IMF Publication

Exchange Rates and Trade Balance Adjustment in Emerging Market Economies

INTERNATIONAL MONETARY FUND

INTERNATIONAL MONETARY FUND

Exchange Rates and Trade Balance Adjustment in Emerging Market Economies

Prepared by the Policy Development and Review Department

In collaboration with the Research Department and in consultation with other Departments

Approved by Mark Allen

October 10, 2006

Contents Page

I. Introduction 4

II. The Analytics of Trade Balance Adjustment 8

III. Country Classification and Estimation Strategy 13

IV. Empirical Results 16
A. Exports 16
B. Imports 20
C. Model Fit 22
D. Trade Balance 22

V. Conclusions 28

References 41

Boxes
1. Trade Equations 9
2. Marshall-Lerner Redux 12
3. Tracking Trade Developments during Capital Account Crises 24

Tables
1. Export Volumes: Coefficient Estimates and Implied Elasticities 17
2. Pricing Equation for Manufacturing Exporters: Coefficient Estimates and Implied Elasticities 19
3. Inflation Rate: Coefficient Estimates and Implied Elasticities (post-1994) 20
4. Import Volumes and Absorption Impact: Coefficient Estimates and Implied Elasticities ..21
5. Effects of Devaluations on Export-Import Values and on the Trade Balance 23

Figures

1. Price Deflators, 1980−2005 15
2. Profiles for Exports, Imports, and Trade Balances 26
3. Effect of a Depreciation on the Trade Balance 27

Appendices

I. Overview of the Empirical Literature on Trade Volume Price Elasticities
and Pricing to Market 29
II. Data Description and Sample 33
III. Robustness Tests 35
IV. Estimation Procedures 38

EXECUTIVE SUMMARY

Estimates of the impact of exchange rate movements on the trade balance are central to the Fund's surveillance and program design work. This paper examines the impact of nominal exchange rate movements on the trade balance in a panel of 46 (mostly) middle-income and emerging market countries over the period 1980−2005.

The paper finds that simple econometric specifications yield surprising rich and complex dynamics—relative prices respond to the nominal exchange rate and pass-through effects, import and export volumes respond to relative price changes, and the trade balance responds to changes in import and export values. Within the inherent limitations of the partial equilibrium nature of the "trade elasticities" approach being used, and of assessing responses that ultimately depend on the deviation that initially exists between the real exchange rate and its equilibrium level, as well as the usual econometric caveats, key results include:

- The impact of exchange rate movements on the U.S. dollar value of exports depends crucially on the nature of the country's predominant export—manufactures, non-oil commodities, or oil. Regarding imports, in addition to the direct impact through relative prices, a nominal exchange rate movement may affect imports via wealth and balance sheet effects on domestic absorption.

- Taking account of these various channels and dynamics, the econometric estimates suggest that for a country with an initial trade balance and an export-to-GDP ratio of 40 percent, a 10 percent permanent nominal exchange rate depreciation would improve the trade balance by 1½ to 2 percent of GDP over the medium term depending on the class of exporter, with most of the movement occurring within the first 3 to 5 years.

- The elasticity of export values tend to be small, so most of the response of the trade balance comes from the behavior of imports. For countries that need an exchange rate depreciation to narrow an unsustainable deficit, this implies that the adjustment will come through a combination of expenditure switching and expenditure reduction, including through wealth and balance sheet effects of an exchange rate depreciation. For a country with large trade surpluses, an appreciation will have some impact on reducing that surplus—but mainly by increasing the country's imports rather than reducing its exports.

- Given the larger (negative) price elasticity of imports compared to exports, a condition akin to the Marshall-Lerner condition governs whether a nominal exchange rate depreciation (appreciation) will improve (respectively, deteriorate) the trade balance measured in foreign currency terms of a country that is small in its import markets but large—i.e. faces a downward-sloping demand curve—in its key export markets. The larger the initial trade surplus, the less likely that this condition will be fulfilled—or at least the smaller the deterioration of the trade balance in response to an exchange rate appreciation.

I. INTRODUCTION[1]

1. Among the central questions for the work of the Fund is the role of the exchange rate in external adjustment. For program design, it is often necessary to calculate the exchange rate correction required to reestablish external viability. Estimates of the effects of exchange rate movements on the external balance may also be required in surveillance contexts—for instance, to determine the configuration of multilateral exchange rates consistent with reducing global imbalances, or to help ensure that effective balance of payments adjustment is not being vitiated through exchange rate manipulation.[2] Such estimates may also have a useful bearing on current efforts to extend CGER-type analysis to emerging market countries.[3]

2. While there is an extensive academic literature on estimating "trade equations" (Appendix I), most studies focus on specific goods, or on imports, or on exports (but not both), making it difficult to infer the impact on the *aggregate* trade balance. Yet, from a macroeconomic perspective, it is this aggregate effect that is of importance. Moreover, most studies are based on the experience of advanced countries or on large samples of developing countries; few focus on emerging market countries. To help fill this gap, this paper examines the impact of exchange rate movements on the balance of trade in goods and non-factor services (hereafter, the "trade balance").[4] The results are based on a panel of 46 (mostly) middle-income countries over the period 1980−2005.

3. Beyond its sample coverage, the analysis in this paper offers three innovations relative to the existing literature. First, it articulates—and seeks to quantify—the various channels through which a given movement of the exchange rate can affect the aggregate trade balance. Second, countries are classified according to their predominant export—oil, non-oil commodities, or manufactures—to allow for differences in the response of the trade balance to exchange rate movements that might arise from the structure of the country's exports. Third, in considering the impact of a nominal exchange rate change on the trade balance, the analysis takes account of the endogenous dynamics of domestic prices and costs as well as the effect on imports arising from balance sheet and wealth effects on aggregate demand. Throughout this paper the emphasis is on the foreign currency value of the trade balance, as opposed to the literature's traditional focus on the domestic currency trade

---

[1] This paper was prepared by a staff team headed by Atish Ghosh and comprising Alun Thomas, Juan Zalduendo, Luis Catão, Bikas Joshi, Uma Ramakrishnan, and Lupin Rahman, under the supervision of Carlo Cottarelli, Deputy Director of the Policy Development and Review Department, and the general guidance of Mark Allen, Director of the Policy Development and Review Department. The staff team was assisted by Olivia Carolin, Barbara Dabrowska, and Siba Das.

[2] See *Surveillance Over Exchange Rates* Decision No. 5392-(77/63), April 29, 1977, as amended.

[3] CGER stands for Consultative Group on Exchange Rates.

[4] The effect of exchange rate changes on factor services and transfers is not examined in this paper. This effect would need to be added to fully assess the role of exchange rate changes in external adjustment.

balance, in part because the focus here is on the external viability of emerging market economies that typically borrow in foreign currencies.

4. One drawback of trade equations is that they seem to suggest that there is no role for monetary or fiscal policies in the adjustment process. However, the trade elasticities approach can be readily reconciled with models that emphasize the role of macroeconomic policies (such as fiscal consolidation) in external adjustment by recognizing the partial equilibrium nature of the analysis. In particular, trade elasticities yield the impact on the trade balance of a *given* movement of the nominal exchange rate—without asking how that exchange rate movement comes about. Under a pegged exchange rate regime, the exchange rate parity is a policy choice (at least in the short run; in the longer run, the viability of the peg will depend on the consistency of macroeconomic policies). More generally, under flexible regimes, the exchange rate is an endogenous variable, and part of the impact of monetary and fiscal policies on the trade balance will be *via* the effect on the exchange rate (or on economic activity).[5] Although this paper examines the impact of a change in the nominal exchange rate on the trade balance, it does so while abstracting from the policies (and other shocks) that bring about an exchange rate movement. Typically, the macroeconomic policies that cause the exchange rate change will also have direct effects on the trade balance, and may also lead to different responses of the trade balance to exchange rate movements, but these channels are not considered in this paper. A further caveat concerns the use of aggregate trade data. While useful for identifying macroeconomic effects, such data cannot control for changes in the composition of firms in response to relative price movements and are subject to problems of endogeneity because of the difficulty of finding good instruments. Moreover, exchange rate movements may have long-term implications for firms' production and location decisions that are difficult to capture with aggregate data. More generally, there may be "endogenous growth effects" whereby a depreciation increases exports and the long-run productivity and growth, which are not considered here.

5. With these caveats in mind, how does a permanent change in the nominal exchange rate—for concreteness, a depreciation—affect the trade balance? Clearly, a permanent nominal depreciation will have an immediate impact on the prices of imports and of exports, but it will also set in motion domestic price and cost dynamics—so there will not be a fully corresponding permanent movement of the real exchange rate. Over time, the effect of the exchange rate on relative prices of imports and exports (relative to foreign competitors or non-traded goods) diminishes, though this also depends on the deviation that might initially exist between the real exchange rate and its equilibrium level. In the meantime, however, the movement of relative prices should induce changes in the volume of exports and of imports. Therefore, whether the long-run effect is larger or smaller than the immediate impact

---

[5] For instance, in the Mundell-Fleming model, under a pegged exchange rate, a fiscal expansion elicits a capital inflow and monetary expansion, stimulating economic activity and thus deteriorating the trade balance. Under a floating exchange rate regime, the fiscal expansion leads to an appreciation of the exchange rate and a deterioration in the trade balance (though no impact on activity, as the increase in government spending fully crowds out net exports).

depends on the relative magnitudes of two opposing forces: the speed at which the volume elasticities rise in the long run as consumers and producers have greater scope for substitution, and the speed at which relative prices return to their initial values (assuming that the economy was initially in equilibrium) which would tend to dampen long-run volume changes.

6. The effect on the foreign currency value of exports depends on the structure of the country's exports. For a country that mainly exports commodities (for which demand is more likely to be fully elastic at the given world price), the exchange rate depreciation does not change export prices measured in foreign currency (e.g., the U.S. dollar) terms, but may induce a positive supply response by raising the domestic currency price of exports relative to non-traded goods. Since dollar prices remain constant, and volumes increase, the foreign currency value of exports should rise as well.

7. By contrast, for countries that predominantly export manufactures (or other differentiated products whose demand is likely to be downward sloping), the nominal exchange rate depreciation might encourage firms to take advantage of the currency depreciation to raise market share by allowing the foreign currency price to fall; if so, this will elicit higher demand. However, even if there is a positive supply response, the decline in the dollar price means that the net effect on the value of exports is, at least theoretically, ambiguous.

8. Turning to imports, assuming the country is "small" in the market for its imports, the depreciation (and consequent volume response) should not alter the foreign currency price. Nevertheless, there will be a volume effect that arises both from substitution away from imports whose price relative to non-traded goods has risen, as well as from balance sheet and wealth effects of the exchange rate depreciation on domestic absorption and thus on import demand. Since dollar prices remain constant, the decline in import volumes implies a reduction in the foreign currency value of imports.

9. Piecing these together yields the aggregate impact of a depreciation on the trade balance.[6] Since this impact operates through the effects on the value exports and of imports—possibly in opposing directions—the net effect depends on their initial magnitudes; that is, on whether the country has an initial trade surplus or deficit. In the benchmark case of initially balanced trade, the empirical estimates suggest short-run elasticities (expressed as the change in the trade balance-to-export ratio for a 1 percent depreciation of the nominal exchange rate) are around 0.4 for oil and non-oil commodity exporters but only 0.1 for manufactures—mainly because the fall in the dollar price for these goods more than offsets the higher export volume. In the longer run, however, price elasticities are more similar across different types of exporting countries, ranging from 0.4 to 0.5. To put this in perspective, an elasticity of 0.5 implies that, for a country with an export-to-GDP ratio of 40 percent (slightly above the

[6] Examining the effects of a depreciation on economic growth is beyond the scope of this paper. The economic impact of external adjustment in program contexts is discussed in "The Design of IMF-Supported Programs" (OP 241).

sample average), a 10 percent nominal exchange rate depreciation would improve the trade balance by about 2 percent of GDP (conversely, an appreciation would deteriorate the trade balance).[7] For manufacturing exporters, which have a long-run elasticity at the lower end of the above range, the improvement is somewhat smaller—around 1.6 percent of GDP.

10. That a nominal exchange rate depreciation should have a long-run effect on the trade balance may seem surprising, and arises because the nominal exchange rate change is taken as given and therefore the original source of the shock (whether nominal or real) is not specified. Depending on the source of the depreciation—for example, a monetary expansion—there may be a greater responsiveness of domestic prices, possibly fully offsetting the exchange rate depreciation over time, in which case there would be no long run impact on the trade balance. Likewise, if the real exchange rate was initially in equilibrium, a purely nominal shock is unlikely to alter relative prices in the long run.

11. Going beyond the case where trade is initially balanced, the response is not symmetric to whether the country has an initial surplus or deficit. The larger the initial surplus, the less likely is a depreciation to (further) improve the trade balance or an appreciation to reduce the surplus—or, even if the impact has the expected sign, its magnitude will be smaller than when trade is initially balanced. By contrast, the larger the initial deficit, the more likely is a depreciation to improve the trade balance or an appreciation to (further) deteriorate the deficit—and the magnitude of the impact will be larger than when trade is initially balanced.

12. Finally, it bears emphasizing that—as with any econometric exercise—the estimates obtained herein are subject to margins of uncertainty. In particular, studies based on individual goods or sectors typically find larger price elasticities than studies based on aggregate trade volumes. This may reflect different sectors of the economy being at different points in the cycle, with an exchange rate movement that is beneficial for one sector not being appropriate for another—so the impact on the aggregate trade balance of an exchange rate change is indeed smaller than the sum of the estimated effects on individual sectors. But it may also reflect the problems of econometric misspecifications in aggregate studies, in which case the price elasticities obtained by them could be biased downward (though there are also reasons why micro studies may yield downward biased estimates; Appendix I).

13. The remainder of this paper is organized as follows. Section II discusses the various channels through which the exchange rate may have an impact on the trade balance. Section III describes the country sample and classification by type of exports. Section IV presents the main empirical results. Section V concludes. Appendices survey the literature and discuss data, econometric, and robustness issues.

---

[7] To allow for a zero trade balance, elasticities are defined as $\eta = (dTB / x_{val})/(de / e)$. Hence $dTB / GDP = (x_{val} / GDP) \times \eta \times (de / e) = 0.40 \times 0.50 \times 0.1 = 0.02$.

II. THE ANALYTICS OF TRADE BALANCE ADJUSTMENT

14. Standard open economy models predict that an exchange rate movement will affect the trade balance but do not always articulate fully the channels and dynamics through which this will occur. The exchange rate change—for concreteness, a permanent nominal depreciation—may be the result of exchange rate policy (a devaluation under a peg; sterilized intervention under a float) or the result of other macroeconomic policies and shocks. In the latter case, the exchange rate will be one channel through which the effect of monetary and fiscal policies on the trade balance is manifested, but there may be direct effects as well, which are not considered here.

15. The exchange rate change—abstracting from how it comes about—will set in motion changes in other relative prices. But which prices are relevant? For an **exporter of commodities**—for which demand for its product is perfectly elastic at the world price—the depreciation cannot change the foreign currency price. Moreover, since demand is not the constraint, any volume response is determined by the supply side. The depreciation may elicit such a supply response by raising the domestic currency price of exports relative to non-tradables—proxied by the consumer price index (CPI). But since the depreciation will also increase the CPI (or, more generally, costs for exporters such as wages or imported inputs) the effect on the relative price for exporters will be positive, but not one-to-one with the depreciation, and will tend to decline over time. The higher relative price—especially if persistent—will draw resources into the export sector, eliciting a positive volume response (Box 1, equation 1).[8] Since the foreign currency price of exports has remained unchanged and volumes have increased, the value of exports should rise. Finally, while the elasticity of exports to a *given* relative price change may be expected to increase over time, rising costs mean that the effect of the depreciation on the relative price tends to diminish, so the volume response in the longer run may be smaller or larger than the response in the short run depending on which of the two forces dominates.

[8] This effect is likely to be smaller among non-renewable resources. However, even in the case of commodities such as oil, a positive supply response might exist as some oil reserves that were previously uneconomical to extract become profitable at higher relative prices.

Box 1. Trade Equations

For countries that predominantly export **commodities**, the demand for exports is assumed to be perfectly elastic at the world price (in foreign currency terms) while the supply equation is:

$$x_c^{vol} = f\left(\frac{p^x}{cpi},\ Y^*, \Delta cap\ , gap\right) \tag{1}$$

where x_c^{vol} is the volume of exports of goods and non-factor services, p^x and cpi are, respectively, the export deflator (in domestic currency) and the consumer price index, Oil prices are used as the export deflator for oil exporters and non-oil commodity prices (weighted by the country's commodity exports) are used as the export deflator for non-oil commodity exporters. While the price-taking assumption for commodity exporters implies that foreign demand should only affect the market price, it is possible that world demand is not perfectly elastic so that demand is not fully reflected in the price. In such cases, the output of partner countries might play an independent role in the supplier's decision. Thus, to reduce the risk of omitted variable bias, the output of partner countries weighted by their share in the exports of the exporting country (Y^*) is added to the volume equation of commodity exporters. The supply of commodities is also assumed to depend on resource availability—the economy's cyclical position (*gap*) and the scope for expanding production through improvements in productivity (Δcap)—proxied by the change in GDP per capita in PPP terms.

For countries that predominantly export **manufactures**, the demand function is:

$$x_{\mathrm{m}}^{vol} = f\left(\frac{p^x}{ulc},\ Y_t^*\right) \tag{2}$$

where x_m^{vol} is the volume of goods and non-factor services exports, p^x is the export price deflator (in domestic currency), *ulc* is the trade-weighted average of the (domestic currency equivalent) of unit labor costs in the country's trading partners and Y^* is the output of partner countries weighted by their share in the exports of the exporting country.

Manufacturing exporters are assumed to set the local currency price of their goods according to conditions in the destination market and local costs. The **manufacturing export price** is assumed to depend on the trade-weighted average of unit labor costs in manufacturing in the country's export markets (in foreign currency terms, ulc^*), the exchange rate *e* (which captures the pricing-to-market behavior), and the consumer price index (*cpi*) as a proxy for domestic costs. The variables Δcap (growth of GDP per capita in PPP terms) and *gap* (real GDP relative to its Hodrick-Prescott trend) control for resource availability. Thus,

$$p_m^x = f(ulc^*,\ e\ ,\ cpi\ ,\ \Delta cap\ ,\ gap\ ) \tag{3}$$

Box 1. Trade Equations (continued)

The **consumer price index** is assumed to depend on import prices and domestic costs. The import price is proxied by movements in the nominal exchange rate assuming immediate and full pass-through to the domestic price. Domestic costs are assumed to depend on changes in productivity, Δcap, and the output gap, *gap* (real GDP relative to the HP trend):

$$\Delta cpi = f(\Delta\, e\,,\ cpi\ \ e,\ \Delta \text{cap},\ gap\ ) \qquad (4)$$

Since experience in capital account crises suggests that the balance sheet impact of large depreciations can have pervasive effects on economic activity, an equation is estimated for real **absorption** to the real (CPI-deflated) exchange rate (with an interactive dummy for countries with external debt ratios above 40 percent of GDP) and to real disposable income.

$$a^{vol} = f(\frac{e}{cpi}, D\frac{e}{cpi},\ Y^{D}) \qquad (5)$$

where a^{vol} is real absorption, *e* is the nominal exchange rate, *cpi* is the consumer price index, D is a dummy variable that is unity if the external debt-to-GDP ratio exceeds 40 percent and zero otherwise, and Y^{D} is real disposable income (GDP minus government revenues).

Absorption feeds into the **demand for imports:**

$$m^{vol} = f(\frac{p^{m}}{cpi},\ \text{a}^{\text{vol}}\ ) \qquad (6)$$

where m^{vol} is the volume of imports, p^{m} is the local currency import price deflator, *cpi* (the consumer price index) proxies the price deflator of nontradables, and a^{vol} is the real absorption.

16. For **exporters of manufactures**—or other differentiated products that face a downward sloping demand curve—the depreciation will, for a given local currency price of exports, reduce the foreign currency price (relative to foreign competitors), eliciting greater demand (Box 1, equation 2). The supply function is implicitly defined by the pricing equation, whereby exporters determine the local currency price of exports according to conditions in the destination market and local costs—for instance, unit labor costs in manufacturing in the destination market, the exchange rate (to capture pricing-to-market), and the CPI as a proxy for domestic costs (inasmuch as the CPI reflects the prices of non-traded goods, this term also captures the competition from the non-traded goods sector for domestic resources such as labor). This supply function—the pricing equation—will also respond to the cyclical position of the domestic economy and developments in productivity

(Box 1, equation 3).[9] Typically, therefore, there will be at least some response of the local currency price of exports to a depreciation. Hence, while the depreciation will reduce the foreign currency price, it will be less than a proportionate decline. The fall in the relative price of exports, in turn, increases the volume of exports—though, again, given endogenous price dynamics, this might be different in the short run than in the long run. In sum, the crucial difference between exporters of commodities and those of manufactures is that, for the latter, the foreign currency price falls (which is how the positive volume response comes about). Since prices for manufactures exports decline while volumes increase, the net effect on the U.S. dollar value of exports is a priori ambiguous.

17. Turning to **imports**, assuming the country is small in the world market, a depreciation leads to a corresponding increase in the domestic currency price of imports—though, if the CPI rises as well, the relative price of imports will not increase fully in line with the depreciation. Standard import demand functions postulate that the volume of imports depends negatively on its relative price and positively on economic activity or aggregate demand (usually proxied by real GDP growth). The higher relative price leads to substitution away from imports—necessarily reducing the dollar value of imports as volumes decline.[10]

18. Although most empirical studies treat aggregate demand as exogenous when considering the impact of a depreciation on the demand for imports, experience in recent capital account crises suggests that adverse balance sheet effects from large devaluations can lead to a collapse of economic activity, thus reducing imports (and improving the trade balance). Even in less extreme situations, exchange rate movements can have balance sheet effects on firms—or wealth effects on households—thus affecting aggregate demand and, indirectly, the volume of imports; see Box 1, equations (4) and (5). Ideally, estimation of the impact of exchange rate changes on aggregate demand would take full account of the local and foreign currency components of household wealth (including net foreign asset positions, housing wealth, and stock market valuation); in practice, only crude proxies are available.

[9] The export demand function and the pricing equation together determine manufactures' exporters profitability, which may have longer-term implications for the supply of exports, which are not fully captured here. For instance, following an exchange rate appreciation, if exporters maintain the domestic currency price, the exchange rate appreciation will translate into a higher foreign currency price, reducing demand, and thus revenues and profits—if there are fixed costs, profitability will fall as well. If exporters wish to maintain market share, they need to lower the domestic currency price of exports, partially offsetting the exchange rate impact. This cuts into their profitability, and their ability to do so depends on what happens to their costs (for instance, imported inputs—proxied by the exchange rate—and domestic costs, proxied by the CPI). Over time, the reduced profitability may lead to firms exiting, further lowering exports—this latter effect is difficult to capture empirically, however, as noted below.

[10] The effect on the local currency value of imports is ambiguous as the higher price might outweigh the lower volume. It is this ambiguity that gives rise to the traditional Marshall-Lerner condition, which is the condition under which a devaluation will improve the *domestic currency value* of the trade balance.

19. Piecing together these various effects on exports and on imports yields the impact of a nominal exchange rate depreciation on the **trade balance**. Since there are different—sometimes opposing—effects on exports than on imports, the net impact on the trade balance depends upon the relative magnitudes of the effects. Indeed, akin to the Marshall-Lerner condition, there is a corresponding condition for a depreciation (appreciation) to improve (deteriorate) the foreign currency value of the trade balance (Box 2). While assuming that the country's trade position is initially in balance is a useful benchmark, the effects of a nominal exchange rate depreciation are sensitive to the initial trade position.

Box 2. Marshall-Lerner Redux

The traditional Marshall-Lerner condition gives the condition under which a depreciation of the exchange rate will improve the trade balance, measured in local currency terms, of an economy that is "small" in both its export and import markets. [1/] An analogous condition determines whether the trade balance, measured in foreign currency terms, of a country that is large in its export market will improve, and may be derived as follows. Let the trade balance in U.S. dollars be defined as $TB^* = p_x^* x_{vol}(p_x^*) - p_m^* m_{vol}(p_m)$ where $p_x^* = p_x / e$; p_x is the local currency export price; *e* are units of national currency per U.S. dollar, p_m is the local currency import price, and p_m^* is the foreign currency import price . Differentiating this expression with respect to the exchange rate yields:

$$dTB^* = dp_x^* x_{vol} + p_x^* dx_{vol} - dp_m^* m_{vol} - p_m^* dm_{vol}$$

Defining the exchange rate elasticity of the local currency price as $\eta_e^{p_x}$ and the foreign price elasticity of the export volume (from the demand function) as $\eta_{p_x^*}^{x_{vol}}$, gives $dp_x^* / p_x^* = (\eta_e^{p_x} - 1)\ de/e$ and $dx_{vol} / x_{vol} = \eta_{p_x^*}^{x_{vol}}\ dp_x^* / p_x^*$, the change in the value of exports may be written:

$$dx_{val}^* = dp_x^* x_{vol} + p_x^* dx_{vol} = dp_x^* x_{vol} + p_x^* (\eta_{p_x^*}^{x_{vol}}) x_{vol} (dp_x^* / p_x^*) = dp_x^* x_{vol} (1 + \eta_{p_x^*}^{x_{vol}}) =$$

$$x_{val} (\eta_e^{p_x} - 1)(1 + \eta_{p_x^*}^{x_{vol}})\ de/e$$

Likewise, $dm_{val}^* = dp_m^* m_{vol} + p_m^* dm_{vol} = p_m^* dm_{vol}$. Assuming the foreign currency price of imports is fixed, the domestic price of imports is $p_m = p_m^*\ e$ so that $dp_m = p_m^*\ de$ (i.e., the exchange rate feeds through fully to domestic import prices) $dm_{vol} = m_{vol} \eta_{p_m}^{m_{vol}} (dp_m / p_m) = m_{vol} \eta_{p_m}^{m_{vol}} (de/e)$.

Hence $dm_{val}^* = dp_m^* m_{vol} + p_m^* dm_{vol} = p_m^* m_{vol} \eta_{p_m}^{m_{vol}} (de/e) = m_{val}^* \eta_{p_m}^{m_{vol}} (de/e)$

Combining terms: $dTB^* = x_{val}\ (de/e)\{(\eta_e^{p_x} - 1)(1 + \eta_{p_x^*}^{x_{vol}}) - (1/\alpha)\ \eta_{p_m}^{m_{vol}}\}$ where $x_{val}^* = \alpha\ m_{val}^*$, and α is the ratio of exports to imports. Hence, the "Marshall-Lerner" condition will be met (i.e., an exchange rate depreciation will improve the trade balance) if and only if:

$$(\eta_e^{p_x} - 1)\ (1 + \eta_{p_x^*}^{x_{vol}}) - \frac{1}{\alpha} \eta_{p_m}^{m_{vol}} > 0 .$$

Box 2. Marshall-Lerner Redux (continued)

A crucial assumption in the above derivation is that there is some degree of pricing-to-market. However, if there is no pricing-to-market (in other words, if $\eta_e^{p_x}=0$) and we assume that $\alpha=1$ so that trade is in balance, the above inequality collapses into the familiar "Marshall-Lerner" condition; that is,

$$-\eta_{p_x^*}^{x_{vol}} - \eta_{p_m}^{m_{vol}} > 1.$$

A corresponding condition can be derived for the commodity exporters, who are assumed to face fully elastic world demand but whose export volume may respond to changes in domestic relative prices.

1/ On empirical evidence for the Marshall-Lerner condition and the existence of a J-curve, see Rose and Yellen (1989).

III. Country Classification and Estimation Strategy

20. Much of the cross-country academic literature examines trade elasticities of industrialized countries or large samples of developing countries (Appendix I), rather than middle-income or emerging market countries, and typically does not distinguish countries according to their dominant class of exports. Moreover, this literature has generally focused only on the volume effects of changes in real exchange rates. This paper goes beyond the existing literature by looking not only at the effects of relative price changes on volumes, but also at the pass-through effect of nominal exchange rate changes on relative prices and the combined impact on export and import values as, ultimately, the goal is to examine the effects of nominal exchange rate changes on the trade balance.

21. The sample in this paper covers forty-six emerging market economies (Appendix II), most of which are classified as middle-income countries (according to the World Bank *World Development Indicators*); two low-income countries (India and Pakistan) are included given their importance in world trade and their access to market financing. Transition economies are excluded because of the significant structural changes they experienced during the 1990s and because their trade patterns prior to transition were dominated by administrative trading arrangements among CMEA members.[11] Annual data covering the period 1980−2005 are used in all estimations except the inflation equation, which is estimated since the early 1990s given the evidence suggesting that exchange rate pass-through to domestic prices has weakened over time.

22. As discussed above, the response of exporters to a depreciation of the exchange rate is likely to depend upon the market structure of the good—in particular, the elasticity of global demand for their products. Ideally, this would be incorporated in the analysis by considering each country's exports separately (at least broad categories), and then aggregating to obtain the full effect on the trade balance. In the absence of the requisite data,

[11] CMEA stands for Council for Mutual Economic Assistance.

however, countries are categorized according to their dominant export—oil, non-oil commodities, or manufacturing.[12] One disadvantage of this approach is that this analysis, like other studies that focus on macro aggregates, cannot consider inter-sectoral effects such as the crowding out of manufactures in response to booming commodity exports—though these are more likely to be relevant for low-income countries than most emerging market countries.

23. How representative of the country's entire exports is this classification? For countries classified as oil exporters, the average share of oil in merchandise exports is 77 percent, for non-oil commodity exporters and manufactures exporters, the average shares are around 65 percent; across categories, the lowest share of the predominant export is around 45 percent (Appendix II lists the export classification of countries and period coverage). Figure 1 compares the country's export deflator (which is a weighted average of the deflators of the country's actual exports) to the price that is assumed to be relevant to the decisions for that category of exporters—the oil price for oil exporters, non-fuel commodity prices for other commodity exporters, and the unit labor costs in the manufacturing sector of destination markets for manufactures. The close correspondence between these prices and the countries' overall export price deflators suggests that this broad categorization by the country's predominant export is indeed reasonable.

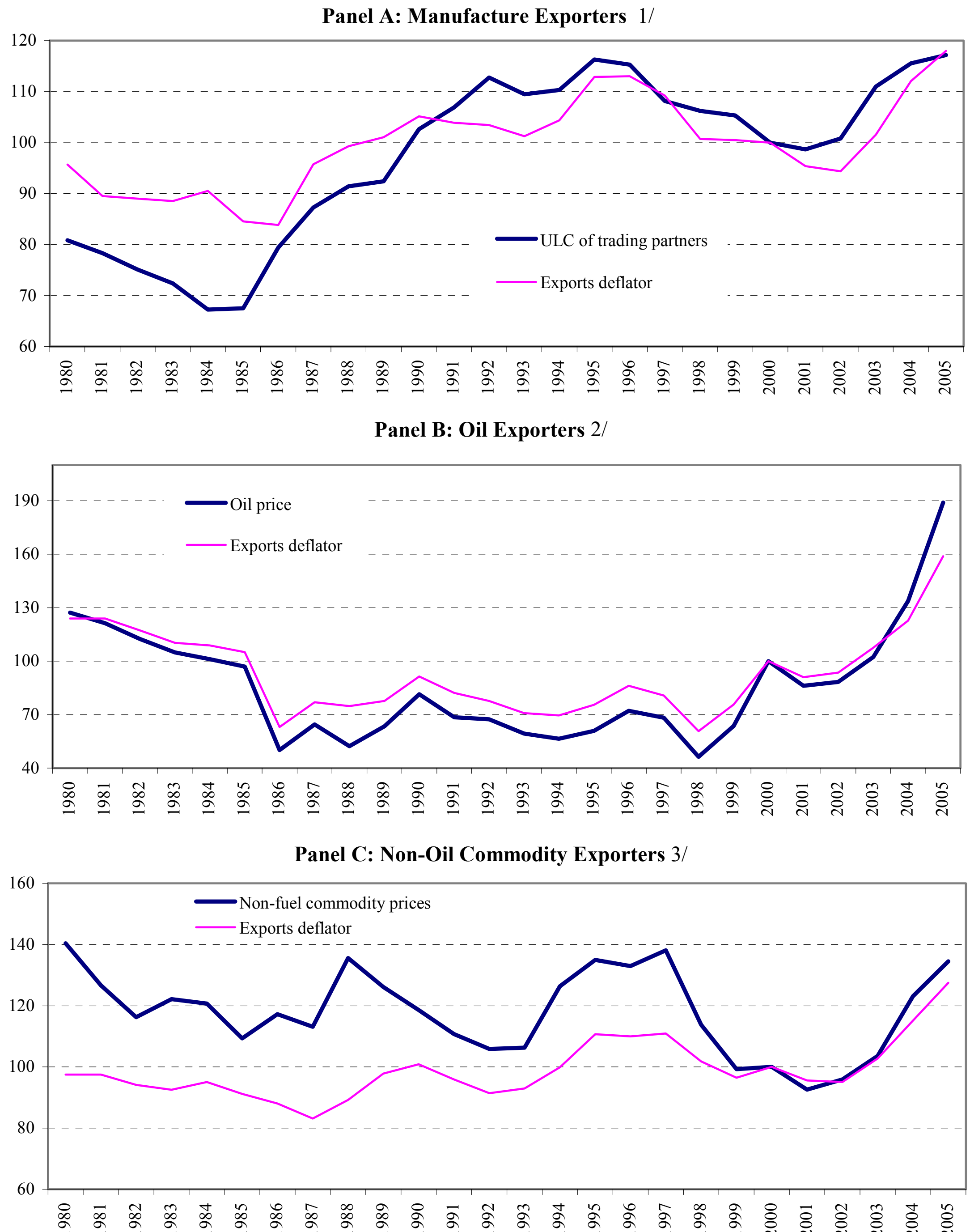
24. Since commodity prices and import prices are assumed to be exogenous, only two price equations need to be estimated; namely, the price equation for manufacturing exports and the response of the CPI to a change in the exchange rate.[13] Four trade volume equations are estimated (one for imports, and one for each of the three categories of exports—though the latter are estimated jointly using interactive regressors for each category). In addition, an equation for the volume of absorption is estimated to capture the response of absorption to real exchange rate changes—the nominal exchange rate deflated by the CPI; see Box 1.[14]

[12] The dominant export category is obtained from the export classification over the period 1980−2005 and the country grouping may differ from the current WEO classification. Robustness tests reported in Appendix III show that elasticities estimated for the period 1992−2005 based on trade shares over this latter period yield broadly similar results. While non-factor services are included in the econometric analysis, they are grouped with the principal goods export category, which may be problematic in cases where services represent a large fraction of exports (e.g. Jamaica). It is worth noting, however, that excluding this and other countries that are borderline in their classification does not change the paper's main conclusions (Appendix III). Also, it would be preferable to exclude re-exports from the data for manufacturing exporters; e.g., the calculations in footnote 6 are based on the assumption of an export-to-GDP ratio of 40 percent. If re-exports are important, the effective export ratio—and thus the impact of an exchange rate movement on the trade balance—will be correspondingly smaller.

[13] Treating import prices as exogenous is supported by estimation results presented in Appendix III; specifically, both the short and long-run import price elasticities with respect to the nominal exchange rate are very close to unity.

[14] Most export functions estimations do not distinguish between the class of goods exports; see Senhadji and Montenegro, 1999, for country-specific estimates of export elasticities.

Figure 1. Price Deflators, 1980-2005
(Average across all countries in category; indices, 2000=100)



Source: International Monetary Fund, WEO database.

1/ Foreign unit labor costs in manufacturing (ULC), weigthed by trade exports to advanced economies.
2/ Oil price is the simple average of three spot prices; Brent, West Texas, and Dubai.
3/ Non-fuel commodity export price, weighted by commodity shares of non-oil exports to the world.

25. Estimation using a panel of countries poses some econometric challenges, in particular due to the possible non-stationarity of the data, and the likelihood that country effects are correlated with the lagged dependent variable. Arellano and Bond (1991) first derived an estimator that is valid under these conditions, taking advantage of the number of cross section units (46 countries) being large relative to the number of time periods (an average of 24 years). Their estimator was later modified by Blundell and Bond (1998) to incorporate levels and first-differences as instruments, which is the estimator used in the paper.[15] In terms of instrumentation, the relative price variables are instrumented by their lagged values in the export and import volume equations to limit possible simultaneity bias. Moreover, real absorption is also instrumented in the import demand function by lags of the real exchange rate and disposable income in addition to its own lagged values.

26. As a robustness test of the basic results, alternative estimators based on cointegration tests are also used. The first estimator is the mean group (MG) estimator and consists of estimating separate auto-regressive distributed lag models for each country, where dependent and independent variables enter the right-hand side. The MG estimator then derives the full panel estimates as simple averages of individual country coefficients. The second estimator recognizes that the long-run response of the dependent variable to exchange rate changes might be the same across countries and uses this restriction by pooling the individual long-run regression coefficients; the latter estimator is called the pooled mean group (PMG) estimator. These alternative estimation techniques yield broadly similar results, suggesting that the findings are robust (see Appendix III for details).

IV. Empirical Results

A. Exports

27. Export volume equations for the three categories of exporters are estimated jointly using interactive terms. For the commodity exporters, the relative price coefficient is expected to be positive as these exporters are assumed to be small in the world commodities markets, and therefore unable to influence the world price. Moreover, since there may be lags in the supply response—and resources are unlikely to shift to the export sector if price movements are temporary—a three-year backward average of the relative price is used. Coefficient estimates are reported in Table 1 with all variables defined in logarithms except for the output gap which is defined in percent of GDP.

---

[15] The asymptotic bias of the estimator being used is less than that of fixed-effects estimators (Alonso-Borrego and Arellano, 1999) and, even in the presence of unit roots, the estimator has very small biases (Binder, Hsiao, and Pesaran, 2005).

Table 1. Export Volumes: Coefficient Estimates and Implied Elasticities

	Oil exporters (supply)		Non-oil commodity exporters (supply)		Manufacturing exporters (demand)	
	Coefficient estimates	Long-run elasticities	Coefficient estimates	Long-run elasticities	Coefficient estimates	Long-run elasticities
Volume						
First lag	0.85 ***		0.85 ***		0.85 ***	
Relative price 1/						
Contemporaneous	0.02	0.16	0.09 **	0.02	-0.17 ***	-0.53 **
First lag	0.01		-0.08 **		0.09	
Income effects 2/						
Contemporaneous	1.87 **	1.27 ***	1.02 ***	1.87 ***	1.48 ***	2.38 ***
First lag	-1.67 **		-0.73 *		-1.11 **	
Change in per capita GDP (PPP terms)						
Contemporaneous	0.65 **		0.44			
First lag	-0.12		0.12			
Output gap						
First lag	0.22 ***		0.02			
Diagnostic statistics						
# observations	186		310		511	
# countries	9		14		23	
R squared	0.97		0.97		0.97	
Tests						
Hansen test	20.97		20.97		20.97	
A-B test for AR(1)	-4.61 ***		-4.61 ***		-4.61 ***	
A-B test for AR(2)	-1.01		-1.01		-1.01	

Source: IMF staff estimates.

Note: * = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level. Estimation with intercept.

1/ World non-oil commodity prices divided by CPI for non-oil commodity exporters; world oil price divided by CPI for oil exporters; and export deflator divided the ULC of trading partners for manufacturing exporters. All prices defined in domestic currency. For commodity exporters (oil and non-oil) the relative price is a 3-year moving average.
2/ Real GDP of trading partners for all export equations.

28. Foreign demand has a large impact on exports across the three categories, with short-run elasticities ranging from about 1 for non-oil commodity exports to 1.5 for manufactures and 1.9 for oil. Long-run elasticities are generally higher (except for oil exports) and remain high even with the inclusion of a trend term to proxy for increased product variety and declining trade costs. Turning to the effects of relative prices, the elasticities are substantially smaller than income elasticities. For manufactures, the elasticity is negative, representing a demand response, and is statistically significant.[16] The magnitude of the coefficient implies that a 1 percent decrease in the price of the home country's exports (relative to those of foreign competitors) would increase the volume of exports by 0.17 percent in the short run and by 0.53 percent in the long run. For commodities, the price elasticities—while positive, as expected for supply responses—are considerably lower in magnitude. This is consistent with the view that the supply of exhaustible resources is fairly inelastic with respect to price; only the price elasticity of non-oil commodities is statistically significant.

16 Inclusion of the export price relative to the CPI (to capture resource shifts from the non-traded goods sector) yields a statistically insignificant negative coefficient, contrary to the positive coefficient that would normally result from a supply response (see Appendix III). The pricing equation, however, does include the CPI as a proxy for domestic costs and the price of non-traded goods. Limiting the sample to the 1992-05 period to allow for increased competition in manufactures had no effect on the coefficient estimates.

29. While the volume equations yield the effect of a relative price change on exports, determining the impact of a nominal exchange rate depreciation requires a pricing equation that links the exchange rate to relative prices. For manufactures, the pricing equation determines the domestic currency price of exports and represents the exporters' supply function (Table 2).[17] Export prices respond positively to unit labor costs of competitors and domestic costs—as proxied by the CPI—as well as to the nominal exchange rate, possibly because of pricing-to-market strategies. Indeed, the direct impact of a 1 percent depreciation of the nominal exchange rate is to elicit a 0.58 percent increase in the local currency price of exports. In addition, however, since the CPI enters the pricing equation with a coefficient of 0.40—and itself increases by 0.21 percent in response to a nominal exchange rate depreciation (Table 3)[18]—the total response is 0.66 percent (=0.58+0.40 x 0.21). Therefore, if the exchange rate depreciates by 1 percent, the foreign currency price of manufactures falls by 0.34 percent (-1+0.66).[19] The combination of a small pass-through effect and an inelastic volume response to price changes yields a very small short-run elasticity of manufactures' export volumes to nominal exchange rate depreciation of $0.06\ (= -0.17 \times -0.34)$ percent. Moreover, since this volume response (0.06) is less than the foreign currency price response (-0.34 percent), the depreciation *lowers* the U.S. dollar value of manufacture exports in the short run (though in the long-run U.S. dollar value of exports remains roughly unchanged; see Table 5). The CPI equation used in this paper does not control for a country's exchange rate regime. Since a country with a fixed exchange regime is likely to experience a smaller pass-through of exchange rate changes into domestic prices—and thus a larger movement of relative prices—the effect of a nominal depreciation on the trade balance will be larger (Appendix III).

[17] While the assumption of pricing-to-market is more plausible for large emerging market countries, excluding these countries has no effect on the coefficient estimates (Appendix III).

[18] The results in Table 3 are based on the post-1994 sample (rather than the period 1980-2005) because of a common finding in the literature that exchange rate pass-through to consumer prices has declined in recent years. This is confirmed here; estimated on the full (1980-2005) sample yields an immediate pass-through of 0.36 percent and a long-run pass-through of 0.91 percent, compared to 0.21 percent and 0.64 percent for the post-1994 sample. The post-1994 period also eliminates most episodes of hyperinflation. Inflation rates are transformed by $\tilde{\pi} = \pi/(1+\pi)$ so that they lie in the interval (-100, 100) in order to reduce the effect of outliers, and estimation excluding annual inflation rates higher than 10 percent provides similar results (Appendix II).

[19] If exports of manufactures have a high import content, the pass-through effect is likely to be even smaller because the depreciation will raise costs by more than the increase in the CPI.

Table 2. Pricing Equation for Manufacturing Exporters: Coefficient Estimates and Implied Elasticities

	Coefficient estimates	Long-run elasticities
Export deflator		
First lag	0.73 ***	
Exchange rate in local currency per US$		
Contemporaneous	0.58 ***	0.90 ***
First lag	-0.34 ***	
Unit labor costs (ULC) of competitors 1/		
Contemporaneous	0.20 **	0.58 ***
First lag	-0.05	
CPI index (logs); proxy for domestic costs		
Contemporaneous	0.40 ***	0.09
First lag	-0.38 ***	
Change in per capita GDP (PPP terms)		
Contemporaneous	-0.06	
First lag	0.09	
Output gap		
First lag	-0.01	
Diagnostic Statistics		
# observations	511	
# countries	23	
R squared	0.99	
Tests		
Hansen test	14.19	
A-B test for AR(1)	-1.60	
A-B test for AR(2)	-0.66	

Source: IMF staff estimates.

Note: * = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level. Estimation with intercept.

1/ ULC of trading partners for manufacturing exporters; in foreign currency.

30. For oil and non-oil commodities, the foreign currency price of exports is determined in international markets, so a nominal depreciation leads to a corresponding increase in the domestic currency price of exports. The relative price that is relevant for resources to shift into the export sector, however, is assumed to be the export price relative to the CPI. Taking account of the impact on the CPI, a 1 percent nominal exchange rate depreciation raises the relative price of oil and non-oil commodity exports by 0.79 (=1-0.21) percent, Table 3. Although the short-run supply response is weak—amounting to 0.02 to 0.09 percent for oil

and non-oil commodities—the U.S. dollar value of exports rises slightly since the foreign currency price is constant and there is a positive (albeit small) volume response; Table 5.[20]

Table 3. Inflation Rate: Coefficient Estimates and Implied Elasticities (post-1994) 1/

	Coefficient estimates	Long-run elasticities
Inflation Rate		
First lag	0.52 ***	
Nominal exchange rate change		
Contemporaneous	0.21 ***	0.64 ***
First lag	0.00	
Change in per capita GDP (PPP terms)		
First lag	-0.05	
Output gap		
First lag	0.04	
CPI		
First lag	-0.07 ***	
Nominal exchange rate		
First lag	0.04 ***	
Diagnostic statistics		
# observations	506	
# countries	46	
R squared	0.82	
Tests		
Hansen test	40.04	
A-B test for AR(1)	-4.12 ***	
A-B test for AR(2)	-1.04	

Source: IMF staff estimates.

Note: * = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level. Estimation with intercept.

1/ The inflation rate and nominal exchange rate change have been transformed to lie in the interval (-100, 100) percent to limit the impact of outliers.

B. Imports

31. For imports, a standard import demand function is estimated, where the relative price is the import deflator divided by the CPI, and real absorption is the "activity" variable.[21] The

[20] Particularly for non-renewable commodities, a small supply elasticity is to be expected.

[21] While imports could also be split according to import category, the assumption made here is that imports are much more diversified than exports.

price elasticities of -0.21 in the short run and -0.44 in the long run are economically and statistically significant (Table 4). Reflecting the typically high "activity" elasticity of imports in middle-income and emerging market countries, the absorption elasticity is well over unity—that is, 1.57 in the short run and 1.54 in the long run. Hence, as was the case for exports, the income effects are much larger than the relative price effects.

Table 4. Import Volumes and Absorption Impact: Coefficient Estimates and Implied Elasticities

	Coefficient estimates	Long-run elasticities		Coefficient estimates	Long-run elasticities
Import volume			Real domestic demand		
First lag	0.74 ***		First lag	0.81 ***	
Relative price for import demand 1/			Real exchange rate 1/		
Contemporaneous	-0.21 ***	-0.44 ***	Contemporaneous	-0.08 ***	-0.07
First lag	0.09		First lag	0.07 **	
Real domestic demand			Real exchange rate (for high debt countries)		
Contemporaneous	1.57 ***	1.54 ***	Contemporaneous	-0.08 ***	-0.39 ***
First lag	-1.16 ***		First lag	0.00	
			Disposable income to CPI ratio		
			Contemporaneous	0.32 ***	0.72 ***
			First lag	-0.19 **	
Diagnostic Statistics			Diagnostic Statistics		
# observations	824		# observations	824	
# countries	41		# countries	41	
R squared	0.96		R squared	0.96	
Tests			Tests		
Hansen test	36.31		Hansen test	33.28	
A-B test for AR(1)	-3.73 ***		A-B test for AR(1)	-4.25 ***	
A-B test for AR(2)	0.68		A-B test for AR(2)	-1.43	

Source: IMF staff estimates.

Note: * = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level. Estimation with intercepts.

1/ Using CPI as the deflator.

32. Beyond the direct substitution effect, a nominal exchange rate depreciation may affect imports indirectly, via wealth or balance sheet effects on absorption.[22] To the extent that the country is a net external debtor (has a negative net foreign asset position), the depreciation raises the real burden of that debt. By contrast, for countries with trade surpluses that are also net creditors, it is appreciation pressures that have a negative effect on absorption (and, thus, import volumes). In addition, disposable income and wealth of firms and households are eroded by the rise in the consumer price index that results from the exchange rate depreciation. In the absence of data on the currency composition of sectoral balance sheets, Table 4 models real absorption as a function of the real (CPI-deflated) exchange rate depreciation (with an interactive dummy for countries with external debt ratios

[22] Support for this view is provided in Becker and Mauro (2006) and Frankel (2005).

above 40 percent of GDP) and of real disposable income.[23] Recalling that a 1 percent depreciation of the nominal exchange rate increases the CPI immediately by 0.21 percent (Table 3), the estimates imply real absorption would decline by some 0.13 percent (=(0.08+0.08) x 0.79) for those countries with debt ratios above 40 percent of GDP via the external wealth term; the corresponding effect in the long run is 0.17 percent.[24]

33. Finally, combining the substitution and balance sheet effects, a 1 percent depreciation of the nominal exchange rate reduces import volumes by 0.36 percent in the short run and by 0.42 percent in the long run. Since the country is assumed to be small in the market for its imports, and therefore foreign exporters do not price to its market, this translates into a corresponding change in the value of imports.[25]

C. Model Fit

34. How well do these equations fit? The R^2 values are very high—though, in part, this reflects the levels estimation of possibly non-stationary variables—and the standard errors relative to the mean are less than three-quarters of 1 percent. Therefore, a more exacting test of the model is its ability to explain developments in exports and imports in exceptional circumstances and in the face of very large exchange rate movements using dynamic forecasts. The recent capital account crises provide such a test. While the estimated model is unable to capture fully the decline in imports and export volumes in the crisis year and the extent of the rebound over the following two years, it is able to capture changes in export values fairly closely (Box 3).

D. Trade Balance

35. The trade balance response to a nominal exchange rate depreciation differs across the three country types—oil, non-oil commodities, and manufactures exporters—and may also differ within each category depending on whether the country is initially in surplus or deficit. As shown in Table 5, the short-run elasticity of the trade balance in foreign currency for a 1 percent depreciation of the nominal exchange rate—starting from balanced trade—is lower among manufactures exporters (0.08) than is the case for commodity exporters (averaging about 0.4). For example, if the country has an export-to-GDP ratio of 40 percent, slightly

---

[23] Defining the interactive dummy for balance sheet effects as countries that have both (i) gross external debt ratios of over 40 percent of GDP and (ii) negative net foreign asset positions (based on the Lane and Milesi-Ferreti database) leads to very similar results.

[24] The effect of the increase in the CPI on real income is excluded here because nominal income would also likely be affected by the depreciation. Simply assuming that the increase in the CPI would lead to a corresponding reduction in real disposable income would likely overestimate the impact of the exchange rate depreciation.

[25] As previously noted, this assumption is supported by the evidence that, among emerging markets, both the short and long-run import price elasticities with respect to the nominal exchange rate are very close to unity (see Appendix III). This contrasts with estimates as low as 0.2 among G7 countries (see Appendix I).

above the average export-to-GDP ratio in the sample, **a 10 percent nominal exchange rate depreciation would only have a 0.3 percent of GDP immediate impact on the trade balance of a manufactures exporter but would improve a commodity exporter's trade balance by about 1½ percent of GDP.** For both groups of countries, however, most of the improvement in the trade balance comes from the impact on imports (Table 5).

36. **Over the medium term, the impact of an exchange rate depreciation on the trade balance converges for the various categories of exporters—with a 10 percent depreciation leading to an improvement of the trade balance of 1½ to 2 percent of GDP depending on the class of exporter.** The speed of adjustment depends on the various dynamics of relative prices responding to the change in the exchange rate and of import and export volumes responding to relative price movements. To get a sense of the trajectory to the long run equilibrium, Figure 2 plots the change in the export deflator and export volume for exporters of manufactures following a 10 percent depreciation and the effects on the trade balance for all three export categories (in percent of GDP) assuming a country with an export-to-GDP ratio of 40 percent. The simulation suggests that for exporters of manufactures, there is no long-run pass-through of the currency depreciation to the foreign currency price so that the valuation effect approaches zero over time. This of course reduces the initial adverse impact of the depreciation on the value of exports expressed in foreign currency and leads to the gradual improvement of the trade balance (Figure 3, panel 1). The trade balance of the oil- and non-oil commodity exporters improves on impact because of the sharp fall in imports but then stabilizes over time because of the waning effects on imports of the currency depreciation. For all three categories, most of the adjustment in the trade balance takes place within 3-5 years of the exchange rate depreciation, with the effect of a 10 percent depreciation leveling out within 6-7 years.

Table 5. Effects of Devaluations on Export-Import Values and on the Trade Balance
(percent change for a depreciation of 1 percent) 1/ 2/

	Oil exporters	Non-oil commodity exporters	Manufacturing exporters	Oil exporters	Non-oil commodity exporters	Manufacturing exporters
	Short-run effects			Long-run effects		
Export value in foreign currency	0.01	0.07	-0.28	0.06	0.01	-0.02
Import value in foreign currency	-0.36	-0.36	-0.36	-0.42	-0.42	-0.42
	Initial trade balance is in equlibrium (α=0) 3/					
Trade balance in foreign currency	0.37	0.43	0.08	0.48	0.42	0.40
	Initial trade balance is in deficit (α=0.75) 3/					
Trade balance in foreign currency	0.37	0.41	0.15	0.46	0.42	0.40
	Initial trade balance is in surplus (α=1.25) 3/					
Trade balance in foreign currency	0.37	0.44	0.00	0.49	0.43	0.39

Source: IMF staff estimates.

1/ Results based on the Arrelano-Bond estimator.

2/ Initial trade balance equal to zero with elasticity defined as $\eta = (dTB / x_{val}) / (de / e)$.

3/ α is defined in Box 2.

Box 3. Tracking Trade Developments during Capital Account Crises

Periods of sharp changes in exchange rates such as those experienced during a capital account crisis provide a useful benchmark for the robustness of the set of estimated equations. A list of capital account crises (CAC) was constructed based on existing literature (Ghosh et al., 2002, and Ramakrishnan and Zalduendo, 2006). The list includes eleven capital account crises since the mid-1990s (Argentina, Brazil, Ecuador, Indonesia, Korea, Malaysia, Mexico, Philippines, Thailand, Turkey, and Uruguay).

One way of assessing the model's robustness is to evaluate its predictive power by calculating the standard deviation of the projection errors relative to the mean value of the dependent variable. Dynamic forecasts are calculated for the various groups using predicted values for the lagged dependent variables. For the CAC sample, the standard deviation of the predicted error in relation to exports is large at about 3½ percent for manufacturing exports and 4 percent for imports. This compares with ¾ percent for both exports and imports using the full sample. This difference is to be expected given the large real shocks experienced during the capital account crises.

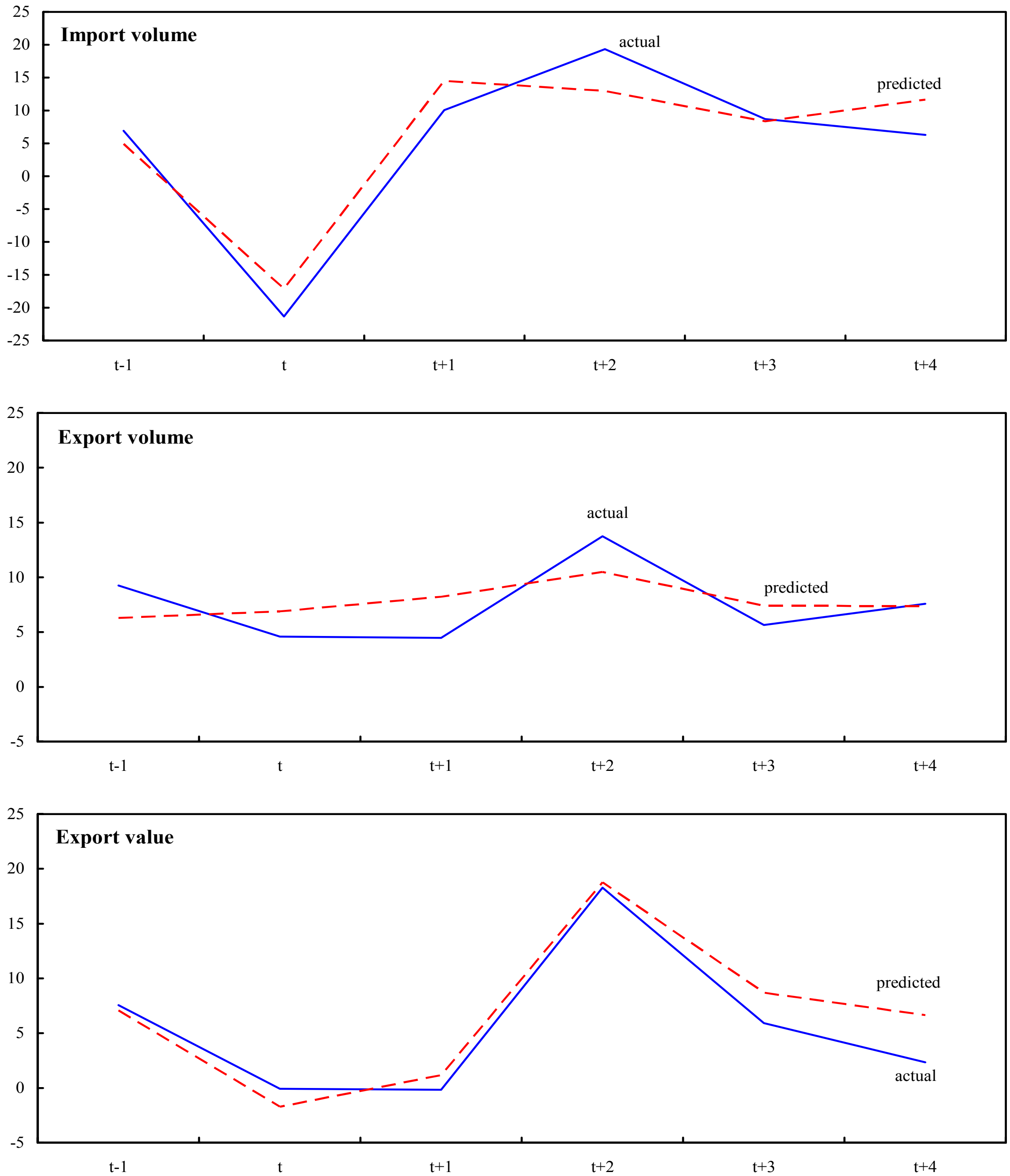
Fit of Export and Import Equations

	Standard error relative to mean
Exports of manufactures	
Full sample	0.74
CAC periods	3.40
Imports	
Full sample	0.71
CAC periods	4.12

The Box Figure presents average values for the actual and predicted import and export volumes around the time of each capital account crises. For imports, the model underpredicts the full extent of the decline in volumes by about 5 percent in the first year of the crisis and also underpredicts the subsequent rebound by about the same magnitude. The behavior of export volumes is much more stable during the crisis period. However, the model once again fails to capture the decline in volume growth during the first year of the crisis and the later rebound in volume growth. Interestingly, the change in export value in foreign currency matches the actual developments very closely around the time of the crisis suggesting that export prices were predicted to be lower in periods t and t+1 and higher in period t+2.

Overall, while the model captures much of the main dynamics of import and export values, it does not do so fully—especially in the years close to the crisis. This is not surprising, as the behavior of the economy is likely to be different during crises periods and when changes in real exchange rates are large—including through wealth and balance sheet effects that the model accounts for only partially.

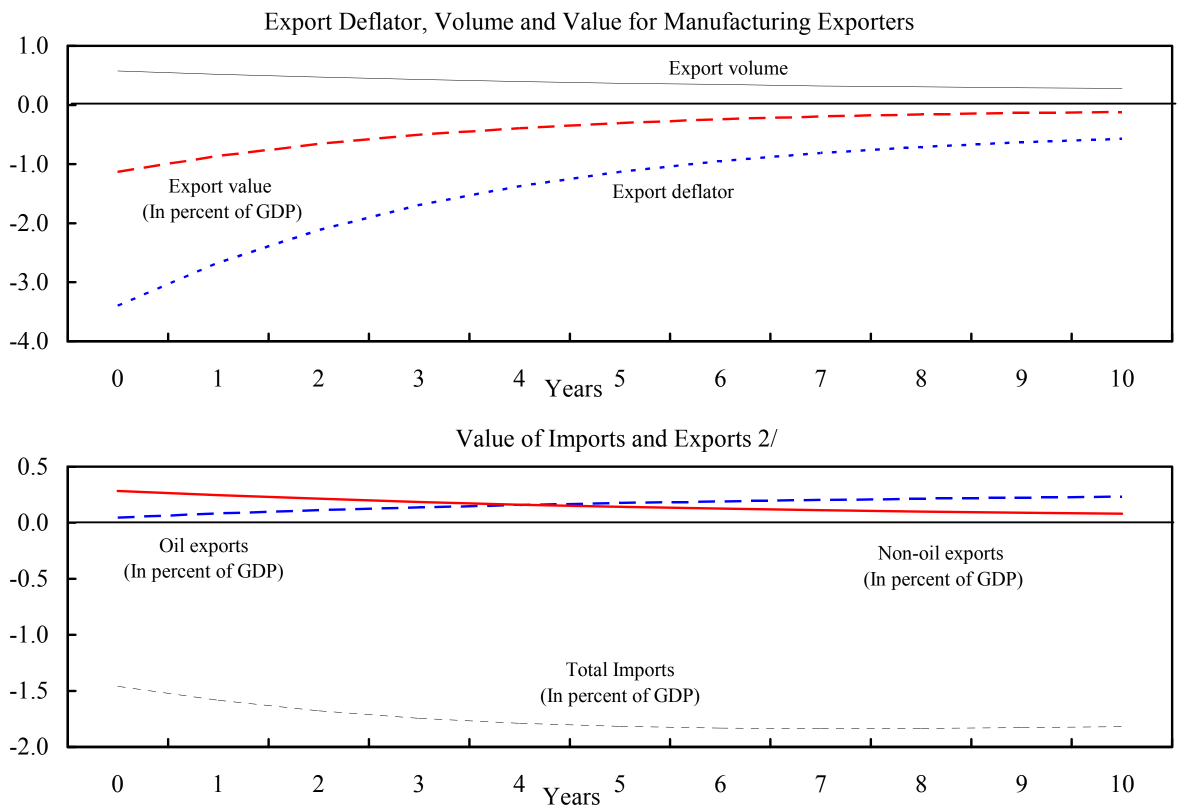
Imports and Exports of Goods and Services: Actual and Predicted Growth Rates 1/ 2/



Source: International Monetary Fund; WEO database; and IMF staff estimates.
1/ Average of annual percentage changes of actual and predicted volumes and values (US dollars) for Argentina, Brazil, Ecuador, Indonesia, Korea, Malaysia, Mexico, Philippines, Thailand, Turkey, and Uruguay.
2/ t refers to the first year of the capital account crisis.

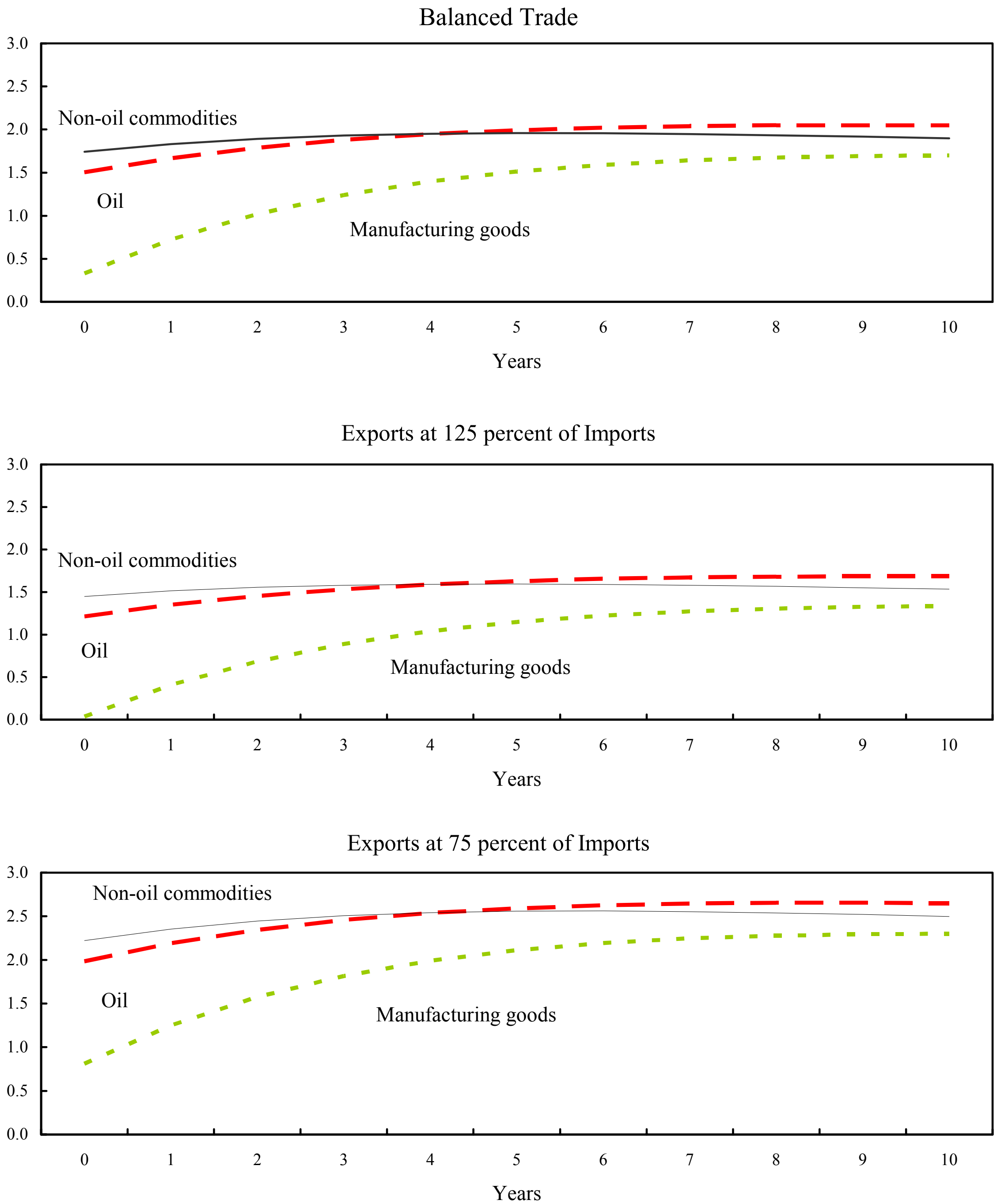
37. As indicated above, the response of the trade balance to a nominal exchange rate depreciation may also depend on whether the country has an initial surplus or deficit—particularly in the case of manufactures exporters because, for them, the export value response has an opposite effect on the trade balance than the import value response. From Box 2, given the larger (negative) price elasticity of imports compared to the value of exports, the modified "Marshall-Lerner" condition is more likely to be satisfied—and hence a depreciation (appreciation) is more likely improve (deteriorate) the trade balance—the larger are imports in relation to exports; that is, the larger the initial trade deficit. The sensitivity of the trade balance response to initial conditions can be seen in Figure 3 (panels 2 and 3), which compares the trade balance dynamics starting from an initial deficit and an initial surplus. For example, assuming exports at 40 percent of GDP and imports at 32 percent of GDP, a 10 percent depreciation would raise the trade balance for a country that exports manufactures by about 1¼ percent of GDP in the medium term. Conversely, assuming exports at 40 percent of GDP and imports at 50 percent of GDP, a 10 percent depreciation would raise the trade balance for a country that exports manufactures by about 2¼ percent of GDP over the medium term.

Figure 2. Profiles for Exports, Imports, and Trade Balances
(Percent change following a 10 percent nominal exchange rate depreciation) 1/



Source: International Monetary Fund, staff estimates.
1/ These profiles assume a 10 percent depreciation of the nominal exchange rate for a country with export and import ratios at 40 percent of GDP.
2/ Imports refers to all countries; exports refers to oil and non-oil commodity exporters.

Figure 3. Effect of a Depreciation on the Trade Balance
(Percent change following a 10 percent nominal exchange rate depreciation) 1/



Source: International Monetary Fund, staff estimates.
1/ These profiles show changes in the trade balance (in percent of GDP) following a 10 percent depreciation of the nominal exchange rate in period zero. The export ratio is fixed at 40 percent of GDP, while the import ratio is 40 percent in the first panel, 32 percent in the second panel and 50 percent of GDP in the third panel.

V. Conclusions

38. Assessing the impact of exchange rate movements on the trade balance is important for the Fund's work in both program and surveillance contexts. Even very simple econometric specifications yield surprising rich and complex dynamics as relative prices respond to the nominal exchange rate, import and export volumes respond to relative price movements, and the trade balance responds to changes in import and export values.

39. The analysis suggests several important findings. The response of a country's trade balance depends crucially on the market structure of its exports; in particular, whether it primarily exports goods for which there is highly elastic demand at a given world price, or differentiated products with downward sloping demand curves. As regards imports, wealth and balance sheet effects on domestic absorption is an important additional channel through which the exchange rate may affect the trade balance in emerging market economies. Export volume and pricing-to-market elasticities tend to be quantitatively small, so most of the response of the trade balance comes from the behavior of imports. Given the larger (negative) price elasticity of imports compared to the value of exports, the impact of an exchange rate movement will depend on the initial trade balance, with a condition akin to the Marshall-Lerner condition governing whether a nominal exchange rate depreciation (appreciation) will improve (respectively, deteriorate) the trade balance measured in foreign currency terms of a country that is small in the market for its imports but large in its export market. Specifically, the larger the initial trade surplus, the less likely that this condition will be fulfilled—or at least the smaller the impact on the trade balance of an exchange rate movement.

40. Overall, the estimated elasticities are by no means negligible; a 10 percent nominal depreciation leads to an improvement in the trade balance of about 1½ to 2 percent of GDP depending on the class of exporter and assuming an export-to-GDP ratio similar to the average for the countries in the sample (40 percent). Moreover, the impact on economic activity and output of external adjustment would of course be correspondingly larger than in the absence of an exchange rate adjustment. Of course, these results need to be interpreted with care given the caveats raised earlier. It should also be noted that the paper focuses on the *average* impact of a nominal exchange rate change on the trade balance, and therefore does not differentiate between countries whose real exchange rates may be in or out of equilibrium during the sample period. In principle, the closer the real exchange rate to its equilibrium value, the more a nominal exchange rate depreciation is likely to be eroded through a rise in domestic costs and pricing behavior of exporters. Finally, it bears emphasizing that the results pertain to middle-income countries and, therefore, cannot be used on their own to examine global imbalances; for example, as previously noted, pricing-to-market on the import side is largely absent in this sample of countries even though studies on advanced economies show that these effects are quantitatively important—implying a more limited impact of the exchange rate on the volume of imports for such countries.

Appendix I. Overview of the Empirical Literature on Trade Volume Price Elasticities and Pricing to Market

The trade elasticities literature—a partial-equilibrium approach to studying external adjustment using price (and income) elasticity of imports (or exports)—has a long history in empirical international trade. Since the seminal contribution of Houthakker and Magee (1969), which has influenced much of the subsequent research in this area, the literature has used developments in methodologies, theory-based inclusion of additional variables, and increased sample sizes to further refine the estimates.[26] As illustrated in the survey of Goldstein and Khan (1985), past empirical explorations have largely focused on advanced economies, but recent papers have increasingly covered developing and other emerging market countries.

Table AI. Estimates of Price Elasticities in Selected Papers

	Period	Number of countries		Exports 1/		Imports 1/	
Houthakker and Magee (1969)	1951-66	15	2/	-0.5		-0.4	
Reinhart (1994)	1968-92	12	3/	-0.3	4/	-0.6	
Senhadji (1998)	1960-93	77	5/	...		-0.3	6/
		77	5/	...		-1.1	7/
Senhadji and Montenegro (1999)	1960-93	75	5/	-0.2	6/	...	
		75	5/	-1.0	7/	...	
Caporale and Chui (1999)	1960-92	21	3/	-0.5	8/	-0.5	8/
		21	3/	-1.2	9/	-0.5	9/
Hooper, Johnson, and Marquez (2000)	1950-97 10/	7	2/	-0.3	6/	-0.1	6/
		7	2/	-0.9	7/	-0.4	7/
Marquez (2002)	1980 to late '90s	8	3/	-2.1		-0.7	
Bahmani-Oskooee and Kara (2005)	Mid 1970s to '90s	28	3/	-1.0		-1.2	

1/ Simple average of country estimates.
2/ Industrial countries only.
3/ Developing countries only.
4/ Industrial countries' demand for developing country exports.
5/ Industrial and developing countries.
6/ Short-run estimates.
7/ Long-run estimates.
8/ Dynamic Ordinary Least Squares (DOLS) estimator à la Stock and Watson (1993).
9/ Autoregressive Distrubuted Lag (ARDL) estimator à la Pesaran and Shin (1995).
10/ Period coverage differs; from mid 1950s to early 1970 to either 1996Q4 or 1997Q1.

This appendix examines some of the more recent estimates of price elasticities based on aggregate macroeconomic data on import and export volumes, both for industrialized as well as developing countries. Estimates of price elasticities of export and import demand vary

[26] References to earlier research, including an influential methodological critique by Orcutt (1950), can be found in Goldstein and Khan's (1985) review in the *Handbook of International Economics*. Tables 4.1 and 4.2 of the review provide comprehensive lists of long- and short-run price elasticities for exports and imports.

greatly depending on the sample of countries, definition of relative price,[27] choice of control variables, the time period, and the underlying methodology. The elasticities reported in Table AI may to some extent be compared with the short-run and long-run volume elasticities in Table 1 of the main body of the text and the import demand volume elasticities reported in Table 4, though it should also be noted that the estimates in Table 1 distinguish between class of exports and those for manufactures are based on the estimation of a demand function. Recognizing the time series properties of the variables underlying the estimation of trade elasticities, most recent papers—unlike simple OLS estimates of Houthakker and Magee (1969)—use a cointegration framework à la Johansen (1988). In addition to this line of research, trade economists have also estimated equations with specified micro foundations, generally yielding higher elasticities. This is generally attributed to the effect of aggregation over different goods. It should be noted, however, that cost heterogeneity among producers within a sector also implies different levels of pass-through from exchange rates to aggregate prices; more precisely, if a country devalues, the less efficient firms exporting to the country are likely to exit. This means that the calculated pass-through to prices will be greater using micro data than using aggregate price indices and thus—for a given volume change—an upward bias to the volume elasticities derived from micro studies.

What are the main findings of the empirical literature? Reinhart (1994), in an early application of the literature using a cointegration framework, examines the relationship between relative prices and imports and exports in twelve developing countries in Asia, Africa, and Latin America. She finds very low price elasticities, well below unity, suggesting the need for large price swings to affect trade patterns. Hooper, Johnson, and Marquez (2000) focus on trade elasticities for G-7 countries. They develop a system of equations for real imports and exports, as well as real GDPs and relative prices, also allowing for dynamic adjustments by specifying error-correction equations. They generally find more elastic coefficients in the long run than in the short run. Marquez (2002) also examines the specific case of East Asian countries, finding much higher long-run price elasticities for imports and exports. He also finds—with the exception of Indonesia—the sum of long-run price elasticities to be less than -1, indicating an improvement in the current account balance in response to a real exchange rate depreciation.

Other recent papers have applied the Pesaran-Shin approach to autoregressive distributed lag (ARDL) modeling. Senhadji (1998) and Senhadji and Montenegro (1999) apply this technique on a sample of over 70 countries to estimate comparable sets of price (and income) elasticities, both for the short and the long run. Both papers find that—consistent with

[27] A variety of measures have been used to proxy relative prices of imports and exports. Houthakker and Magee define the relative price of imports as a ratio of the price index of imports into a given country to the country's wholesale price index and the relative price of exports as the ratio of the price index of a country's (real) exports to the export price index of the other exporting countries. Reinhart (1994) uses a simple ratio of import unit values (in domestic currency) to CPI and export unit values deflated by industrial countries' consumer prices (in U.S. dollars). Senhadji (1999) uses the ratio of import deflator to the GDP deflator as a measure of the relative price of imports, while Senhadji and Montenegro (1998) define the relative price of exports as the export price of the home country relative to the price of its competitors.

Hooper, Johnson, Marquez (2000)—while average price elasticities are close to zero in the short run, they approach unity in the long run. Furthermore, they document a wide range of estimates for the cross-section of countries in the sample. Caporale and Chui (1999) calculate import and export price (and income) elasticities for a sample of 21 countries, both industrialized and emerging. While they also report results of the dynamic OLS methodology, à la Stock and Watson (1995), they find that the ARDL approach produces coefficients more consistent with theoretical priors. Most recently, Bahmani-Oskooee and Kara (2005) apply these techniques to a sample of 28 countries, concluding that almost all price elasticities are negative and highly significant. They find that while developing countries tend to have price elasticities of less than unity, no clear pattern is found among industrialized countries. They also conclude that the Marshall-Lerner condition is met in the long run and, thus, that a devaluation would generally improve the trade balance.

As noted above, use of more micro-level data by trade economists have yielded much higher elasticities. In an influential paper, Riedel (1988) found Hong Kong's manufactured goods to face an infinitely elastic demand in world markets. While larger elasticities for small open economies are in line with trade theory, Panagariya, Shah, and Mishra (1996) found the magnitude implausible due to weaknesses in Riedel's methodology. Examining demand for Bangladesh's garment products in the U.S. market, using a well-specified demand equation, they find own-price elasticity to exceed (in absolute value) 65 in most specifications. Regarding import demand, Kee, Nicita, and Olarreaga (2004) have recently estimated over 300,000 import demand elasticities for 4,625 goods in 117 countries, finding a simple average of -1.67 (and a median of -1.08). They find import demand to be more elastic at a disaggregated level and elasticities to be higher among larger countries and lower income countries. Some authors (Abeysinghe and Choy, 2005) have examined the effect on export volume price elasticities of high import content in exports, finding evidence of lower elasticities.

Pricing to Market and Exchange Rate Pass-through for Emerging Markets

The literature on the analysis of the relationship between exchange rate movements and goods prices is more recent than on trade elasticities but correspondingly voluminous, especially for industrial countries. It has focused on two related areas of research: pricing-to-market and exchange rate pass-through. Recent papers on prices and exchange rate movements have examined whether pricing-to-market exists and the extent of the corresponding markup adjustment. Goldberg and Knetter (1997) argue that pricing-to-market (PTM) studies for industrialized countries find convincing evidence of price discrimination even among seemingly homogenous goods. Gaulier et al (2006) examine pricing-to-market behavior for a set of 130 industrial and developing countries and find some evidence of pricing-to-market behavior in over half of the industries examined and especially for final consumption goods. Studies on specific industries in emerging markets also suggest PTM behavior. Lee (1995) and Kim (2003) find PTM behavior among Korean export industries and Tongzon and Menon (1994) report PTM behavior for export industries in Singapore.

Motivated by the rise in industrial organization and strategic trade theory, empirical studies have examined the pass-through of exchange rate movements to both aggregate import prices

and import prices of specific industries. Much of this literature has focused on industrialized countries, in particular the US and Japan, and employed a single-equation estimation approach to assess the effects of the exchange rate change. The range of estimates varies across countries, with those for the US centered around 20 percent in the short-run and 40 percent in the long-run (Marazzi, Sheets, and Vigfusson, 2005), while those for the OECD are centered around 46 percent and 65 percent respectively (Campa and Goldberg, 2005). For G7 countries, Ihrig, Marazzi, and Rothenberg, (2006) estimate a pass-through effect of 40 percent for the period 1990-2004

Applied work for emerging market and developing countries is more limited. Barhoumi (2005a, 2005b) finds that the long-run exchange rate pass-through to import prices for a panel of developing countries varies between 64 percent and 83 percent depending on the chosen estimation methodology. Sahminan (2002) finds a similar long-run pass through estimate of about 83 percent on average for Thailand, Singapore, and Philippines. Taking account of the effects of market concentration, Lee (1997) estimates that about 62 percent of exchange rate movements pass-through to import prices across industries in Korea and that higher market concentration among specific industries weakens the pass-through effect.

Appendix II. Data Description and Sample

Export volume refers to exports of goods and services expressed in domestic currency at 2000 prices.

Export deflator for oil exporters is the average spot oil price converted into domestic currency.

Export deflator for non-oil commodity exporters is the weighted average spot commodity price index based on the share of these commodities in the exports of the commodity exporters and converted into domestic currency.

Domestic prices are represented by the consumer price index.

Foreign income is the output of partner countries weighted by their share in the exports of the exporting country.

The change in capacity is measured by the change in GDP per capita in PPP terms.

The output gap is measured as the log difference between actual output and trend output calculated using a HP filter over 20 years.

Export deflator for manufacturing exporters is export value divided by export volume, both in domestic currency.

Table AII. Country Sample

Country and exporter class	Beginning date	End date	Country and exporter class	Beginning date	End date
Oil Exporters			Manufacture Exporters		
Algeria	1980	2005	Botswana	1982	2005
Egypt	1988	2005	Brazil	1982	2005
Gabon	1980	2005	China	1980	2005
Iran	1981	2005	India	1980	2005
Libya	1991	2005	Indonesia	1988	2005
Oman	1991	2005	Jamaica	1980	2005
Syria	1980	2005	Jordan	1982	2005
Trinidad and Tobago	1982	2005	Korea	1980	2005
Venezuela	1980	2005	Lebanon	1992	2005
			Malaysia	1987	2005
Non-Oil Commodity Exporters			Mauritius	1980	2005
Argentina	1981	2005	Morocco	1980	2005
Bolivia	1981	2005	Mexico	1982	2005
Chile	1980	2005	Namibia	1982	2005
Colombia	1981	2005	Pakistan	1983	2005
Costa Rica	1986	2005	Philippines	1980	2005
Dominican Republic	1980	2005	Singapore	1982	2005
Ecuador	1991	2005	South Africa	1980	2005
El Salvador	1982	2005	Sri Lanka	1982	2005
Guatemala	1984	2005	Swaziland	1982	2005
Honduras	1980	2005	Thailand	1982	2005
Panama	1980	2005	Tunisia	1983	2005
Paraguay	1980	2005	Turkey	1980	2005
Peru	1982	2005			
Uruguay	1982	2005			

Relative export price for manufacturing exporters is the trade-weighted average of the domestic currency equivalent of unit labor costs in the country's trading partners.

Real absorption is output minus net exports expressed in domestic currency at 2000 prices.

Real disposable income is output minus government revenues deflated by the CPI index.

Import volume refers to imports of goods and services expressed in domestic currency at 2000 prices.

Import deflator is import value divided by import volume, both in domestic currency.

All variables are taken from the World Economic Outlook Database. The sample of countries encompasses all of the middle-income countries listed in the World Bank Development Report except for countries with a population of less than 1 million and transition economies. It also includes India and Pakistan given their importance in world trade and access to market financing.

Appendix III. Robustness Tests

This appendix describes the results of four robustness tests; specifically, the (i) effect of structural changes on volume elasticities, (ii) evidence on weakening pass-through effects of devaluations to inflation (controlling for high inflation cases), (iii) for manufacturers, evidence of pricing to market behavior even if large exporters are dropped from the sample and the absence of terms of trade effects on the supply of these goods, and (iv) estimates that show that import prices change almost one-to-one with a change in exchange rates.

The reported export volume elasticities may be affected by numerous factors, in particular structural changes that might lead to differences in trade patterns and to changes in trade costs. Such structural changes might explain the relatively large income elasticities obtained and, more importantly, could call into question the classification based on trade shares discussed in the main body of the text.

Table AIII-1. Export Volumes in Different Samples (Long-run Elasticities)

	# observ.	# countries	Relative price		Income effects	
	Baseline (1980-2005; see Table 1)					
Oil	186	9	0.16		1.27	***
Non-oil	310	14	0.02		1.87	***
Manufactures	511	23	-0.53	**	2.38	***
	1007	46				
	Baseline with time trend					
Oil	186	9	0.16		0.86	*
Non-oil	310	14	0.02		1.42	**
Manufactures	511	23	-0.60	**	1.98	***
	1007	46				
	Shorter time period (1992-2005)					
Oil	117	9	0.24	***	0.58	
Non-oil	169	13	0.14	**	1.27	**
Manufactures	312	24	-0.61	***	2.04	***
	598	46				

Source: IMF staff estimates.

Note: * = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level. Estimation with intercept.

To examine these factors, Table AIII-1 contrasts the baseline export volume elasticities with those obtained after adding a time trend. As shown in the table, income elasticities are somewhat lower but there is no meaningful change in the relative price elasticities. More importantly, given how countries are assigned to the three export categories in this paper, an estimation over a shorter time period reduces the risk that changes in trade patterns might have led to classifying countries according to trade shares that might no longer be valid. However, a shorter time period (1992−2005) only leads to the classification of the Dominican Republic as a manufacturing exporter (rather than a non-oil commodity exporter) and yields broadly similar results as to price and income elasticities.

An additional source of sample bias might arise when borderline countries—e.g., those that might have broadly similar trade shares in two of the three categories defined—are forced into one category alone. In effect this aggregation disregards some of characteristics of a country's trade patterns. For example, Egypt is classified as an oil exporter in the estimations in this paper, but could have also been classified as a manufacturing exporter. Dropping these borderline cases does not meaningfully change the estimates regarding volume elasticities (not shown).

Table AIII-2. Inflation Equation, Effect of a Change in Exchange Rates 1/

	# observ.	Short-run	Long-run
Period 1980-2005	1007	0.35 ***	0.91 ***
Period 1995-2005 (baseline)	506	0.21 ***	0.64 ***
Period 1980-2005 (low inflation only) 1/	634	0.12 **	0.88 ***
Period 1995-2005 (low inflation only) 1/	406	0.09 **	0.56 ***

Source: IMF staff estimates.

1/ Data with annual inflation rates of less than 10 percent. Specification mimics the equation estimated in Table 3.

As to the inflation equation, it is generally argued that the pass-through effect from

nominal exchange rate changes have declined over time. These pass-through effects are also influenced by high inflation events, though to some extent the estimates in this paper control for the latter by transforming the inflation rate and the nominal exchange rate change so that both lie in the interval (-100, 100) percent. As expected, Table AIII-2 shows that pass-through effects are indeed smaller in recent years, declining from 0.35 to 0.21 in the short-run and from 0.91 to 0.64 in the long-run. The table also shows that excluding high inflation cases (annual inflation rates of over 10 percent) results in slightly lower pass-through effects. It is also worth noting that fewer high inflation cases exist post-1994 than is the case over the preceding 15 years—20 percent of the observations are high inflation cases compared to about 54 percent in the sample covering the 1980-1994 period.

The price equations discussed in this paper do not control for a country's exchange rate regime. Since a country with a fixed regime is likely to experience a smaller pass-through of exchange rate movements into domestic prices, this could in turn increase the improvement of the trade balance that would arise from a permanent nominal depreciation. Indeed, as shown in Table AIII-3, a 10 percent depreciation would about 50 percent higher among countries with fixed regimes.

Table AIII-3. Impact on the Trade Balance of a 10 Percent Depreciation 1/
(In percent of GDP)

	Commodity exporters		Manufacturing exporters	
	Short-run	Long-run	Short-run	Long-run
Fix and flexible regimes	1.6	1.8	0.3	1.6
Fix regime countries	1.6	2.9	0.3	2.5

1/ Assuming that trade is in balance and that the export to GDP ratio is 40 percent.

The paper also argues that pricing to market behavior applies to manufacturing exporters. But could this be influenced by the economic importance of some of the countries in the sample? Table AIII-4 shows that the pricing to market behavior remains valid even if the five largest emerging market economies (EMEs), all of which are manufacturing exporters, are excluded from the sample; the short- and long-run pricing to market coefficients are largely unchanged (0.89 and 0.87 in the long-run and 0.58 and 0.53 in the short-run). Moreover, as indicated in footnote 13, the volume of

Table AIII-4. Pricing Equation for Manufacturing Exporters for Different Samples 1/

	Coefficient estimates	Long-run elasticities	Coefficient estimates	Long-run elasticities
	Baseline		Drop five largest countries	
Export deflator				
First lag	0.73 ***		0.73 ***	
Exchange rate in local currency per US$				
Contemporaneous	0.58 ***	0.89 ***	0.53 ***	0.87 ***
First lag	-0.34 ***		-0.30 ***	
Unit labor costs (ULC) of competitors 1/				
Contemporaneous	0.20 **	0.57 ***	0.18 **	0.69 ***
First lag	-0.05		0.01	
CPI index (logs); proxy for domestic costs				
Contemporaneous	0.40 ***	0.09	0.41 ***	0.05
First lag	-0.38 ***		-0.40 ***	
Change in per capita GDP (PPP terms)				
Contemporaneous	-0.06		-0.12	
First lag	0.09		0.01	
Output gap				
First lag	-0.01		0.07	
Diagnostic Statistics				
# observations	511		396	
# countries	23		18	
R squared	0.99		0.99	
Tests				
Hansen test	14.19		10.74	
A-B test for AR(1)	-1.60		-1.43	
A-B test for AR(2)	-0.66		-0.53	

Source: IMF staff estimates.

Note: * = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level. Estimation with intercept.

1/ Drops China, Mexico, Korea, India, and Brazil—64 percent of total sample GDP in 2002.

exports of manufactures does not respond to movements in the internal terms of trade because the export deflator relative to domestic prices (as measured by the CPI) has an insignificant negative coefficient (-0.08) when this variable is added to the specification in Table 1 while the coefficient on relative export prices remains stable and significant at -0.16. As was the case for the price equation, the pricing to market equation (not shown) remains largely unchanged when (i) high inflation cases are dropped or (ii) the estimation period is 1995-2005.

Finally, the paper assumes that the pricing to market behavior does not apply to the imports of the EMEs. Implicitly, it is assumed that imports are so diversified that an exchange rate depreciation will translate into immediately higher import prices in domestic currency. Table AIII-5 provides estimates for a basic form of price equation for imports. The first estimation applies only to manufacturing exporters and the second to all countries in the sample. In both cases the evidence is quite overwhelming: pricing to market does not appear to apply to the imports of EMEs. In fact, the adjustment in the domestic price of imports is particularly rapid—both short- and long-run coefficients are one. Adding foreign labor costs yields similar results regarding the reaction of import prices in domestic currency to a change in exchange rates.

Table AIII-5. Pricing Equation for Imports

	Coefficient estimates	Long-run elasticities	Coefficient estimates	Long-run elasticities
Import deflator				
First lag	0.77 ***		0.76 ***	
Exchange rate in local currency per US$				
Contemporaneous	0.97 ***	0.99 ***	0.97 ***	1.01 ***
First lag	-0.73 ***		-0.73 ***	
Diagnostic Statistics				
# observations	511		1007	
# countries	23		46	
Tests				
Hansen test	21.29		45.24	
A-B test for AR(1)	-2.17 **		-3.38 ***	
A-B test for AR(2)	-0.85		-0.21	

Source: IMF staff estimates.

Note: * = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level. Estimation with intercept.

Appendix IV. Estimation Procedures

This appendix discusses alternative estimation methods and the robustness of the paper's main findings.

Arellano-Bond Estimator

The baseline specification is estimated using the Blundell and Bond (1998) GMM-system estimator, which is a development of the earlier Arellano and Bond (1991) estimator and exploits the fact that the number of cross section units (countries) is large relative to the time periods. Under these conditions, the estimators satisfy asymptotic properties of normality and stationarity.

Since the price and volume series used in this paper are persistent, they are assumed to follow an AR(1) model. An unobserved unit specific time-invariant effect which is stochastic allows for heterogeneity across countries. While the disturbances are assumed to be uncorrelated across countries, they are likely correlated with the lagged dependent variable, requiring the use of first differences to eliminate this effect. To control for the serial correlation induced by first differencing requires instruments that are lagged one additional period because of the dependence of the differenced error term on its lagged value. Therefore, variables that could be considered endogenous such as the relative price terms in the volume equations are estimated with lags of two periods. Since the first-differenced error term has a first-order moving representation of serial correlation, the generalized method of moments (GMM) estimator provides a framework for correcting for this bias and hence obtaining efficient coefficient estimates.[28]

While the equations are estimated in level terms, they can be rewritten in terms of changes and lagged levels to derive short-run and long-run elasticities. For example, taking a generic equation expressed in levels with one lagged dependent term and a contemporaneous and lagged exogenous term

$$X_t = \beta_0 + \beta_1 X_{t-1} + \delta_0 Y_t^* + \delta_1 Y_{t-1}^*$$

This equation can be transformed into the following representation

$$\Delta X_t = \beta_0 + (\beta_1 - 1) X_{t-1} + \delta_0 \Delta Y_t^* + (\delta_0 + \delta_1) Y_{t-1}^*$$

In this case the short-run elasticity of X with respect to Y is δ_0 and the long-run elasticity is $(\delta_0 + \delta_1)/(1-\beta_1)$.

[28] In terms of specification tests, while the first differenced error term has first order serial correlation, it should not be subject to second order serial correlation; this hypothesis is tested following the methodology proposed by Bond and Windmeijer (2002). With more than three periods, the model is over-identified and the GMM test for over-identifying restrictions can be used to ascertain the number of instruments; it should be noted, however, that this test loses statistical power as the number of time series data points increases (Bowsher, 2002).

These elasticities are calculated in each of the estimated equations and allow for comparability with the estimates derived from the two estimators discussed below.

Mean Group and Pooled Mean Group Estimators

As the time-series dimension of the data increases, alternative estimators based on cointegration tests are commonly used. Therefore, to confirm the validity of the baseline specification estimates presented in the body of the paper, estimates are also obtained from two alternative estimators. The first estimator was proposed by Pesaran and Smith (1995)—mean group (MG) estimator—and consists of estimating separate auto-regressive distributed lag models for each country, where dependent and independent variables enter the right-hand side. The MG estimator then derives the full panel estimates as simple averages of individual country coefficients. The second estimator recognizes that the long-run response of the dependent variable to exchange rate changes might be the same across countries and Pesaran, Shin, and Smith (1999) propose a maximum likelihood-based estimator called "pooled mean group" (PMG) that pools the individual long-run regression coefficients. The validity of the cross-sectional long-run homogeneity restriction—and hence the suitability of the PMG estimator—can be tested by a Hausman-type statistic (the *h*-statistic).

Mean Group and Pooled Mean Group Estimates

To conserve on degrees of freedom while allowing for reasonably rich dynamics, the number of lags used to obtain the MG and PMG estimates is set to a maximum of 2. The estimation period is 1980−2005 for all the countries

The results for the oil-exporting group are consistent with the prior that the supply of oil exports is fairly inelastic in terms of price since the price elasticity estimates only vary between 0.16 and 0.43. By the same token, the volume elasticity of oil exports to world income is very low at 0.35 for the PMG estimator, suggesting that the supply of oil is not particularly sensitive to income developments. This contrasts with the results for non-oil commodity exports, which display considerably greater sensitivity to world income growth and lower sensitivity to price changes.

Exports of manufactures have the greatest sensitivity to trading partners income. Moreover, the *h*-statistic for this variable rejects the long-run cross-country homogeneity restriction, indicating considerable cross-country heterogeneity in the way manufacturing exports respond to changes in trading partners income. Relaxing the cross-country homogeneity restriction (in other words, focusing on the MG estimator), the estimates indicate no significant response of export volumes to relative price movements (i.e., a non-statistically significant long-run price elasticity of 0.30). Although the long-run price elasticity of export volumes using the Arellano-Bond procedure is significantly negative (about −0.53), the price elasticity estimate excludes pass-through effects that, when included, result is a long-run volume response to a currency depreciation of only 0.02. In other words, both the MG estimator and the Arellano-Bond estimator suggest that the long-run volume response is small. This weak response might reflect the large costs of moving in and out of export markets.

Regarding the import equation, the estimates overwhelmingly point to a highly significant income elasticity of imports in the range of 1.7 to 2.1. A low *h*-statistic value indicates that long-run slope homogeneity restriction cannot be rejected; that is, the PMG estimator is preferred to the MG estimator. This points to a relative price elasticity of -0.56 and an income elasticity of 1.70, very close to the estimates obtained using the Arellano-Bond procedure.

Table AIV-1. Trade Elasticities and Estimation Methodologies

	Oil exporters (supply)	Non-oil commodity exporters (supply)	Manufacturing exporters (demand)	Import demand (all countries)
	System GMM (Table 1 through 3, main body of paper)			
Long-run price elasticities	0.16	0.02	-0.53 **	-0.44 ***
Long-run income elasticities 2/	1.27 ***	1.87 ***	2.38 ***	1.54 ***
# observations	186	310	511	824
	Mean group estimator (Pesaran and Smith, 1995)			
Long-run price elasticities	0.24	0.16	0.30	-0.73
Long-run income elasticities 2/	0.96	1.98	4.96 ***	2.13 ***
# observations	267	330	602	1177
	Pooled mean group estimator (Pesaran, Shin, and Smith, 1999)			
Long-run price elasticities	0.43 ***	0.28 ***	0.59	-0.56 ***
Long-run income elasticities 2/	0.35 ***	2.21 ***	2.11 ***	1.70 ***
# observations	192	330	602	1177

Source: IMF staff estimates.

Note: * = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level.

1/ Demand equation for system GMM and supply equation for group estimators.

2/ Real GDP of trading partners for all export equations and domestic real GDP for the import equation.

In sum, the results from the three estimators indicate that these are robust to alternative assumptions about the importance of the time-series component of the data. They show that imports are more sensitive to relative price movements than exports of manufactures and that the latter respond strongly to movements in foreign income. Moreover, the long-run effect of a depreciation is quite similar. In this regard, Table AIV-2 indicates that a 1 percentage point depreciation leads to a ⅓ percentage point improvement in the trade balance for manufacture exporters starting from a position of balanced trade. For oil and non-oil exporters, the improvement is stronger when the PGM estimator is used because of the higher estimated long-run export supply price elasticities. However, the difference is small—about 0.15 percent.

Table AIV-2. Long-run Effects of Devaluations on Export-Import Values and on the Trade Balance (in foreign currency) for Different Classes of Exporters (percent change for a depreciation of 1 percent) 1/

	Oil exporters	Non-oil commodity exporters	Manufacturing exporters
Estimates using the Arellano-Bond estimator	0.48	0.42	0.40
Estimates using the Pooled Mean Group estimator	0.65	0.59	0.42

Source: IMF staff estimates.

1/ Initial trade balance equal to zero with elasticity defined as $\eta = (dTB / x_{val}) / (de / e)$.

References

Abeysinghe, T. and K. Choy, 2005, “Modeling Small Economy Exports: The Case of Singapore,” SCAPE Working Paper Series, No. 2005/01.

Alonso-Borrego, C. and M. Arellano, 1999, “Symmetrically normalized instrumental variable estimation using panel data,” *Journal of Business and Economic Statistics*, Vol. 76, pp. 309-21.

Arellano, M., and S. Bond, 1991, “Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations,” *Review of Economic Studies*, Vol. 58, pp. 277-97.

Bahmani-Oskooee, M., and O. Kara, 2005, “Income and Price Elasticities of Trade: Some New Estimates,” *International Trade Journal*, Vol. 19, No. 2, pp. 165-78.

Barhoumi, K., 2005a, “Exchange Rate Pass-Through Into Import Prices In Developing Countries: An Empirical Investigation” *Economics Bulletin,* Vol.3, No.26, pp.1-14.

Barhoumi, K., 2005b, “Long-Run Exchange Rate Pass-Through Into Import Prices In Developing Countries: An Homogenous or Heterogeneous Phenomenon?” *Economics Bulletin,* Vol.6, No.14, pp.1-12.

Becker, T. and P. Mauro, 2006 “Output Drops and the Shocks that Matter,” Working Paper No. 06/172 (Washington: International Monetary Fund).

Binder, M., C. Hsiao, and M. Pesaran, 2005, “Estimation and inference in short panel vector autoregressions with unit roots and cointegration,” *Econometric Theory*, Vol. 21, pp. 795-837.

Blundell, R. and S. Bond, 1998, “Initial conditions and moment restrictions in dynamic panel data models,” *Journal of Econometrics*, Vol. 87, pp. 115-43.

Bond, S., C. Bowsher, and F. Windmeijer, 2001, “Criterion-Based Inference for GMM in Autoregressive Panel Data Models” *Economics Letters*, Vol. 73 pp. 379-88.

Bond, S. and F. Windmeijer, 2002, “Projection Estimators for Autoregressive Panel Data Models” *Econometrics Journal*, Vol. 1 pp. 141-62.

Campa, J. and L. Goldberg, 2005, “Exchange Rate Pass-Through Into Import Prices’, *The Review of Economics and Statistics*, Vol. 87(4), pp.679-690.

Caporale, G. and M. Chui, 1999, “Estimating Income and Price Elasticities of Trade in a Cointegrating Framework,” *Review of International Economics*, Vol. 7, No. 2, pp. 254-64.

Frankel. J., 2005, “Contractionary Currency Crashes in Developing Countries,” mimeo, Harvard University.

Gaulier, G., A. Lahreche-Revil, and I. Mejean, 2006, “Structural Determinants of the Exchange-Rate Pass-Through”, CEPII Research Center Working Paper.

Ghosh, A., et al. 2005, “The Design of IMF-Supported Programs,” Occasional Paper No. 241 (Washington: International Monetary Fund).

Goldberg, P. and M. Knetter, 1997, “Goods Prices and Exchange Rates: What Have We Learned”, *Journal of Economic Literature*, Vol.35, No.3, pp.1243-1272.

Goldstein, M. and M. Khan, 1985, “Income and Price Effects in International Trade,” in Jones, R., and P. Kenen, eds., *Handbook of International Economics*, Vol. II (Amsterdam: Elsevier), pp. 1042-99.

Hooper, P., K. Johnson, and J. Marquez, 1998, “Trade Elasticities for G-7 Countries,” International Finance Discussion Paper No. 609 (Washington: Board of Governors of the Federal Reserve System).

Houthakker, H. and S. Magee, 1969, “Income and Price Elasticities in World Trade,” *Review of Economics and Statistics*, Vol. 51, No. 2, pp. 111-25.

Ihrig, J., M. Marazzi, and A. Rothenberg, 2006, “Exchange-Rate Pass-Through in the G7 Countries’, Board of Governors of the Federal Reserve System, International Finance Discussion Papers No. 851.

Ito, T. and K. Sato, 2006, “Exchange Rate Changes and Inflation in Post-Crisis Asian Economies: VAR Analysis of the Exchange Rate Pass-Through”, NBER Working Paper No 12395.

Johansen, S., 1988, “Statistical Analysis of Cointegration Vectors,” *Journal of Economic Dynamics and Control*, Vol. 12, pp. 231-54.

Kee, H., A. Nicita, and M. Olarreaga, 2004, “Import Demand Elasticities and Trade Distortions,” Policy Research Working Paper No. 3452 (Washington: The World Bank).

Kim, H., 2003, “The Relative Exchange Rate and Export Price Rivalry”, *Bank of Korea Economic Papers,* Vol.6, No2, pp.80-110.

Lane, Philip and Gian Maria Milesi-Ferretti, 2006, “The External Wealth of Nations Mark II: Revised and Extended Estimates of Foreign Assets and Liabilities, 1970–2004,” Working Paper No. 06/69 (Washington: International Monetary Fund).

Lee, J., 1995, “Pricing-to-Market in Korean Manufacturing Exports”, *International Economic Journal*, Vol.9, No.4, pp.1-12.

Lee, J., 1997, “The Response of Exchange Rate Pass-Through to Market Concentration in a Small Economy: The Evidence from Korea”, *Review of Economics and Statistics*, Vol.79, No.1, pp.142-5.

Marazzi, M., N. Sheets, and R. Vigfusson, 2005, "Exchange Rate Pass-Through to US Import Prices: Some New Evidence", Board of Governors of the Federal Reserve System, International Finance Discussion Papers No. 833.

Marquez, J., 2002, *Estimating Trade Elasticities* (Boston: Kluwer).

Orcutt, G., 1950, "Measurement of Price Elasticities in International Trade," *Review of Economics and Statistics*, Vol. 32, No. 2, pp. 117-32.

Panagariya, A., S. Shah, and D. Mishra, 1996, "Demand Elasticities in International Trade: Are They Really Low?" Policy Research Working Paper No. 1712 (Washington: The World Bank).

Pesaran, H. and R. Smith, 1995, "Estimating long-run relationships from dynamic heterogeneous panels," *Journal of Econometrics*, Vol. 68, pp. 79-113.

Pesaran, H. and Y. Shin, 1996, "Cointegration and Speed of Convergence to Equilibrium," *Journal of Econometrics*, Vol. 67, pp. 117-143.

Pesaran, H., Y. Shin, and R. Smith, 1999, "Pooled Mean Group Estimation of Dynamic Heterogeneous Panels" *Journal of American Statistical Association*, Vol. 94, pp. 621-34.

Ramakrishnan, U. and J. Zalduendo, 2006, "The Role of IMF Support in Crisis Prevention," Working Paper No. 06/75 (Washington: International Monetary Fund).

Reinhart, C., 1994, "Devaluation, Relative Prices, and International Trade: Evidence from Developing Countries," Working Paper No. 94/140 (Washington: International Monetary Fund).

Riedel, J., 1988, "The Demand for LDC Exports of Manufactures: Estimates from Hong Kong," *Economic Journal*, Vol. 98, pp. 138-48.

Rose, A. and J. Yellen (1989), "Is there a J-curve?" Journal of Monetary Economics, 24, pp 53-68.

Sahminan, S., 2002, "Exchange Rate Pass-Through into Import Prices: Empirical Evidence from Some Southeast Asian Countries", mimeo.

Senhadji, A., 1998, "Time-Series Estimation of Structural Import Demand Equations: A Cross-Country Analysis," *Staff Papers*, Vol. 45, No. 2, pp. 236-68.

Senhadji, A. and C. Montenegro, 1999, "Time Series Analysis of Export Demand Equations: A Cross-Country Analysis," *Staff Papers*, Vol. 46, No. 3, pp. 259-73.

Stock, J. and M. Watson, 1993, "A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems," *Econometrica*, Vol. 61, pp. 783-820.

Tongzon, J. and J. Menon, 1994, "Exchange Rates and Export Pricing in a Small Open NIC: The Singaporean Experience", *Singapore Economic Review*, Vol.39, No.2, pp.201-11.