, classical theory predicts that an elimination of a trade surplus in a country (i) increases both relative and real incomes; (ii) appreciates the real exchange rate; (iii) increases the employment share in the non-traded sector; and (iv) reduces exports. All of these effects are reversed in the trade deficit countries as the trade imbalance is eliminated.

As insightful as these predictions are, classical theory leaves many unanswered questions. First and foremost, while the directions of the effects outlined above are well-established, stylized small-country or two-country models are too simplistic to reliably gauge the magnitudes involved. Second, the world is a great deal more complex than the simple models. The real world features many heterogeneous countries with highly asymmetric trade relationships between them. While this distinction is non-existent in two-country models, in the real world the elimination of the People's Republic of China's trade surplus will likely have a very different global impact than the elimination of Japan's trade surplus, since those two countries occupy different positions in the world trading system. In addition, the world is increasingly engaged in intermediate input trade ("the global supply chains"), and thus a rebalancing in, say, People's Republic of China will have knock-on effects on countries supplying inputs to its traded and non-traded sectors. Finally, the world has many surplus and many deficit countries at the same time. An elimination of the trade imbalance in several surplus countries simultaneously may yield heterogeneous effects in the different surplus countries. While the complexity of the real-world global economy may not overturn the basic predictions of the classical theory, in order to develop a set of quantitative results about the impact of rebalancing, we must develop a framework that goes some way towards reflecting the rich heterogeneity of countries and trading relationships observed in the world today.

This paper uses a large-scale quantitative model of production and trade to simulate global impact of rebalancing. The analysis is based on a Ricardian-Heckscher-Ohlin framework that features 75 countries (including 14 from Developing Asia), 19 tradeable and 1 non-tradeable sector, multiple factors of production, as well as the full set of cross-sectoral input-output linkages forming a global supply chain. The model is implemented on sectoral trade and production data, in such a way that it matches the sector-level bilateral trade shares in our sample of countries as well as the countries' relative incomes. In the baseline equilibrium, we solve the model under the observed levels of trade imbalances in each country. We then compare outcomes to the counterfactual scenario in which "external rebalancing" took place, and each country is constrained to have balanced trade. This exercise thus follows the approach of Obstfeld and Rogoff (2005) and Dekle, Eaton and Kortum (2007, 2008). We examine the impact of rebalancing on a range of outcomes, including relative wages, real exchange rates, the size of the non-tradeable sector, and finally welfare.

Our model quantifies these impacts both for Developing Asia and the rest of the world. In the surplus countries in the region (People's Republic of China, Republic of Korea, Malaysia, among others) relative wages (with respect to the U.S.) rise by double digits, 17.5% at the median, and the real exchange rate with respect to the U.S. appreciates by a similar, slightly smaller, amount. Interestingly, the trade-weighted real exchange rate in these countries appreciates by much less (1.5% at the median), with Republic of Korea and Taipei, China actually experiencing modest real depreciations in trade-weighted terms. This difference is due to the fact that these countries trade a great deal among themselves, and thus as they are all appreciating against the United States, their real appreciation against each other is much more modest.

As expected, a rebalancing towards greater domestic demand in the surplus countries is accompanied by an increase in the size of the non-tradeable sector. At the median, the share of labor in the non-tradeable sector rises by 4 percentage points. This is a modest change in proportional terms: the average share of labor in the non-tradeable sector is two-thirds in this group of countries. Finally, the impact on welfare of the rebalancing is a fraction of a percent among the surplus countries (0.4% at the median). Welfare corresponds to the real income in this model. A rebalancing leads to a rise in factor prices, and an increase in the price level. The net effect on welfare is more subdued than either the change in nominal factor prices or the change in the price level.

The impact is roughly opposite for the deficit countries in Developing Asia (India, Sri Lanka, Viet Nam, among others). While for 4 out of 7 Developing Asia deficit countries wages relative to the U.S. rise, the average increase is much more subdued at about 5.1%. While the real exchange with respect to the U.S. appreciates in most of these countries, the trade-weighted real exchange depreciates in all of them, on average by 6%. As rebalancing requires a reduction in domestic spending, the share of labor in the non-tradeable sector shrinks by 3 percentage points. All in all, these countries experience a significant reduction in welfare, of about 2.6% on average.

It is intuitive that countries running surpluses tend to benefit from the reductions in their own trade surplus, and vice versa. However, the multilateral trade patterns are also important for understanding the impact of rebalancing on these economies. Countries that currently export mostly to the deficit countries (chiefly the U.S.) tend to experience reductions in welfare due to the rebalancing. By contrast, countries exporting to the major surplus countries (chiefly the People's Republic of China) tend to benefit.

In addition to the classical contributions discussed above, our paper is related to the more recent literature on the impact of external rebalancing. Obstfeld and Rogoff (2005) simulate rebalancing in a 3-country (U.S., Europe, Asia) Armington model. Dekle, Eaton and Kortum (2007, 2008) perform a similar exercise in a Ricardian model with 42 countries and 2 sectors (tradeable and non-tradeable). Our paper is the first to evaluate global rebalancing in a multi-sector framework with a full-fledged within- and cross-sectoral set of input-output linkages. This allows for a much greater degree of precision regarding each country's impact on its trading partners. In addition, our paper is the first, to our knowledge, to apply this quantitative approach with the particular emphasis on Developing Asia.

The rest of the paper is organized as follows. Section 2 lays out the quantitative framework and discusses the details of calibration and estimation. Section 3 discusses the main results, and Section 4 concludes.

2 Quantitative Framework

Motivated by the discussion in the Introduction, our goal is to assess the impact of global rebalancing in an appropriately rich quantitative model. Classical theory emphasizes that in order to model rebalancing, it is essential for the framework to feature (i) both traded and non-traded sectors (Salter 1959, Swan 1960) and (ii) endogenous specialization (Dornbusch et al. 1977). We also argued that a reliable assessment will require (iii) a large number of countries and (iv) a sufficiently rich production structure that features multiple sectors and a fully articulated set of input-output linkages between them, forming a global supply chain. It turns out that a multi-sector version of the Eaton and Kortum (2002, henceforth EK) Ricardian model provides the necessary tractability to build a quantitative framework of this scale.

2.1 The Environment

The world is comprised of $N = 75$ countries, indexed by n and i. There are $J = 19$ tradeable sectors, plus one nontradeable sector $J + 1$. Utility over these sectors in country n is given by

$$U_n = \left(\sum_{j=1}^{J} \omega_j^{\frac{1}{\eta}} \left(Y_n^j\right)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}\xi_n} \left(Y_n^{J+1}\right)^{1-\xi_n}, \tag{1}$$

where Y_n^{J+1} is the nontradeable-sector composite good, and Y_n^j is the composite good in tradeable sector j. That is, utility is Cobb-Douglas in tradeables and non-tradeables, implying that consumers have a constant expenditure share devoted to tradeable goods, equal to ξ_n in country n. In turn, the bundle of tradeables is a CES (constant elasticity of substitution) aggregate of the J tradeable sectors, with η the elasticity of substitution between the tradeable sectors, and ω_j the taste parameter for tradeable sector j.

The assumption that utility is Cobb-Douglas in tradeables and non-tradeables will have quantitative implications for the extent of labor reallocation following external rebalancing. Generally, a higher elasticity of substitution would imply greater factor reallocation, as demand will respond more to relative price changes. It is well known that Cobb-Douglas utility implies an elasticity of substitution between tradeables and the non-tradeables equal to 1. This assumption is not too far from the available estimates. Herrendorf, Rogerson and Valentinyi (2012) estimate the elasticity of substitution between services (which in our model is interpreted as non-tradeables) and manufacturing of 0.9. Other estimates show even smaller substitution possibilities. For instance, Święcki (2013) estimates that elasticity to be 0.2, implying very little substitution possibilities between manufacturing and services. Under that elasticity, the labor reallocation towards non-tradeables in surplus countries will be even smaller.

A related issue is the role of preference non-homotheticity. For instance, a surplus country like People's Republic of China will experience an income increase when external rebalancing takes place. Non-homothetic preferences such that higher incomes imply greater demand for nontradeables would translate into even greater reallocation of labor to the non-tradeable sector following rebalancing. As will become clear below, however, the change in real income due to rebalancing is rather modest – a fraction of a percent for the surplus Developing Asia countries. Thus, we would not expect a large change in the relative demand for non-tradeables acting through a non-homotheticity channel following rebalancing.

All goods and factor markets are competitive, and all production features constant returns to scale, implying that all profits are zero. There are two factors of production, labor (with country n endowed with L_n units) and capital (K_n). Production uses labor, capital, and intermediate inputs from other sectors. The cost of an input bundle in country n and sector j is:

$$c_n^j = \left(w_n^{\alpha_j} r_n^{1-\alpha_j}\right)^{\beta_j} \left(\prod_{k=1}^{J+1} \left(p_n^k\right)^{\gamma_{k,j}}\right)^{1-\beta_j},$$

where w_n is the wage of workers, r_n is the return to capital, and p_n^k is the price of intermediate input from sector k in country n. That is, the production function is Cobb-Douglas in the two primary factors K_n and L_n and the intermediate inputs. The intermediate inputs can come from any other sector.

The share of payments to labor in value added (also known as "labor intensity") is given by α_j. It varies by sector: some sectors will be very labor-intensive, others less so. The share of value added in the value of total output is given β_j. It varies across sectors as well: some sectors will spend a lot on intermediate inputs relative to the value of gross output, others less so. Finally, $\gamma_{k,j}$ captures the usage in sector j of intermediate inputs coming from sector k. Precisely, $\gamma_{k,j}$ is the share of spending on sector k inputs in total input spending in sector j. These shares will vary by output industry j as well as input industry k. That is, we allow for the Apparel sector, say, to use a great deal of Textile inputs, but much fewer Basic Metals inputs.

Each sector $j = 1, ..., J+1$ is composed of a continuum of varieties $q \in [0, 1]$ unique to each sector. Perfectly competitive producers can produce each variety q in each sector j in every country n. However, productivities will differ across countries in each q and j. Producing one unit of good q in sector j in country n requires $\frac{1}{z_n^j(q)}$ input bundles. Following EK, productivity $z_n^j(q)$ for each $q \in [0, 1]$ in each sector j is random, and drawn from the Fréchet distribution with cdf:

$$F_n^j(z) = e^{-T_n^j z^{-\theta}}.$$

In this distribution, T_n^j is a central tendency parameter. It varies by both country and sector, with higher values of T_n^j implying higher *average* productivity draws in sector j in country n. The parameter θ captures dispersion, with larger values of θ implying smaller dispersion in draws.

The intuition for this physical environment is as follows. Each j should be thought of as a very large sector, say Textiles, Apparel, or Electrical Machinery. Within each sector, there is a large number of varieties q. If j is Apparel, then blue cotton T-shirts, green cotton T-shirts, black socks, etc, are different varieties q within Apparel. Each country can produce each q, but productivities will vary across countries: Japan may happen to be better at blue cotton T-shirts than Viet Nam, but Pakistan may be better than Japan at producing black socks. While we may not be able to say with confidence whether Japan or Pakistan are better at making black socks, we will be able to make statements about the *average* productivity of each country in the Apparel sector, captured by T_n^j. Since there is a continuum of varieties q, and the Fréchet distribution has infinite support, even countries with a very low T_n^j relative to their trading partners will have a few q's in which they got an unusually high draw, and thus they would be able to produce individual varieties even in its (on average) comparative disadvantage sectors.

Why impose the assumptions that there is a continuum of varieties in each sector, and that productivity draws come from a Fréchet distribution? The reasons are realism and tractability. Real-world trade flows within broad sectors are characterized by substantial two-way trade: pairs of countries often ship similar products to each other. This setup allows us to model that phenomenon and thus successfully match global bilateral trade flows within each sector. The Fréchet distributional assumption helps because it yields especially simple analytical expressions for bilateral trade shares, thus making model estimation and calibration easy even for a very large number of countries.

The production cost of one unit of good q in sector j and country n is thus equal to $c_n^j/z_n^j(q)$. International trade is subject to "iceberg" costs: $d_{ni}^j > 1$ units of good q produced in sector j in country i must be shipped to country n in order for one unit to be available for consumption there. The trade costs need not be symmetric – d_{ni}^j need not equal d_{in}^j – and will vary by sector. We normalize $d_{nn}^j = 1$ for any n and j. The price at which country i supplies tradeable good q in sector j to country n is:

$$p_{ni}^j(q) = \left(\frac{c_i^j}{z_i^j(q)} \right) d_{ni}^j.$$

Buyers of each good q in tradeable sector j in country n will shop globally, and will only buy from the cheapest source country. Thus the price actually paid for this good in country n will be:

$$p_n^j(q) = \min_{i=1,\ldots,N} \left\{ p_{ni}^j(q) \right\}.$$

International trade happens whenever the cheapest provider of some variety q to some market n is foreign. Note that there are several ways to be the cheapest supplier of good q in sector j in country n. A country may become the cheapest source of a good because it is productive (high $z_i^j(q)$), it has cheap inputs (low c_i^j), or it has low trade costs.

Output in sector j in produced from varieties $q \in [0,1]$ using a CES production function:

$$Q_n^j = \left[\int_0^1 Q_n^j(q)^{\frac{\varepsilon-1}{\varepsilon}} dq \right]^{\frac{\varepsilon}{\varepsilon-1}},$$

where ε denotes the elasticity of substitution across varieties q, Q_n^j is the total output of sector

j in country n, and $Q_n^j(q)$ is the amount of variety q that is used in production in sector j and country n. Note that some of the $Q_n^j(q)$'s will be imported, except in the non-tradeable sector.

Trade is not balanced. We incorporate trade imbalances following the approach of Dekle, Eaton and Kortum (2007, 2008) and assume that at a point in time, a trade imbalance represents a transfer from the surplus to the deficit country. Specifically, the budget constraint (or the resource constraint) of the consumer is

$$\sum_{j=1}^{J+1} p_n^j Y_n^j = w_n L_n + r_n K_n - D_n, \tag{2}$$

where p_n^j are prices of sector j output in country n, and D_n is the trade surplus of country n. When D_n is negative, countries are running a deficit and consume more than their factor income. The deficits add up to zero globally, $\sum_n D_n = 0$, and are thus transfers of resources between countries.

2.2 Characterization of Equilibrium

Given the preferences and technology described above and the exogenous parameters of the model, we can find the global equilibrium in this economy. Factors of production (K_n and L_n) are perfectly mobile across sectors within a country, but immobile across countries. Intuitively, the global equilibrium is a set of resource allocations and prices such that all markets clear, both domestically and internationally. What follows is the formal definition of equilibrium and the detailed statement of the equilibrium conditions in this economy.

The **competitive equilibrium** of this model world economy with exogenous trade deficits consists of a set of prices, allocation rules, and trade shares such that (i) given the prices, all firms' inputs satisfy the first-order conditions, and their output is given by the production function; (ii) given the prices, the consumers' demand satisfies the first-order conditions; (iii) the prices ensure the market clearing conditions for labor, capital, tradeable goods and nontradeable goods; (iv) trade shares ensure exogenous trade deficit for each country.

The set of prices includes the wage rate w_n, the rental rate r_n, the sectoral prices $\{p_n^j\}_{j=1}^{J+1}$, and the aggregate price P_n in each country n. The allocation rules include the capital and labor allocation across sectors $\{K_n^j, L_n^j\}_{j=1}^{J+1}$, final consumption demand $\{Y_n^j\}_{j=1}^{J+1}$, and total demand $\{Q_n^j\}_{j=1}^{J+1}$ (both final and intermediate goods) for each sector. The trade shares include the expenditure share π_{ni}^j in country n on goods coming from country i in sector j.

2.2.1 Demand and Prices

It can be easily shown that the price of sector j's output will be given by:

$$p_n^j = \left[\int_0^1 p_n^j(q)^{1-\varepsilon} dq \right]^{\frac{1}{1-\varepsilon}}.$$

Following the standard EK approach, it is helpful to define

$$\Phi_n^j = \sum_{i=1}^{N} T_i^j \left(c_i^j d_{ni}^j \right)^{-\theta}.$$

This value summarizes, for country n, the access to production technologies in sector j. Its value will be higher if in sector j, country n's trading partners have high productivity (T_i^j) or low cost (c_i^j). It will also be higher if the trade costs that country n faces in this sector are low. Standard steps lead to the familiar result that the price of good j in country n is simply

$$p_n^j = \Gamma \left(\Phi_n^j \right)^{-\frac{1}{\theta}}, \tag{3}$$

where $\Gamma = \left[\mathbf{\Gamma} \left(\frac{\theta+1-\varepsilon}{\theta} \right) \right]^{\frac{1}{1-\varepsilon}}$, with $\mathbf{\Gamma}$ the Gamma function. The consumption price index in country n is then:

$$P_n = B_n \left(\sum_{j=1}^{J} \omega_j (p_n^j)^{1-\eta} \right)^{\frac{1}{1-\eta}\xi_n} (p_n^{J+1})^{1-\xi_n}, \tag{4}$$

where $B_n = \xi_n^{-\xi_n}(1-\xi_n)^{-(1-\xi_n)}$.

Given the set of prices $\{w_n, r_n, P_n, \{p_n^j\}_{j=1}^{J+1}\}_{n=1}^{N}$, we first characterize the optimal allocations from final demand. Consumers maximize utility (1) subject to the budget constraint (2). The first order conditions associated with this optimization problem imply the following final demand:

$$p_n^j Y_n^j = \xi_n (w_n L_n + r_n K_n - D_n) \frac{\omega_j (p_n^j)^{1-\eta}}{\sum_{k=1}^{J} \omega_k (p_n^k)^{1-\eta}}, \text{ for all } j = \{1, .., J\} \tag{5}$$

and

$$p_n^{J+1} Y_n^{J+1} = (1-\xi_n)(w_n L_n + r_n K_n - D_n).$$

2.2.2 Production Allocation and Market Clearing

The EK structure in each sector j delivers the standard result that the probability of importing good q from country i, π_{ni}^j, is equal to the share of total spending on goods coming from country

i, X_{ni}^j/X_n^j, and is given by

$$\frac{X_{ni}^j}{X_n^j} = \pi_{ni}^j = \frac{T_i^j \left(c_i^j d_{ni}^j\right)^{-\theta}}{\Phi_n^j}.$$

Let Q_n^j denote the total sectoral demand in country n and sector j. Q_n^j is used for both final consumption and intermediate inputs in domestic production of all sectors. That is,

$$p_n^j Q_n^j = p_n^j Y_n^j + \sum_{k=1}^{J}(1-\beta_k)\gamma_{j,k}\left(\sum_{i=1}^{N}\pi_{in}^k p_i^k Q_i^k\right) + (1-\beta_{J+1})\gamma_{j,J+1} p_n^{J+1} Q_n^{J+1}.$$

Total expenditure in sector $j = 1, ..., J+1$ of country n, $p_n^j Q_n^j$, is the sum of (i) domestic final consumption expenditure $p_n^j Y_n^j$; (ii) expenditure on sector j goods as intermediate inputs in all the traded sectors $\sum_{k=1}^{J}(1-\beta_k)\gamma_{j,k}(\sum_{i=1}^{N}\pi_{in}^k p_i^k Q_i^k)$, and (iii) expenditure on the j's sector intermediate inputs in the domestic non-traded sector $(1-\beta_{J+1})\gamma_{j,J+1} p_n^{J+1} Q_n^{J+1}$. These market clearing conditions summarize the two important features of the world economy captured by our model: complex international production linkages, as much of world trade is in intermediate inputs, and a good crosses borders multiple times before being consumed (Hummels, Ishii and Yi 2001); and two-way input linkages between the tradeable and the nontradeable sectors.

In each tradeable sector j, some goods q are imported from abroad and some goods q are exported to the rest of the world. Country n's exports in sector j are given by $EX_n^j = \sum_{i=1}^{N} \mathbb{1}_{i \neq n} \pi_{in}^j p_i^j Q_i^j$, and its imports in sector j are given by $IM_n^j = \sum_{i=1}^{N} \mathbb{1}_{i \neq n} \pi_{ni}^j p_n^j Q_n^j$, where $\mathbb{1}_{i \neq n}$ is the indicator function. The total exports of country n are then $EX_n = \sum_{j=1}^{J} EX_n^j$, and total imports are $IM_n = \sum_{j=1}^{J} IM_n^j$. Exogenous trade deficit requires that for any country n, $EX_n - IM_n = D_n$.

Given the total production revenue in tradeable sector j in country n, $\sum_{i=1}^{N} \pi_{in}^j p_i^j Q_i^j$, the optimal sectoral factor allocations must satisfy

$$\sum_{i=1}^{N} \pi_{in}^j p_i^j Q_i^j = \frac{w_n L_n^j}{\alpha_j \beta_j} = \frac{r_n K_n^j}{(1-\alpha_j)\beta_j}.$$

For the nontradeable sector $J+1$, the optimal factor allocations in country n are simply given by

$$p_n^{J+1} Q_n^{J+1} = \frac{w_n L_n^{J+1}}{\alpha_{J+1}\beta_{J+1}} = \frac{r_n K_n^{J+1}}{(1-\alpha_{J+1})\beta_{J+1}}.$$

Finally, for any n the feasibility conditions for factors are given by

$$\sum_{j=1}^{J+1} L_n^j = L_n \text{ and } \sum_{j=1}^{J+1} K_n^j = K_n.$$

2.3 Welfare

Welfare in this framework corresponds to the indirect utility function. Straightforward steps using the CES functional form can be used to show that the indirect utility in each country n is equal to total income divided by the price level. Since both goods and factor markets are competitive, total income equals the total returns to factors of production. Thus total welfare in a country is given by $(w_n L_n + r_n K_n)/P_n$, where the consumption price level P_n comes from equation (4). Expressed in per-capita terms it becomes

$$\frac{w_n + r_n k_n}{P_n}, \tag{6}$$

where $k_n = K_n/L_n$ is capital per worker. This expression is the metric of welfare in all counterfactual exercises below. Importantly, we do not include the direct effect of consuming (or transferring away) D_n when calculating the welfare levels of countries. Rather, we focus on real factor incomes.

2.4 Calibration

The equations above define the equilibrium in this economy. Analytical solutions of this model are not available. However, the equilibrium can be found numerically. Essentially, the equilibrium conditions are simply a set of non-linear equations in the prices and resource allocations. Solving the model amounts to finding a solution to this set of equations.

Any numerical implementation, of course, requires us to take a stand on the values of every parameter in the model. Specifically, we must take a stand on the following sets of parameters: (i) moments of the productivity distributions T_n^j and θ; (ii) trade costs d_{ni}^j; (iii) production function parameters α_j, β_j, $\gamma_{k,j}$, and ε; (iv) country factor endowments L_n and K_n; and (v) preference parameters ξ_n, ω_j, and η. What follows is a detailed discussion of how each parameter is picked. As there are many parameters to be chosen, we follow three broad approaches to choosing them. First, in some cases we use data and model-implied relationships to estimate sets of parameters structurally. This is the most sophisticated approach. Second, some parameters can be easily computed with basic data, without the need to rely on the model structure explicitly. Finally, in a very limited set of cases, we simply adopt parameter values estimated elsewhere in the literature and commonly used. This approach is followed only in cases where the model does not provide enough guidance on how to compute these parameters based on data.

The structure of the model is used to estimate the sector-level technology parameters T_n^j for a large set of countries. The estimation procedure relies on fitting a structural gravity equation implied by the model, and using the resulting estimates along with data on input costs to back out underlying technology. Intuitively, if controlling for the typical gravity determinants of trade, a country spends relatively more on domestically produced goods in a particular sector, it is revealed to have either a high relative productivity or a low relative unit cost in that sector. The procedure then uses data on factor and intermediate input prices to net out the role of factor costs, yielding an estimate of relative productivity. This step also produces estimates of bilateral sector-level trade costs d_{ni}^{j}. The parametric model for iceberg trade costs includes the common geographic variables such as distance and common border, as well as policy variables, such as regional trade agreements and currency unions. The detailed procedures for all three steps are described in Levchenko and Zhang (2011) and reproduced in Appendix A.

Estimation of sectoral productivity parameters T_n^j and trade costs d_{ni}^j requires data on total output by sector, as well as sectoral data on bilateral trade. For 52 countries in the sample, information on output comes from the 2009 UNIDO Industrial Statistics Database. For the European Union countries, the EUROSTAT database contains data of superior quality, and thus for those countries we use EUROSTAT production data. The two output data sources are merged at the roughly 2-digit ISIC Revision 3 level of disaggregation, yielding 19 manufacturing sectors. Bilateral trade data were collected from the UN COMTRADE database, and concorded to the same sectoral classification. We assume that the dispersion parameter θ does not vary across sectors. There are no reliable estimates of how it varies across sectors, and thus we do not model this variation. We pick the value of $\theta = 8.28$, which is the preferred estimate of EK.[1] It is important to assess how the results below are affected by the value of this parameter. One may be especially concerned about how the results change under lower values of θ. Lower θ implies greater within-sector heterogeneity in the random productivity draws. Thus, trade flows become less sensitive to the costs of the input bundles (c_i^j), and the gains from intra-sectoral trade become larger relative to the gains from inter-sectoral trade. Elsewhere (Levchenko and Zhang 2011) we re-estimated all the technology parameters using instead a value of $\theta = 4$, which has been advocated by Simonovska and Waugh (2011) and is at or near the bottom of the range that has been used in the literature. Overall, the outcome was remarkably similar. The correlation between estimated T_i^j's under $\theta = 4$ and the baseline is above 0.95, and there is actually somewhat greater variability in T_i^j's under $\theta = 4$.

The production function parameters α_j and β_j are estimated using the UNIDO and EUROSTAT production data, which contain information on output, value added, employment, and wage bills. To compute α_j for each sector, we calculate the share of the total wage bill in value added, and take a simple median across countries (taking the mean yields essentially the same results).

[1] Shikher (2004, 2005, 2011), Burstein and Vogel (2012), and Eaton, Kortum, Neiman and Romalis (2011), among others, follow the same approach of assuming the same θ across sectors. Caliendo and Parro (2010) use tariff data and triple differencing to estimate sector-level θ. However, their approach may suffer from significant measurement error: at times the values of θ they estimate are negative. In addition, in each sector the restriction that $\theta > \varepsilon - 1$ must be satisfied, and it is not clear whether Caliendo and Parro (2010)'s estimated sectoral θ's meet this restriction in every case. Our approach is thus conservative by being agnostic on this variation across sectors.

To compute β_j, we take the median of value added divided by total output.

The intermediate input coefficients $\gamma_{k,j}$ are obtained from the Direct Requirements Table for the United States. We use the 1997 Benchmark Detailed Make and Use Tables (covering approximately 500 distinct sectors), as well as a concordance to the ISIC Revision 3 classification to build a Direct Requirements Table at the 2-digit ISIC level. The Direct Requirements Table gives the value of the intermediate input in row k required to produce one dollar of final output in column j. Thus, it is the direct counterpart to the input coefficients $\gamma_{k,j}$. Note that we assume these to be the same in all countries.[2] In addition, we use the U.S. I-O matrix to obtain α_{J+1} and β_{J+1} in the nontradeable sector, which cannot be obtained from UNIDO.[3] The elasticity of substitution between varieties within each tradeable sector, ε, is set to 4 (as is well known, in the EK model this elasticity plays no role, entering only the constant Γ).

The total labor force in each country, L_n, and the total capital stock, K_n, are obtained from the Penn World Tables 6.3. Following the standard approach in the literature (see, e.g. Hall and Jones 1999, Bernanke and Gürkaynak 2001, Caselli 2005), the total labor force is calculated from the data on the total GDP per capita and per worker.[4] The total capital is calculated using the perpetual inventory method that assumes a depreciation rate of 6%: $K_{n,t} = (1-0.06)K_{n,t-1}+I_{n,t}$, where $I_{n,t}$ is total investment in country n in period t. For most countries, investment data start in 1950, and the initial value of K_n is set equal to $I_{n,0}/(\gamma + 0.06)$, where γ is the average growth rate of investment in the first 10 years for which data are available.

The share of expenditure on traded goods, ξ_n in each country is sourced from Yi and Zhang (2010), who compile this information for 36 developed and developing countries. For countries unavailable in the Yi and Zhang data, values of ξ_n are imputed based their level of development. We fit a simple linear relationship between ξ_n and log PPP-adjusted per capita GDP from the Penn World Tables on the countries in the Yi and Zhang (2010) dataset. The fit of this simple bivariate linear relationship is quite good, with an R^2 of 0.55. For the remaining countries, we then set ξ_n to the value predicted by this bivariate regression at their level of income. The taste parameters for tradeable sectors ω_j were estimated by combining the model structure above with data on final consumption expenditure shares in the U.S. sourced from the U.S. Input-Output matrix, as described in Appendix A. The elasticity of substitution between broad sectors within

[2]di Giovanni and Levchenko (2010) provide suggestive evidence that at such a coarse level of aggregation, Input-Output matrices are indeed similar across countries. To check robustness of the results, we collected country-specific I-O matrices from the GTAP database. Productivities computed based on country-specific I-O matrices were very similar to the baseline values. In our sample of countries, the median correlation was 0.98, with all but 3 out of 75 countries having a correlation of 0.93 or above, and the minimum correlation of 0.65.

[3]The U.S. I-O matrix provides an alternative way of computing α_j and β_j. These parameters calculated based on the U.S. I-O table are very similar to those obtained from UNIDO, with the correlation coefficients between them above 0.85 in each case. The U.S. I-O table implies greater variability in α_j's and β_j's across sectors than does UNIDO.

[4]Using the variable name conventions in the Penn World Tables, $L_n = 1000 * pop * rgdpch/rgdpwok$.

the tradeable bundle, η, is set to 2. Since these are very large product categories, it is sensible that this elasticity would be relatively low. It is higher, however, than the elasticity of substitution between tradeable and nontradeable goods, which is set to 1 by the Cobb-Douglas assumption.

2.5 Basic Patterns

All of the variables that vary over time are averaged over the period 2005-2007 (the latest available year on which we can implement the quantitative model). To assess the impact of rebalancing we use values of D_n for 2011, which is the latest available year total trade data are available for a large sample of countries. The trade balance D_n is defined as goods exports minus goods imports, and the data to compute trade balances are sourced from the World Bank's World Development Indicators. Appendix Table A1 lists the 20 sectors along with the key parameter values for each sector: α_j, β_j, the share of nontradeable inputs in total inputs $\gamma_{J+1,j}$, and the taste parameter ω_j.

Table 1 reports the sample of Developing Asian countries and their trade balances, both in absolute terms and as a share of each country's GDP. In absolute terms, the largest trade surplus (US$224 bln) belongs to the People's Republic China, and the largest trade deficit (−US$110 bln) to India. Of course, those are the largest countries in absolute terms, and thus their trade balances as a share of GDP (0.03 for People's Republic of China, −0.06 for India) are actually some of the most subdued in this group of countries. Relative to GDP, Kazakhstan and Malaysia have the largest trade surplus (0.22 and 0.16 respectively), and Fiji and Sri Lanka the largest deficit (−0.23 and −0.11).

Table 5 reports the same data for the rest of the sample, broken down by country group/region. As is well-known, the United States has the largest trade deficit in absolute terms (−$711bln), and Germany, the largest trade surplus ($199 bln).

3 Counterfactual: Impact of External Rebalancing

This section traces out the impact of external rebalancing on outcomes in Developing Asia and the rest of the world. We proceed by first solving the model under the baseline values of all the estimated parameters and observed trade imbalances, and present a number of checks on the model fit with respect to observed data. Then, we compute counterfactual welfare and sectoral factor allocations under the assumption that all trade imbalances disappear ($D_n = 0$ for all n). We present the impact of external rebalancing on relative wages, real exchange rates, welfare, as well as the sectoral structure of these countries.

Note that in our framework trade deficits take the form of transfers and thus external rebalancing amounts to simply removing those transfers. The exercise follows the treatments of external rebalancing in Obstfeld and Rogoff (2005) and Dekle, Eaton and Kortum (2007, 2008).

The model is static, and thus does not allow us to think about what the surplus countries are getting in return for running a surplus. Presumably, in the real world they are accumulating foreign assets that they can draw on to raise consumption at some future date. Thus, our welfare comparisons should not be thought of as capturing the full present discounted value of eliminating trade imbalances. Rather, they should be seen as capturing utility from current period consumption, relative to the counterfactual current period consumption in the world without imbalances. Note that while our welfare results are subject to this caveat, predictions about real exchange rates and factor allocations are more straightforward to understand, since both refer to static prices and resource allocations, and thus for those it is not crucial what happens in future periods.

Since the model is static and there is no capital accumulation, our exercise also does not feature the impact of rebalancing on the capital stock. At the extreme, if all trade imbalances were turned into capital stock, then a deficit country would experience not just a static loss of income but also a dynamic loss of capital per worker. It would not be feasible to model this channel in our model, because it cannot be identified empirically how much of the trade deficit in each country is consumed or invested, much less what consumption and investment would have been in the rebalancing counterfactual.

3.1 Model Fit

Table 3 compares the wages, returns to capital, and trade shares in the baseline model and in the data. The top panel shows that mean and median wages implied by the model are very close to the data. The correlation coefficient between model-implied wages and those in the data is 0.99. The second panel performs the same comparison for the return to capital. Since it is difficult to observe the return to capital in the data, we follow the approach adopted in the estimation of T_n^j's and impute r_n from an aggregate factor market clearing condition: $r_n/w_n = (1-\alpha)L_n/(\alpha K_n)$, where α is the aggregate share of labor in GDP, assumed to be 2/3. Once again, the average levels of r_n are very similar in the model and the data, and the correlation between the two is about 0.97.

Next, we compare the trade shares implied by the model to those in the data. The third panel of Table 3 reports the spending on domestically produced goods as a share of overall spending, π_{nn}^j. These values reflect the overall trade openness, with lower values implying higher international trade as a share of absorption. The averages are quite similar, and the correlation between the model and data values is 0.84. Finally, the bottom panel compares the international trade flows in the model and the data. The averages are very close, and the correlation between model and data is nearly 0.75.

We conclude from this exercise that our model matches quite closely the relative incomes of countries as well as bilateral and overall trade flows observed in the data. We now use the model to carry out a number of counterfactual scenarios to assess the impact of external rebalancing.

3.2 Main Results

Table 4 presents the impact of rebalancing in Developing Asia. To ease interpretation, we split that group of countries into those with surpluses and deficits. Conveniently, there are 7 in each group. The table reports the change in the wage (relative to the U.S. wage), the change in the real exchange rate (RER) with respect to the U.S., the change in the trade-weighted real exchange rate, the absolute change in the share of labor employed in the non-tradeable sector, and the percentage change in welfare. The units are in percentage points, with the exception of the change in the labor share, which is expressed in absolute terms.

The RER's are defined as follows. The RER with respect to the United States is the ratio of the price levels:

$$RER_{n,US} = \frac{P_n}{P_{US}}.$$

Thus, by convention, an increase in $RER_{n,US}$ represents a real appreciation for country n. The trade-weighted RER is defined similarly, except that in the denominator is the trade-weighted geometric average of all the countries with whom n trades:

$$RER_{n,tw} = \frac{P_n}{\prod_i P_i^{tw_{ni}}},$$

where tw_{ni} is the share of trade with country i (imports plus exports) in total country n's trade (imports plus exports).

A number of results stand out. The surplus countries experience a large increase in wages relative to the U.S., about 20% on average. The magnitude of the shift in the RER relative to the U.S. is of similar, but somewhat smaller, magnitude. This is to be expected, given that the U.S. is the largest deficit country in the world. As the U.S. is forced to consume less, its labor demand falls, and so do wages.[5]

Interestingly, the appreciation in the trade-weighted RER for the surplus countries in Developing Asia is much more subdued, 1.47% at the median compared to 13.3% for the U.S.-based RER. This is to be expected: much of these countries' trade is with each other, and thus even as

[5]Note that this is not a necessary outcome. Rebalancing in the U.S. requires a shift of domestic factors of production from the non-tradeable to the tradeable sectors. If the tradeable sectors were more labor-intensive than the non-tradeable sectors, this may actually raise labor demand in the U.S., since in that case factors would be reallocating from capital- to labor-intensive sectors. In practice, it is if anything the opposite: tradeable sectors are on average less labor intensive than non-tradeable ones, though the difference is not drastic (Table A1).

they are all appreciating relative to the U.S., their trade-weighted appreciation is much smaller. Republic of Korea and Taipei, China even experience modest RER depreciations.

In all of the surplus countries, external rebalancing leads to an increase in the share of labor employed in the non-tradeable sector, as expected. Now that these countries are not transferring income abroad, domestic demand rises, and with it demand for non-tradeables. The change is modest on average: at the median there is a 4 percentage point increase in the share of labor in the non-tradeable sector. On average in this group of countries, the share of labor in the non-tradeable sector is two-thirds. For People's Republic of China, for instance, the labor share in non-tradeables increases by 3 percentage points.

Finally, the impact of external rebalancing on welfare is much smaller than on either relative wages or RER's. At the median, these countries experience a rise in welfare of 0.41%, 2 orders of magnitude less than the average increase in the relative wage. This is sensible: as these countries' relative wages rise dramatically, so do domestic prices. The net impact is positive (with the sole exception of Republic of Korea), but much smaller than the gross changes in either wages or price levels. Note that our metric for welfare is real factor income (6). Thus, we ignore any direct impact of changes in D_n on consumption.

The bottom half of Table 4 presents the results for the deficit countries in Developing Asia. Starting with the relative wage, for 4 out of 7 countries in this sample the relative wage (compared to the U.S.) actually rises. This is because while these countries do have deficits, the deficit of the United States is still larger. By the similar token, 6 out of 7 of these countries actually experience a real appreciation relative to the United States, even though they also have to close their deficits. The picture becomes much clearer when we move to the trade-weighted exchange rates. By this metric, every single one of these countries experiences a real depreciation, with an average of $6-7\%$.

Predictably, the share of labor devoted to the non-tradeable sector falls in these countries due to the rebalancing. The absolute magnitudes are similar to the surplus countries, but with the opposite sign. Finally, all of the countries in this sample experience a fall in welfare, of about 3% on average. This is a much more sizeable welfare change than for the surplus countries.

Table 2 presents the outcomes of the rebalancing for the rest of the world. For the United States, welfare falls by 0.85%. Looking at the summary statistics across regions, we see that by and large welfare falls due to the rebalancing, which reflects the net trade surplus Asia runs with the rest of the world.

3.2.1 Interpretation

As expected, countries that currently run deficits spend less after the rebalancing, and their welfare falls. Countries with observed surpluses spend more, and their welfare rises. The relationship between welfare changes and the initial trade balance is thus positive, and is depicted in Figure 1. The initial trade balance explains quite well the subsequent welfare change. The correlation between these two for Developing Asia is 0.81. Note that our welfare numbers do not include the direct effect of consuming the trade surplus (see Section 2.3). The positive welfare impact of rebalancing comes from the general equilibrium effect of changes in domestic spending on the demand for factors of production, and thus on real wages and the return to capital.

While changes in domestic spending have an impact on countries, in a world integrated through trade we would also expect changes in the trade balances of one's trading partner to affect welfare. Intuitively, an increase in spending in one's trading partner is expected to stimulate a country's exports and therefore increase the demand for that country's factors of production. It turns out that a country's welfare changes due to global rebalancing are strongly positively correlated with whether it exports mostly to the deficit or to surplus countries. Figure 2 presents a scatterplot of welfare changes on the y-axis against the export-share-weighted deficit of a country's trading partners. That is, if a country exports disproportionately to countries currently running deficits, it will have negative values on the x-axis, and vice versa. There is a pronounced positive relationship: countries exporting mostly to deficit countries tend to experience a fall in welfare, while countries exporting more to surplus countries tend to increase their welfare. The correlation between the two variables is 0.82. This scatterplot demonstrates the importance of multilateral trade relationships for fully understanding the importance of rebalancing.

To be more concrete, we can compare the major export destinations of Sri Lanka and Bangladesh to those of Kazakhstan and Taipei, China. Thirty-seven percent of Sri Lanka's and 30% of Bangladesh's exports go to the U.S. and the U.K., the major deficit countries in the world. Thus, a rebalancing hurts the demand for their exports, and leads to reductions in their welfare. By contrast, 21% of Kazakhstan's and 35% of Taipei, China's exports go to the People's Republic of China, the major trade surplus country. This difference in the identity of the major export destination corresponds well to the difference in the welfare impact of rebalancing in these four countries.

4 Conclusion

Fast-growing countries often run sustained trade surpluses. A natural question going forward is what would be the long-run impact of external rebalancing – narrowing or elimination of trade imbalances – on the economies of Developing Asia and the rest of the world. In this paper, we evaluate this question using a quantitative multi-country, multi-sector model of world production and trade that includes 14 economies of Developing Asia as well as 61 other major economies from the rest of the world.

In our Developing Asia sample, there are 7 surplus countries and 7 deficit ones. For the surplus countries (People's Republic of China, Malaysia, and others), the global external rebalancing brings about a significant rise in relative wages, a real appreciation, an increase in the size of the non-traded sector, and an increase in welfare of a fraction of a percent on average. For the deficit countries, the impacts are the opposite: a real depreciation, a shrinking of the non-traded sector, and a $2-3\%$ reduction in welfare. We show that multilateral trade relationships are important for developing the full account of the impact of global rebalancing: countries currently exporting mostly to deficit countries tend to lose from rebalancing, whereas countries exporting to the surplus countries tend to gain in welfare.

Appendix A Procedure for Estimating T_n^j, d_{ni}^j, and ω_j

This appendix reproduces from Levchenko and Zhang (2011) the details of the procedure for estimating technology, trade costs, and taste parameters required to implement the model. Interested readers should consult that paper for further details on estimation steps and data sources.

A.1 Tradeable Sector Relative Technology

We now focus on the tradeable sectors. Following the standard EK approach, first divide trade shares by their domestic counterpart:

$$\frac{\pi_{ni}^j}{\pi_{nn}^j} = \frac{X_{ni}^j}{X_{nn}^j} = \frac{T_i^j \left(c_i^j d_{ni}^j\right)^{-\theta}}{T_n^j \left(c_n^j\right)^{-\theta}},$$

which in logs becomes:

$$\ln\left(\frac{X_{ni}^j}{X_{nn}^j}\right) = \ln\left(T_i^j (c_i^j)^{-\theta}\right) - \ln\left(T_n^j (c_n^j)^{-\theta}\right) - \theta \ln d_{ni}^j.$$

Let the (log) iceberg costs be given by the following expression:

$$\ln d_{ni}^j = d_k^j + b_{ni}^j + CU_{ni}^j + RTA_{ni}^j + ex_i^j + \nu_{ni}^j,$$

where d_k^j is an indicator variable for a distance interval. Following EK, we set the distance intervals, in miles, to [0, 350], [350, 750], [750, 1500], [1500, 3000], [3000, 6000], [6000, maximum). Additional variables are whether the two countries share a common border (b_{ni}^j), belong to a currency union (CU_{ni}^j), or to a regional trade agreement (RTA_{ni}^j). Following the arguments in Waugh (2010), we include an exporter fixed effect ex_i^j. Finally, there is an error term ν_{ni}^j. Note that all the variables have a sector superscript j: we allow all the trade cost proxy variables to affect true iceberg trade costs d_{ni}^j differentially across sectors. There is a range of evidence that trade volumes at sector level vary in their sensitivity to distance or common border (see, among many others, Do and Levchenko 2007, Berthelon and Freund 2008).

This leads to the following final estimating equation:

$$\ln\left(\frac{X_{ni}^j}{X_{nn}^j}\right) = \underbrace{\ln\left(T_i^j (c_i^j)^{-\theta}\right) - \theta ex_i^j}_{\text{Exporter Fixed Effect}} \underbrace{- \ln\left(T_n^j \left(c_n^j\right)^{-\theta}\right)}_{\text{Importer Fixed Effect}}$$
$$\underbrace{-\theta d_k^j - \theta b_{ni}^j - \theta CU_{ni}^j - \theta RTA_{ni}^j}_{\text{Bilateral Observables}} \underbrace{-\theta \nu_{ni}^j}_{\text{Error Term}}.$$

This equation is estimated for each tradeable sector $j = 1, ...J$. Estimating this relationship will thus yield, for each country, an estimate of its technology-cum-unit-cost term in each sector j, $T_n^j(c_n^j)^{-\theta}$, which is obtained by exponentiating the importer fixed effect. The available degrees of freedom imply that these estimates are of each country's $T_n^j(c_n^j)^{-\theta}$ relative to a reference country, which in our estimation is the United States. We denote this estimated value by S_n^j:

$$S_n^j = \frac{T_n^j}{T_{us}^j}\left(\frac{c_n^j}{c_{us}^j}\right)^{-\theta},$$

where the subscript us denotes the United States. It is immediate from this expression that estimation delivers a convolution of technology parameters T_n^j and cost parameters c_n^j. Both will of course affect trade volumes, but we would like to extract technology T_n^j from these estimates. In order to do that, we follow the approach of Shikher (2004). In particular, for each country n, the share of total spending going to home-produced goods is given by

$$\frac{X_{nn}^j}{X_n^j} = T_n^j\left(\frac{\Gamma c_n^j}{p_n^j}\right)^{-\theta}.$$

Dividing by its U.S. counterpart yields:

$$\frac{X_{nn}^j/X_n^j}{X_{us,us}^j/X_{us}^j} = \frac{T_n^j}{T_{us}^j}\left(\frac{c_n^j}{c_{us}^j}\frac{p_{us}^j}{p_n^j}\right)^{-\theta} = S_n^j\left(\frac{p_{us}^j}{p_n^j}\right)^{-\theta},$$

and thus the ratio of price levels in sector j relative to the U.S. becomes:

$$\frac{p_n^j}{p_{us}^j} = \left(\frac{X_{nn}^j/X_n^j}{X_{us,us}^j/X_{us}^j}\frac{1}{S_n^j}\right)^{\frac{1}{\theta}}. \tag{A.1}$$

The entire right-hand side of this expression is either observable or estimated. Thus, we can impute the price levels relative to the U.S. in each country and each tradeable sector.

The cost of the input bundles relative to the U.S. can be written as:

$$\frac{c_n^j}{c_{us}^j} = \left(\frac{w_n}{w_{us}}\right)^{\alpha_j\beta_j}\left(\frac{r_n}{r_{us}}\right)^{(1-\alpha_j)\beta_j}\left(\prod_{k=1}^{J}\left(\frac{p_n^k}{p_{us}^k}\right)^{\gamma_{k,j}}\right)^{1-\beta_j}\left(\frac{p_n^{J+1}}{p_{us}^{J+1}}\right)^{\gamma_{J+1,j}(1-\beta_j)}.$$

Using information on relative wages, returns to capital, price in each tradeable sector from (A.1), and the nontradeable sector price relative to the U.S., we can thus impute the costs of the input bundles relative to the U.S. in each country and each sector. Armed with those values, it is straightforward to back out the relative technology parameters:

$$\frac{T_n^j}{T_{us}^j} = S_n^j \left(\frac{c_n^j}{c_{us}^j} \right)^{\theta}.$$

A.2 Trade Costs

The bilateral, directional, sector-level trade costs of shipping from country i to country n in sector j are then computed based on the estimated coefficients as:

$$\ln \hat{d}_{ni}^j = \theta \hat{d}_k^j + \theta \hat{b}_{ni}^j + \theta \widehat{CU}_{ni}^j + \theta \widehat{RTA}_{ni}^j + \theta \widehat{ex}_i^j + \theta \widehat{\nu}_{ni}^j,$$

for an assumed value of θ. Note that the estimate of the trade costs includes the residual from the gravity regression $\theta \widehat{\nu}_{ni}^j$. Thus, the trade costs computed as above will fit bilateral sectoral trade flows exactly, given the estimated fixed effects. Note also that the exporter component of the trade costs $\widehat{ex}_i^j$ is part of the exporter fixed effect. Since each country in the sample appears as both an exporter and an importer, the exporter and importer estimated fixed effects are combined to extract an estimate of $\theta \widehat{ex}_i^j$.

A.3 Complete Estimation

So far we have estimated the levels of technology of the tradeable sectors relative to the United States. To complete our estimation, we still need to find (i) the levels of T for the tradeable sectors in the United States; (ii) the taste parameters ω_j, and (iii) the nontradeable technology levels for all countries.

To obtain (i), we use the NBER-CES Manufacturing Industry Database for the U.S. (Bartelsman and Gray 1996). We start by measuring the observed TFP levels for the tradeable sectors in the U.S.. The form of the production function gives

$$\ln Z_{us}^j = \ln \Lambda_{us}^j + \beta_j \alpha_j \ln L_{us}^j + \beta_j (1 - \alpha_j) \ln K_{us}^j + (1 - \beta_j) \sum_{k=1}^{J+1} \gamma_{k,j} \ln M_{us}^{k,j}, \quad \text{(A.2)}$$

where Λ^j denotes the measured TFP in sector j, Z^j denotes the output, L^j denotes the labor input, K^j denotes the capital input, and $M^{k,j}$ denotes the intermediate input from sector k. The NBER-CES Manufacturing Industry Database offers information on output, and inputs of labor, capital, and intermediates, along with deflators for each. Thus, we can estimate the observed TFP level for each manufacturing tradeable sector using the above equation.

If the United States were a closed economy, the observed TFP level for sector j would be given by $\Lambda_{us}^j = (T_{us}^j)^{\frac{1}{\theta}}$. In the open economies, the goods with inefficient domestic productivity draws will not be produced and will be imported instead. Thus, international trade and competition introduce selection in the observed TFP level, as demonstrated by Finicelli, Pagano and Sbracia (2012). We thus use the model to back out the true level of T_{us}^j of each tradeable sector in the United States. Here we follow Finicelli et al. (2012) and use the following relationship:

$$(\Lambda_{us}^j)^\theta = T_{us}^j + \sum_{i \neq us} T_i^j \left(\frac{c_i^j d_{us,i}^j}{c_{us}^j} \right)^{-\theta}.$$

Thus, we have

$$(\Lambda_{us}^j)^\theta = T_{us}^j \left[1 + \sum_{i \neq us} \frac{T_i^j}{T_{us}^j} \left(\frac{c_i^j d_{us,i}^j}{c_{us}^j} \right)^{-\theta} \right] = T_{us}^j \left[1 + \sum_{i \neq us} S_i^j \left(d_{us,i}^j \right)^{-\theta} \right]. \qquad \text{(A.3)}$$

This equation can be solved for underlying technology parameters T_{us}^j in the U.S., given estimated observed TFP Λ_{us}^j, and all the S_i^j's and $d_{us,i}^j$'s estimated in the previous subsection.

To estimate the taste parameters $\{\omega_j\}_{j=1}^J$, we use information on final consumption shares in the tradeable sectors in the U.S.. We start with a guess of $\{\omega_j\}_{j=1}^J$ and find sectoral prices p_n^k as follows. For an initial guess of sectoral prices, we compute the tradeable sector aggregate price and the nontradeable sector price using the data on the relative prices of nontradeables to tradeables. Using these prices, we calculate sectoral unit costs and Φ_n^j's, and update prices according to equation (3), iterating until the prices converge. We then update the taste parameters according to equation (5), using the data on final sectoral expenditure shares in the U.S.. We normalize the vector of ω_j's to have a sum of one, and repeat the above procedure until the values for the taste parameters converge.

Finally, we estimate the nontradeable sector TFP using the relative prices. In the model, the nontradeable sector price is given by

$$p_n^{J+1} = \Gamma (T_n^{J+1})^{-\frac{1}{\theta}} c_n^{J+1}.$$

Since we know the aggregate price level in the tradeable sector p_n^T, c_n^{J+1}, and the relative price of nontradeables (which we take from the data), we can back out T_n^{J+1} from the equation above for all countries.

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Table 1. Developing Asia: Country Sample and Deficits

Country	3-Letter Code	Trade Balance	
		US$ billion	Share of GDP
Bangladesh	BAN	-7.31	-0.07
Fiji	FIJ	-0.79	-0.23
India	IND	-110.54	-0.06
Indonesia	INO	31.07	0.04
Kazakhstan	KAZ	37.25	0.22
Malaysia	MAL	42.49	0.16
Pakistan	PAK	-12.35	-0.06
People's Republic of China	PRC	223.70	0.03
Philippines	PHI	-15.03	-0.07
Republic of Korea	KOR	29.35	0.03
Sri Lanka	SRI	-5.75	-0.11
Taipei China	TAP	21.26	0.05
Thailand	THA	20.74	0.06
Viet Nam	VIE	-3.94	-0.03

Notes: This table reports the trade balances in billion US$ and as a share of GDP for the Developing Asia region, as well as the 3-letter codes used to denote the countries.

Table 2. Rest of the World: Country Sample and Deficits

Country	3-Letter Code	Trade Balance US$ billion	Trade Balance Share of GDP	Country	3-Letter Code	Trade Balance US$ billion	Trade Balance Share of GDP
OECD				Latin America and Caribbean			
Australia	AUS	20.31	0.02	Argentina	ARG	12.79	0.03
Austria	AUT	-4.89	-0.01	Bolivia	BOL	1.00	0.05
Belgium-Luxembourg	BLX	-12.23	-0.02	Brazil	BRA	22.09	0.01
Canada	CAN	-10.56	-0.01	Chile	CHL	12.13	0.05
Denmark	DNK	8.61	0.03	Colombia	COL	3.21	0.01
Finland	FIN	5.75	0.02	Costa Rica	CRI	-6.25	-0.16
France	FRA	-82.75	-0.03	Ecuador	ECU	-1.10	-0.02
Germany	DEU	198.81	0.06	El Salvador	SLV	-4.48	-0.20
Greece	GRC	-38.31	-0.13	Guatemala	GTM	-4.78	-0.11
Iceland	ISL	0.85	0.06	Honduras	HND	-4.13	-0.25
Ireland	IRL	56.88	0.27	Mexico	MEX	-6.37	-0.01
Italy	ITA	-29.50	-0.01	Peru	PER	8.10	0.05
Japan	JPN	42.20	0.01	Trinidad and Tobago	TTO	4.62	0.21
Netherlands	NLD	53.60	0.07	Uruguay	URY	-1.08	-0.03
New Zealand	NZL	2.12	0.01	Venezuela RB	VEN	35.82	0.10
Norway	NOR	60.58	0.13				
Portugal	PRT	-23.35	-0.10	Middle East and North Africa			
Spain	ESP	-63.57	-0.04				
Sweden	SWE	12.05	0.02	Egypt Arab Rep.	EGY	-20.24	-0.09
Switzerland	CHE	24.33	0.04	Iran Islamic Rep.	IRN	48.03	
United Kingdom	GBR	-163.53	-0.07	Israel	ISR	-5.61	-0.02
United States	USA	-711.41	-0.05	Jordan	JOR	-7.96	-0.29
				Kuwait	KWT	64.24	0.43
Central and Eastern Europe				Saudi Arabia	SAU	196.47	0.38
				Turkey	TUR	-74.93	-0.10
Bulgaria	BGR	-3.67	-0.07				
Czech Republic	CZE	1.71	0.01	Sub-Saharan Africa			
Hungary	HUN	2.95	0.02				
Poland	POL	-15.41	-0.03	Ethiopia	ETH	-5.16	-0.18
Romania	ROM	-12.96	-0.07	Ghana	GHA	-3.17	-0.09
Russian Federation	RUS	167.14	0.10	Kenya	KEN	-7.42	-0.23
Slovak Republic	SVK	0.79	0.01	Mauritius	MUS	-2.13	-0.20
Slovenia	SVN	-1.51	-0.03	Nigeria	NGA	29.68	0.13
Ukraine	UKR	-14.64	-0.10	Senegal	SEN	-1.97	-0.15
				South Africa	ZAF	1.93	0.00
				Tanzania	TZA	-3.87	-0.17

Notes: Notes: This table reports the trade balances in billion US$ and as a share of GDP for countres in our sample that are outside the Developing Asia region, as well as the 3-letter codes used to denote the countries.

Table 3. The Fit of the Baseline Model with the Data

		model	data
Wages:			
	mean	0.407	0.413
	median	0.147	0.154
	corr(model, data)	*0.990*	
Return to capital:			
	mean	0.966	1.074
	median	0.757	0.758
	corr(model, data)	*0.947*	
π_{nn}^j			
	mean	0.586	0.565
	median	0.631	0.607
	corr(model, data)	*0.839*	
π_{ni}^j, $i \neq n$			
	mean	0.006	0.006
	median	0.0002	0.0002
	corr(model, data)	*0.747*	

Notes: This table reports the means and medians of wages relative to the U.S. (top panel); return to capital relative to the U.S. (second panel), share of domestically produced goods in overall spending (third panel), and share of goods from country i in overall spending (bottom panel) in the model and in the data. Wages and return to capital in the data are calculated as described in Appendix A.

Table 4. Developing Asia: Impact of External Rebalancing

	(1)	(2)	(3)	(4)	(5)
	Δw_n	ΔRER (wrt US)	ΔRER (trade-weighted)	Δ Share of L_n in NT	Δ Welfare
Surplus Countries					
Indonesia	17.47	13.33	1.48	0.04	0.07
Kazakhstan	71.36	36.45	25.25	0.36	1.36
Malaysia	25.57	15.69	4.67	0.14	1.88
People's Republic of China	16.67	12.87	1.39	0.03	0.34
Republic of Korea	14.11	11.57	-2.24	0.01	-0.03
Taipei, China	16.22	12.25	-0.14	0.03	0.46
Thailand	18.72	13.78	1.47	0.05	0.41
Mean	25.73	16.56	4.56	0.10	0.64
Median	17.47	13.33	1.47	0.04	0.41
Deficit Countries					
Bangladesh	6.80	8.34	-1.65	-0.03	-2.57
Fiji	-1.84	4.27	-5.55	-0.08	-4.58
India	-0.25	1.17	-12.63	-0.04	-1.78
Pakistan	6.31	8.26	-8.29	-0.03	-2.86
Philippines	5.09	5.80	-5.97	-0.03	-1.34
Sri Lanka	-12.13	-1.99	-10.46	-0.16	-8.14
Viet Nam	7.18	8.02	-2.25	-0.02	-1.98
Mean	1.59	4.84	-6.68	-0.06	-3.32
Median	5.09	5.80	-5.97	-0.03	-2.57

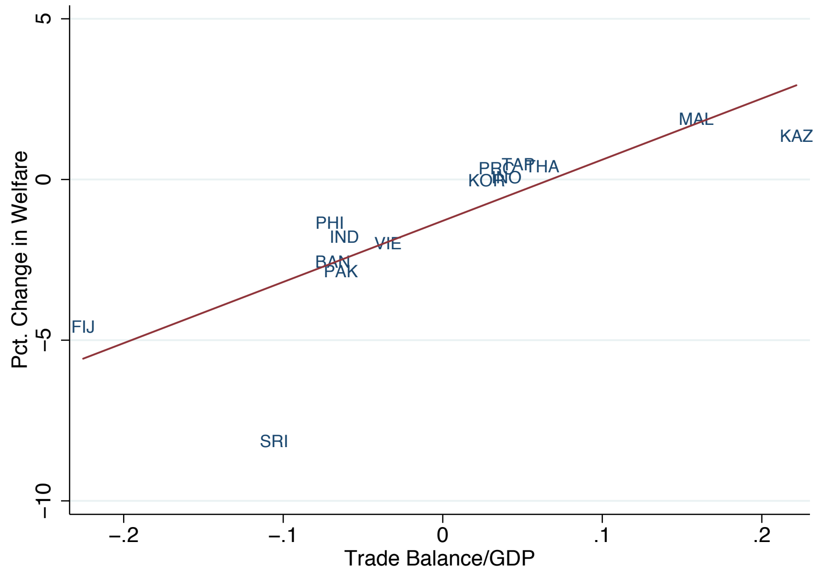
Notes: Units are in percentage points, with the exception of column (2), which is the absolute change in the share of Labor in the non-tradeable sector. This table reports the changes in wages (relative to the U.S., the real exchange rate (both relative to the U.S. price level and trade-weighted, the absolute change in the share of labor in the non-tradeable sector, and the change in welfare, due to the closing of trade imbalances world-wide.

Table 5. Rest of the World: Impact of External Rebalancing

	(1) Δw_n	(2) ΔRER (wrt US)	(3) ΔRER (trade-weighted)	(4) Δ Share of L_n in NT	(5) Δ Welfare
OECD					
Australia	16.88	12.92	2.15	0.02	0.41
Austria	10.71	8.96	-1.88	-0.01	-0.23
Belgium-Luxembourg	9.36	8.17	-1.65	-0.01	-0.43
Canada	5.89	4.26	0.27	-0.00	-0.27
Denmark	14.82	11.69	1.03	0.01	0.12
Finland	14.29	11.54	-1.26	0.01	0.04
France	7.48	6.34	-3.63	-0.01	-0.38
Germany	16.00	12.25	2.20	0.02	0.36
Greece	-11.14	-6.64	-17.30	-0.07	-3.40
Iceland	17.63	13.52	2.13	0.02	0.40
Ireland	33.55	20.29	12.82	0.15	1.71
Italy	9.41	7.82	-2.36	-0.01	-0.28
Japan	13.41	11.03	-1.81	0.00	-0.04
Netherlands	18.37	13.40	2.49	0.03	0.59
New Zealand	13.75	10.87	-0.79	0.01	-0.02
Norway	26.27	18.36	8.61	0.07	1.22
Portugal	-3.11	-1.13	-9.36	-0.05	-1.84
Spain	4.17	3.96	-5.79	-0.02	-0.79
Sweden	14.43	11.61	0.23	0.01	0.05
Switzerland	16.08	12.39	2.56	0.03	0.25
United Kingdom	4.61	4.66	-5.07	-0.02	-0.99
United States	0.00	0.00	-9.54	-0.03	-0.85
Mean	11.49	8.92	-1.18	0.01	-0.20
Median	13.58	10.95	-1.02	0.01	-0.03
Central and Eastern Europe					
Bulgaria	-2.32	1.87	-6.97	-0.09	-3.12
Czech Republic	12.86	10.26	-0.44	0.01	0.04
Hungary	13.71	10.64	0.08	0.01	0.20
Poland	7.97	7.54	-3.41	-0.02	-0.73
Romania	4.40	5.18	-4.31	-0.04	-1.31
Russian Federation	48.20	30.07	18.58	0.15	1.24
Slovak Republic	12.91	10.27	-0.56	0.01	0.07
Slovenia	9.08	7.92	-1.79	-0.02	-0.41
Ukraine	-3.84	3.44	-11.86	-0.10	-5.08
Mean	11.44	9.69	-1.19	-0.01	-1.01
Median	9.08	7.92	-1.79	-0.02	-0.41
Latin America and Caribbean					
Argentina	16.43	11.78	1.33	0.02	0.67
Bolivia	13.03	10.70	0.20	0.01	0.41
Brazil	14.20	11.32	0.11	0.01	0.13
Chile	17.15	12.25	2.98	0.03	0.80
Colombia	12.71	9.84	3.30	0.01	0.09
Costa Rica	-17.65	-9.17	-12.48	-0.12	-6.78
Ecuador	8.91	7.75	0.43	-0.01	-0.60
El Salvador	-4.84	-1.20	-2.23	-0.09	-3.41
Guatemala	-21.90	-11.24	-14.43	-0.14	-8.75
Honduras	-13.93	-3.87	-5.57	-0.16	-7.98
Mexico	5.93	4.44	0.96	-0.00	-0.49
Peru	22.83	15.40	6.43	0.07	1.20
Trinidad and Tobago	42.53	22.05	15.67	0.14	1.63
Uruguay	6.83	7.02	-4.02	-0.03	-1.06
Venezuela, RB	51.46	25.05	19.67	0.20	1.91
Mean	10.25	7.48	0.82	-0.00	-1.48
Median	12.71	9.84	0.43	0.01	0.09
Middle East and North Africa					
Egypt, Arab Rep.	-4.06	3.54	-8.03	-0.08	-5.55
Iran, Islamic Rep.	52.80	37.61	25.26	0.16	0.82
Israel	6.10	5.34	-1.42	-0.02	-0.68
Jordan	-27.74	-5.33	-23.57	-0.21	-18.50
Kuwait	62.02	34.61	22.50	0.37	2.27
Saudi Arabia	474.96	94.41	79.80	4.60	-34.55
Turkey	-2.90	1.69	-9.61	-0.09	-3.68
Mean	80.17	24.55	12.13	0.68	-8.55
Median	6.10	5.34	-1.42	-0.02	-3.68
Sub-Saharan Africa					
Ethiopia	7.59	10.73	-5.77	-0.03	-3.90
Ghana	6.73	7.51	-4.06	-0.03	-1.60
Kenya	1.21	2.02	-9.71	-0.03	-1.68
Mauritius	-12.99	-5.25	-11.59	-0.13	-6.33
Nigeria	76.01	52.98	43.97	0.26	0.39
Senegal	6.62	7.08	-4.18	-0.02	-1.62
South Africa	12.40	10.11	-2.05	0.00	-0.04
Tanzania	-9.77	-2.06	-10.63	-0.07	-6.67
Mean	10.98	10.39	-0.50	-0.00	-2.68
Median	6.68	7.29	-4.98	-0.03	-1.65

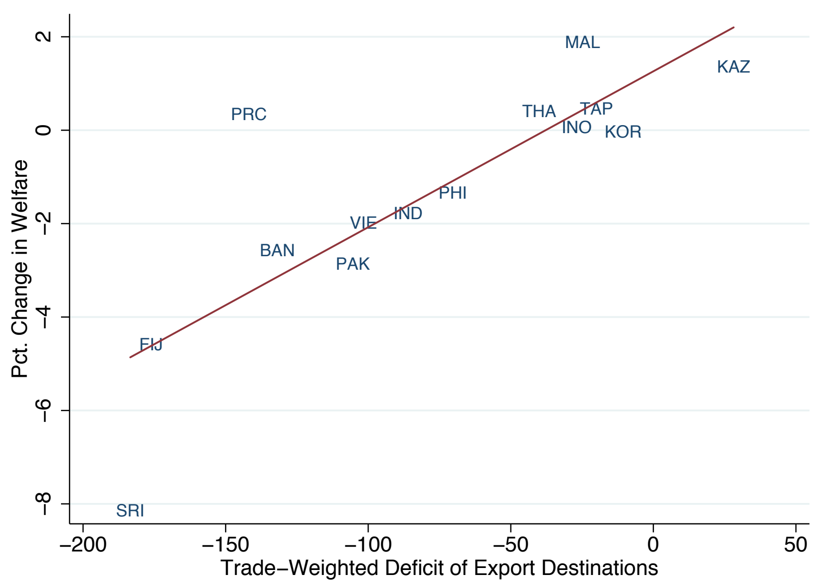
Notes: Units are in percentage points, with the exception of column (2), which is the absolute change in the share of Labor in the non-tradeable sector. This table reports the changes in wages (relative to the U.S., the real exchange rate (both relative to the U.S. price level and trade-weighted, the absolute change in the share of labor in the non-tradeable sector, and the change in welfare, due to the closing of trade imbalances world-wide.

Figure 1. Developing Asia: Initial Trade Balances and Change in Welfare



Notes: This figure displays the welfare gains to Developing Asian countries from external rebalancing against their trade balance as a share of GDP, along with the least-squares fit.

Figure 2. Developing Asia: Trade Imbalances in Export Destinations and Change in Welfare



Notes: This figure displays the welfare gains to Developing Asian countries from external rebalancing against the export-share weighted trade imbalances of their trading partners, along with the least-squares fit. The units on the x-axis are billions US$.

Table A1. Sectors

ISIC code	Sector Name	α_j	β_j	$\gamma_{J+1,j}$	ω_j
15	Food and Beverages	0.290	0.290	0.303	0.169
16	Tobacco Products	0.272	0.490	0.527	0.014
17	Textiles	0.444	0.368	0.295	0.019
18	Wearing Apparel, Fur	0.468	0.369	0.320	0.109
19	Leather, Leather Products, Footwear	0.469	0.350	0.330	0.015
20	Wood Products (Excl. Furniture)	0.455	0.368	0.288	0.008
21	Paper and Paper Products	0.351	0.341	0.407	0.012
22	Printing and Publishing	0.484	0.453	0.407	0.005
23	Coke, Refined Petroleum Products, Nuclear Fuel	0.248	0.246	0.246	0.141
24	Chemical and Chemical Products	0.297	0.368	0.479	0.009
25	Rubber and Plastics Products	0.366	0.375	0.350	0.014
26	Non-Metallic Mineral Products	0.350	0.448	0.499	0.073
27	Basic Metals	0.345	0.298	0.451	0.002
28	Fabricated Metal Products	0.424	0.387	0.364	0.013
29C	Office, Accounting, Computing, and Other Machinery	0.481	0.381	0.388	0.051
31A	Electrical Machinery, Communication Equipment	0.369	0.368	0.416	0.022
33	Medical, Precision, and Optical Instruments	0.451	0.428	0.441	0.038
34A	Transport Equipment	0.437	0.329	0.286	0.220
36	Furniture and Other Manufacturing	0.447	0.396	0.397	0.065
4A	Nontradeables	0.561	0.651	0.788	
	Mean	0.400	0.385	0.399	0.053
	Min	0.248	0.246	0.246	0.002
	Max	0.561	0.651	0.788	0.220

Notes: This table reports the sectors used in the analysis. The classification corresponds to the ISIC Revision 3 2-digit, aggregated further due to data availability. α_j is the value-added based labor intensity; β_j is the share of value added in total output; $\gamma_{J+1,j}$ is the share of nontradeable inputs in total intermediate inputs; ω_j is the taste parameter for tradeable sector j, estimated using the procedure described in Section A.3. Variable definitions and sources are described in detail in the text.