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The US Tourism Trade Balance and Exchange Rate Shocks

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This paper investigates the effect of dollar depreciation on the US tourism trade balance. Export revenue and import spending functions are estimated separately with structural vector autoregressive methods to better capture dynamic adjustments to exchange rate shocks. Quarterly data cover the period of floating exchange rates from 1973 through 2007. Depreciation has no significant effect on tourism export revenue or import spending. US tourists are more sensitive to income than are tourists coming to the US.

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The US Tourism Trade Balance and Exchange Rate Shocks

Tourism is a growing component of world income as well as the US balance of trade. The US ranks first in tourism export revenue and second in import spending (UNWTO, 2008). The US has had a trade surplus in tourism since the 1990s with tourism receipts accounting for 5% of export revenue in 2007. International tourism has grown over the last three decades and has become a major source of income for a number of countries.

The trade balance following a depreciation may exhibit J-curve adjustment, falling due to set contracts but then rising over time. Empirical results in the J-curve literature are mixed. Conditions regarding the J-curve are based on the aggregate trade balance. Some studies have investigated disaggregated industrial trade data but none have explicitly examined tourism. The motivation for examining particular industries is to learn more about the microeconomic behavior of those in the particular market.

There are two basic approaches to examine the trade balance effects of depreciation. The elasticity approach estimates price elasticities directly based on export and import demand functions, employing aggregate price or volume indices (Houthakker and Magee, 1969; Goldstein and Khan, 1978; Rosensweig and Koch, 1988; Senhadji, 1998a; Senhadji and Montenegro, 1999). The trade balance approach estimates the trade balance function to examine any J-curve improvement of trade balance due to the Marshall-Lerner condition (Magee, 1973; Rose and Yellen, 1989; Onafowora, 2003).

The present paper analyzes tourism export revenue and import spending separately to examine their dynamic adjustments to the exchange rate. A structural vector autoregression SVAR model examines quarterly data during the floating exchange rate period from 1973 through 2007. The strength of estimating the two functions separately is that it can capture the short and long term dynamics of each individual function to an exchange rate shock instead of only the net change in the trade balance. The present approach may also avoid the aggregation bias across different goods that may lead to unreliable estimates of export and import demand elasticities that can occur with indices of volumes or prices.

The following section discusses the theoretical framework with tourism spending as a function of income and the exchange rate, followed by a brief review of that part of the J-curve literature focused on disaggregated data. The third section presents the econometric model followed by a section on the empirical results.

1. Tourism Balance of Trade

Socher (1986) points out that tourism as a trading service had not been explicitly integrated into trade theory but this has been recently done by Hazari and Ng (1993), Hazari (1995), Hazari and Nowak (2003), and Hazari and Sgro (2004). The main characteristic of tourism relative to other traded products is that the importers have to visit the exporting country.

Tourism is a luxury good with income elasticity exceeding one in the literature that includes Harrop (1973), Rosensweig (1988), Crouch (1994), Song, and Witt and Li (2009). Dupont, Ghandi, and Weiss (2008) present a long term study of US tourism imports covering 1820 to 2000.

Vogt (2008) separates US tourism exports and imports with data from 1973 to 2002. Error correction models on annual data find that US tourists are more sensitive to the trade weighted exchange rate while foreign tourists to the US are more sensitive to real income. The present study uncovers different adjustment patterns in quarterly data extended through 2007 with structural vector autoregressive methods. Specifically, the responses of US and foreign tourists to nominal exchange rate shocks are statistically insignificant. US tourists are more sensitive to nominal income in the present structural vector autoregressive model. Vogt controls for price differences with a weighted consumer price index that may introduce aggregation bias.

The present study adopts a two-country partial equilibrium model where the home country is the US and the foreign country is the rest of the world (ROW). International and domestic tourism are imperfect substitutes, especially for cultural and natural resource attractions. The assumption of imperfect substitutes follows the literature including Rhomberg (1973), Magee (1975) Goldstein and Khan (1985), and Rose and Yellen (1989). Consumers choose between international and domestic tourism according to preferences and constrained by income Y.

Dollar depreciation, an increase in the dollar price E of foreign currency, raises the price of foreign tourism for US travelers lowering the quantity demanded of imported tourism. Conversely, depreciation lowers the price for foreign tourists coming to the US, raising the quantity demanded of exported tourism. Domestic demand D_m for tourism abroad and foreign demand D_m^* for tourism in the US also depend on respective incomes.

Demand functions in general functional form are

$$D_m = D_m(Y, p, Ep^*) \text{ and}$$

$$D_m^* = D_m^*(Y^*, p/E, p^*) \qquad (1)$$

where Y is US income, Y* foreign income, p the price of tourism in US, and p^* the price of tourism abroad. Positive cross price effects reflect imperfect substitutes. Dollar depreciation lowers US demand D_m for tourism abroad and raises foreign demand D_m^* for international tourism in the US.

Supplies of US and foreign tourism S_x and S_x^* are positive functions of price

$$S_x = S_x(p) \text{ and}$$

$$S_x^* = S_x^*(p^*). \qquad (2)$$

Equilibrium quantities of international tourism are determined in the markets where $D_m = S_x^*$ and $D_m^* = S_x$. The present analysis does not include p and p^* explicitly given the lack of data on prices tourists pay. Prices are implicitly included, however, in export revenue X and import spending M. The only tourism price variation in the model is due to the nominal exchange rate.

Export revenue for the home country is $X = pq_x$ where q_x is tourism quantity,

$$X = X(Y^*, E). \qquad (3)$$

Dollar depreciation lowers the price of international tourism in the US, increasing the quantity q_x and export revenue X.

Similarly, import spending by the home country is $M = Ep^{*}q_m$ that reduces to

$$M = M(Y, E). \tag{4}$$

Depreciation raises the price Ep^{*} of foreign tourism, lowers the quantity q_m, and lowers import spending M assuming import demand is elastic.

The present paper estimates tourism export revenue and import spending functions in log linear form,

$$\ln X = a_0 + a_1 \ln Y^* + a_2 \ln E + \varepsilon \tag{5}$$

$$\ln M = b_0 + b_1 \ln Y + b_2 \ln E + \nu. \tag{6}$$

The Marshall-Lerner condition implies depreciation raises the trade balance. The sum of absolute values of elasticities of export and import demands must exceed unity given balanced trade initially, $|\eta_x|(X/M) + |\eta_m| > 1$ where η_x and η_m are elasticities of export and import demands.

The Appendix shows the coefficients in (5) and (6) are related to these elasticities as $a_2 = -\eta_x$ and $b_2 = \eta_m + 1$. This modified version of the Marshall-Lerner condition $|-a_2|(X/M) - |b_2| > 0$ holds for log linear export revenue and import spending functions.

Various measures have investigated the effects of depreciation on the trade balance. Volume indices are examined by Goldstein and Khan (1978) and Rosenweig and Koch (1988) and real export revenue and import spending by Houthakker and Magee (1969), Senhadji (1998a), and Senhadji and Montenegro (1999). The difference between export revenue and import spending B = X – M is examined by Rose (1991) or Bahmani-Oskoosee and Malixi (1992) and the ratio of net exports to national income B/Y by Demirden and Pastine (1995) and Senhadji (1998b).

Haynes and Stone (1982) propose the ratio X/M utilized by Bahmani-Oskoosee and Brooks (1999), Boyd, Caporale and Smith (2001), and Onafowora (2003). The present paper utilizes this measure B = X/M for comparison with the separately identified models (5) and (6). In natural logs,

$$\ln B = \ln X - \ln M. \tag{7}$$

Substitute (5) and (6) into (7) to find

$$\ln B = (a_0 - b_0) + a_1 \ln Y^* - b_1 \ln Y + (a_2 - b_2)\ln E + (\varepsilon - \nu) \tag{8}$$

or more simply

$$\ln B = c_0 + c_1 \ln Y^* - c_2 \ln Y + c_3 \ln E + \mu. \tag{9}$$

In this trade balance model, an increase in foreign income will improve the trade balance while an increase home income will deteriorate the trade balance. If c_3 is positive, it satisfies the Marshall-Lerner condition.

A weakness of employing the ratio X/M as a proxy for trade balance is that an increase in X/M due to depreciation could be the result of a rise in exports with a fall in imports, a large rise in exports with a smaller rise in imports, a rise in exports with no change in imports, no change in exports with a fall in imports, or a smaller fall in exports with a large fall in imports.

Another weakness is that changes in this ratio could not provide detailed adjustment dynamics for individual export revenue and import spending functions. The income effect on the export revenue or the import spending in this trade balance model could be a joint effect of both foreign income and home income.

The J-curve effect is the hypothesis that the trade balance falls immediately following a depreciation due to previously arranged contracts but rises after an adjustment lag as developed by Magee (1973) and Junz and Rhomberg (1973). The J-curve literature is reviewed by Bahmani-Oskooee and Ratha (2004). Methodology has developed over the years but empirical results remain mixed.

Some studies investigate sector specific responses to depreciation. Meade (1988) finds no J-curve adjustment for non-oil industrial supplies, capital goods excluding automobiles, and consumer goods. Doroodian, Jung and Boyd (1999) report a J-curve effect for agriculture but not manufacturing. Yazici (2006) finds an S-curve for the trade balance in Turkish agriculture, rising initially before falling and finally increasing. Ardalani and Bahmani-Oskooee (2007) examine export and import data for 66 US industries and find the J-curve for only six in an error correction model. Goldstein and Khan (1985) point out that aggregation across different products may result in biased estimates and certainly could disguise different underlying adjustments.

Estimating tourism export revenue and import spending separately is superior to investigate the short and long term dynamics in structural vector autoregressions SVAR and impulse response functions. Tourism is perhaps a small enough fraction of international transactions to ignore its contemporaneous effect on the dollar exchange rate. Though foreign income may affect the exchange rate, its short term effect would be negligible since tourists must plan ahead for international travel and restrictions are imposed in the SVAR model based on prior knowledge.

2. The Econometric Model

Consider the structural vector autoregressive SVAR process of integrated variables

$$\mathbf{A}\mathbf{y}_t = \mathbf{B}(L)\mathbf{y}_{t-1} + \mathbf{u}_t\,, \tag{10}$$

where $\mathbf{A}$ is an $m \times m$ square matrix, $\mathbf{y}_t$ is an $m \times 1$ vector of m difference stationary variables, $\mathbf{B}(L)$ is a matrix lag polynomial, and $\mathbf{u}_t$ is $m \times 1$ vector of m structural shocks. Shocks have zero means, unit variance, and are mutually independent,

$$E\mathbf{u}_t = \mathbf{0} \text{ and } E\mathbf{u}_t\mathbf{u}_t^{'} = \mathbf{I}\,, \tag{11}$$

where $\mathbf{0}$ is an $m \times 1$ null vector and $\mathbf{I}$ is an $m \times m$ identity matrix.

The structural form system of (10) is represented by the following reduced form system of equations,

$$\mathbf{y}_t = \mathbf{C}(L)\mathbf{y}_{t-1} + \boldsymbol{\varepsilon}_t\,, \tag{12}$$

where

$$\mathbf{C}(L) = \mathbf{D}\mathbf{B}(L),\ \boldsymbol{\varepsilon}_t = \mathbf{D}\mathbf{u}_t\text{, and } \mathbf{D} = \mathbf{A}^{-1}. \tag{13}$$

Combining (12) and (13),

$$E\boldsymbol{\varepsilon}_t\boldsymbol{\varepsilon}_t^{'} = E\mathbf{D}\mathbf{u}_t\mathbf{u}_t^{'}\mathbf{D}' = \mathbf{D}\mathbf{D}^{'} = \boldsymbol{\Sigma} \qquad (14)$$

where $\boldsymbol{\Sigma}$ is the variance covariance matrix from the reduced form VAR.

Just identifying the system requires $m(m-1)/2$ identifying assumptions. We employ the conventional approach proposed by Sims (1980) and utilize the Choleski decomposition of $\boldsymbol{\Sigma}$ to find $\mathbf{D}$, an approach that can be useful given prior knowledge on short term relations between variables of interest.

Given the least squares estimates $\mathbf{C}(L)$ and $\boldsymbol{\Sigma}$ from the reduced form, the structural form VAR is recovered with the identified contemporaneous matrix $\mathbf{D}$ followed by the impulse response analysis for structural shocks to the system.

3. Tourism Trade Balance Results

Data on tourism export revenue and import spending including travel and air fare are from the International Transactions Accounts of the Bureau of Economic Analysis. The nominal exchange rate index is the Federal Reserve nominal major currencies index, a trade weighted index including the euro, Canadian dollar, yen, pound, Swiss franc, Australian dollar, and Swedish krona.

US income is nominal GDP. Foreign income in the rest of the world ROW income is the sum of the nominal GDP of the five major tourist arrival countries, the UK, Canada, Japan, France, and Germany, essentially the countries in the major currencies index. Their nominal GDPs are from the *International Financial Statistics* of International Monetary Fund. Quarterly data run from 1973 through 2007 during the floating exchange rate era.

Tourism spending, revenue, and income could be deflated by the price indices but the aggregation bias could result in unreliable estimates as stressed by Goldstein and Khan (1985). The real exchange rate would introduce similar issues. The focus of the present paper remains on nominal variables given the lack of tourism price indices.

Stationarity is pretested to check whether variables are stationary converging to steady state levels. Results of the unit root test from conventional augmented Dickey-Fuller ADF tests are in Table 1. The number of lags is chosen by the Schwarz Information Criterion BIC.

Table 1

The ADF test with an intercept fails to reject the null hypothesis of a unit root for all log level variables except US income Y. The ADF test does not reject the null hypothesis of a unit root for all log level variables with an intercept and time trend. With lags added to US income, the ADF test fails to reject the unit root null hypothesis. The Y series do not appear stationary in Figure 1.

Figure 1

ADF tests reject the unit root null hypothesis for all differenced log variables. All log variables are integrated in the first order, consistent with the apparently stationary differences in Figure 2.

Figure 2

All log variables are I(1) and first differencing can remove nonstationarity. An SVAR with differenced log variables provides estimates and for comparison the tourism trade balance model is also reported.

Contemporaneous relations of each innovation and one unit structural shocks are derived from the estimates. Diagonal element estimates are normalized to one with $Eu_t u_t^{'}$ a diagonal matrix with non unitary variances. Contemporaneous relations of each innovation and 1% structural shocks are derived. The estimated response functions to 1% structural shocks and confidence intervals are obtained taking 5% and 95% percentiles from 10,000 bootstrap simulations.

The order of export revenue of tourism $\mathbf{y}_t = [\Delta E_t \ \Delta X_t \ \Delta Y_t^*]'$ is chosen assuming the nominal exchange rate is not contemporaneously affected by tourism export or foreign income shocks since tourism involves a small fraction of foreign exchange transactions. Foreign income growth may affect the nominal exchange rate but only in the long term. Tourism export is assumed not to be contemporaneously affected by foreign income growth, reasonable if tourism demand is determined at least a quarter in advance.

From estimates of **D** the following contemporaneous relations of each innovation and structural shock are derived,

$$\varepsilon_t^{E} = 0.0146u_t^{E}$$
$$(0.0008)$$

$$\varepsilon_t^{X} = 0.0030u_t^{E} + 0.0558u_t^{X}$$
$$(0.0044) \quad (0.0056)$$

$$\varepsilon_t^{Y*} = -0.0162u_t^{E} + 0.0034u_t^{X} + 0.0381u_t^{Y*}$$
$$(0.0038) \quad (0.0029) \quad (0.0022)$$

with standard errors from 10,000 nonparametric bootstrap simulations. The choice of k = 4 is determined by the Akaike Information Criterion AIC.

Matrix **D** is estimated with the diagonal normalized to one to find contemporaneous innovations to 1% structural shocks. Estimated export revenue response functions are reported in Figure 3.

Figure 3

A 1% depreciation shock decreases tourism export revenue contemporaneously followed by an increase after one quarter and converging to equilibrium after six quarters. The short term exchange rate elasticity is statistically insignificant while the long term elasticity is marginally insignificant. Tourism export revenue exhibits a robust positive response to foreign income shocks as well as its own shocks.

Order of the import spending model $\mathbf{y}_t = [\Delta E_t \ \ \Delta M_t \ \ \Delta Y_t]'$ is justified in the same manner. Both AIC and BIC choose k = 1 but to remove any remaining serial correlation k = 4 is utilized as with export revenue.

From the **D** estimate, the following relations follow,

$$\varepsilon_t^E = \underset{(0.0017)}{0.0319} u_t^E$$

$$\varepsilon_t^M = \underset{(0.0035)}{0.0032} u_t^E + \underset{(0.0053)}{0.0442} u_t^M$$

$$\varepsilon_t^Y = \underset{(0.0006)}{0.0002} u_t^E + \underset{(0.0005)}{0.0016} u_t^M + \underset{(0.0008)}{0.0068} u_t^Y$$

The estimated import spending response functions are in Figure 4.

Figure 4

Responses of import spending are insignificant but appear to decrease contemporaneously with a 1% depreciation shock, increasing after four quarters, and converging to equilibrium after ten quarters. Import tourism spending also exhibits robust positive responses to home income and its own shocks.

Consolidating results, the tourism trade balance deteriorates initially following dollar depreciation, improves after one quarter, and converges to the steady state after ten quarters. Short term deterioration of the trade balance is statistically insignificant while the long term improvement of the trade balance is marginally insignificant within a 90% confidence interval. There is no J-curve but there is a lagged exchange rate effect on export revenue.

For comparison, in the trade balance model $\mathbf{y}_t = [\Delta E_t \Delta B_t \Delta Y_t \Delta Y_t^*]'$ the order of $\mathbf{y}_t$ is chosen assuming the exchange rate is not contemporaneously affected by shocks to the trade balance or home or foreign income, and the trade balance is not contemporaneously affected by shocks to home or foreign income. Home income is assumed not contemporaneously affected by foreign income shocks. While higher foreign income may lead to export demand and income growth in the long term, the effect after a few quarters would be negligible.

From the $\mathbf{D}$ estimate the following relations are derived,

$$\varepsilon_t^E = 0.0147 u_t^E$$
$$(0.0008)$$

$$\varepsilon_t^B = 0.0008 u_t^E + 0.0418 u_t^B$$
$$(0.0041) \quad (0.0026)$$

$$\varepsilon_t^Y = 0.0169 u_t^E + 0.0012 u_t^B + 0.0383 u_t^Y$$
$$(0.0036) \quad (0.0032) \quad (0.0020)$$

$$\varepsilon_t^{Y*} = -0.0002 u_t^E - 0.0010 u_t^B + 0.0000 u_t^Y + 0.0066 u_t^{Y*}$$
$$(0.0006) \quad (0.0005) \quad (0.0006) \quad (0.0007)$$

The choice of k = 4 is determined by the AIC. Matrix **D** with diagonal element normalized to one is estimated and the trade balance response functions are in Figure 5.

Figure 5

The trade balance appears to increase contemporaneously with a 1% depreciation shock but the response is insignificant. The response becomes significant after four quarters and converges to long term equilibrium after eight quarters. There is no evidence of a J-curve but depreciation raises the trade balance. The trade balance exhibits a robust positive response to a positive home income shock that becomes insignificant after four quarters. The trade balance of tourism also exhibits a robust positive response to shocks to foreign income and itself.

Short and long term exchange rate elasticities and long term income elasticities are summarized in Table 2.

Table 2

Long term exchange rate elasticities are $a_2 = 0.88$ for tourism export revenue in (5) and $b_2 = 0.12$ for import tourism spending in (6). The derived exchange rate elasticities for export and import demand are $\eta_x = -0.875$ and $\eta_m = -0.878$. The Marshall-Lerner condition seems to be satisfied at the initial trade balance X/M = 0.591 where $|\eta_x|(X/M) + |\eta_m| = 1.395 > 1$ and at the 1.023 mean X/M where $|\eta_x|(X/M) + |\eta_m| = 1.77 > 1$. However, both elasticities are insignificant. On the contrary, the long term exchange rate elasticity for trade balance model in (9) $c_3 = 1.007$ is positive satisfying the Marshall-Lerner condition.

There is no evidence of a J-curve. Depreciation raises the long term tourism trade balance. However, aggregating the trade data by utilizing the ratio X/M could produce unreliable estimates of exchange rate elasticities. Estimates of export revenue and import spending with an aggregate exchange rate index could also produce aggregation bias. The insignificant exchange rate elasticities in the present study might be the result of the aggregate exchange rate index.

Long term foreign and home income elasticities $a_1 = 0.63$ and $b_1 = 1.99$ are significant while only the foreign income elasticity $c_1 = 0.746$ is significant and home income is insignificant in the trade balance model.

US tourists are much more sensitive to their income. A 10% increase in income induces US tourists to spend nearly 20% more on international tourism. Aggregating the trade data by utilizing the ratio X/M disguises the strong income effect for US tourists. The separate estimates provide more detailed response dynamics.

4. Conclusion

The present structural vector autoregressive model uncovers a long term positive income effect on tourism trade, with US tourists more sensitive to income than foreign tourists to the US. There is no evidence of a J-curve or exchange rate effects on trade in tourism. The present disaggregated data for the particular industry avoids aggregation bias.

In some recent trade studies, researchers investigate sector specific responses to depreciation. The present paper is the first study on the tourism trade balance. The economic model can be applied to analyze effects of nominal exchange rates on the tourism trade balance.

In comparison with the elasticities and trade balance approaches, separate estimations of the export revenue and import spending functions have at least three appealing features. The approach provides a more detailed picture of the underlying dynamics of the time-path of each individual function to exchange rate shocks rather than focusing on the net change in the trade balance. Second, this approach avoids the joint income effect of foreign and home incomes on export revenue or import spending. Specifically, the trade balance estimate disguises the income effect of US tourists going abroad. Third, elasticities of export revenue and import spending are estimated and elasticities of export and import demand are then be derived assuming supplies of tourism are perfectly elastic.

For future trade studies, the methodology advocated in the present paper can be extended to investigate bilateral trade for specific industries or commodities. Instead of aggregate trade data and exchange rate indices, disaggregated trade data on a particular commodities and bilateral exchange rates will produce more revealing insight for practitioners and policymakers.

Table 1. Unit Root Pretests of Log Variables

Variable	Specification	ADF_c	$ADF_{c,t}$
X	Level	-2.16	-1.15
	Differenced	-12.80***	-13.22***
M	Level	-1.98	-0.91
	Differenced	-14.36***	-14.65***
B	Level	-2.02	-1.78
	Differenced	-14.12***	-14.25***
E	Level	-1.06	-1.86
	Differenced	-10.86***	-10.93***
Y	Level	-4.91***	-2.09
	Differenced	-4.88***	-9.28***
Y*	Level	-2.12	-1.69
	Differenced	-5.30***	-5.48***

Note: The number of lags is chosen by the Schwarz Information Criterion (BIC). ADF_c and $ADF_{c,t}$ refer to ADF-t statistics when an intercept is included and when an intercept and time trend are included. *, ** and *** indicate the null hypothesis of unit root is rejected at 10%, 5% and 1% level. Asymptotic critical values are from Harris (1992).

Table 2. Short and Long Term Exchange Rate and Income Elasticities

Elasticities	**Export Revenue X**	**Import Spending M**	**Trade balance B = (X/M)**
E short term	-0.204	-0.101	0.051
90% CI	[-0.769, 0.346]	[-0.309, 0.094]	[-0.445, 0.523]
E long term	0.875	0.122	1.007*
90% CI	[-0.038, 1.900]	[-0.319, 0.530]	[0.085, 2.212]
Y long term	---	1.988*	0.710
90% CI		[0.547, 3.725]	[-1.642, 3.128]
Y* long term	0.633*	---	0.746*
90% CI	[0.190, 1.092]		[0.307, 1.293]

Note: 90% confidence intervals (CI) are obtained by taking 5% and 95% percentiles from 10,000 bootstrap simulations. * represents the coefficients are significant within 90% confidence intervals.

Figure 1. Variable Series

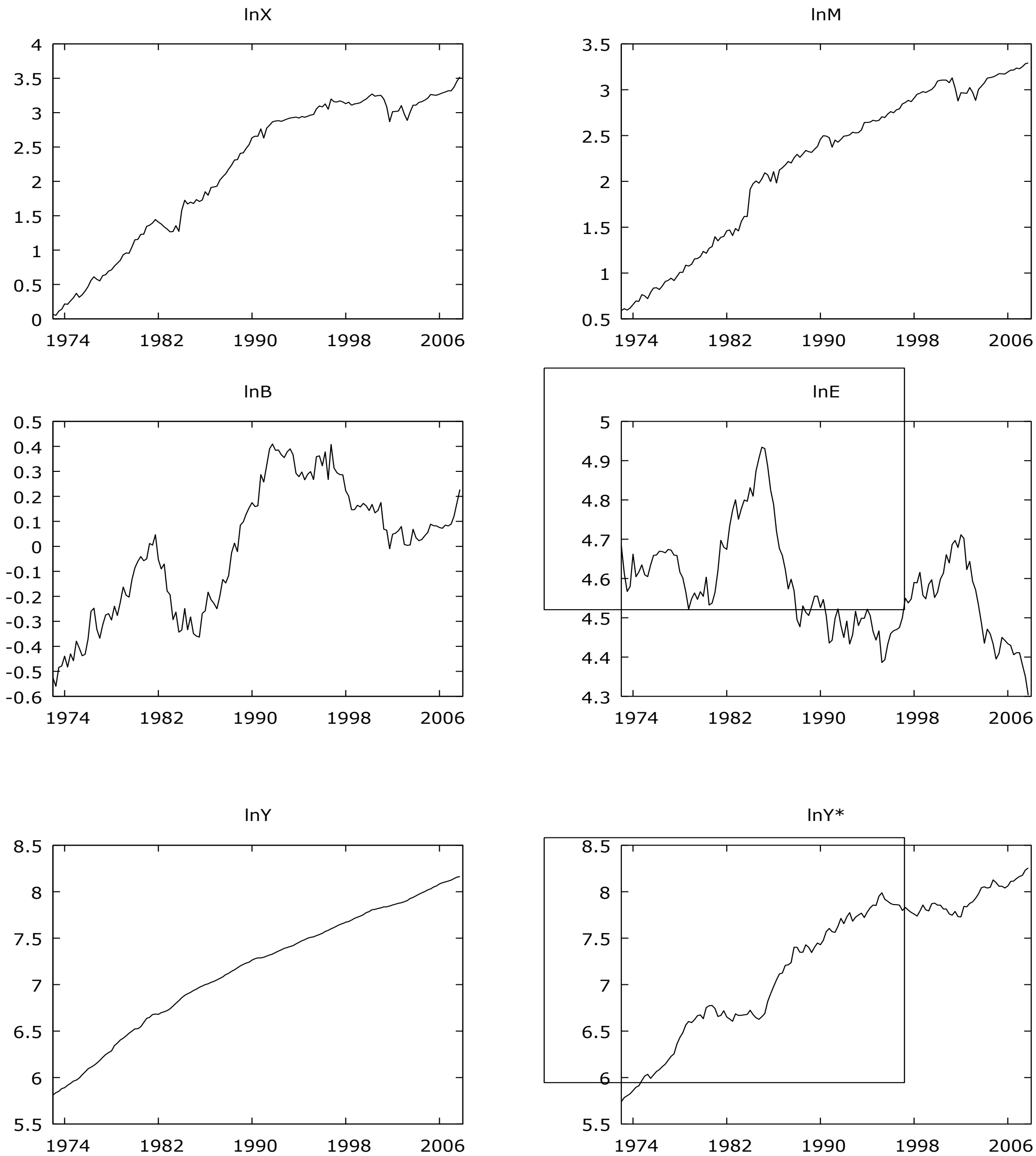


Figure 2. Differences of Variable

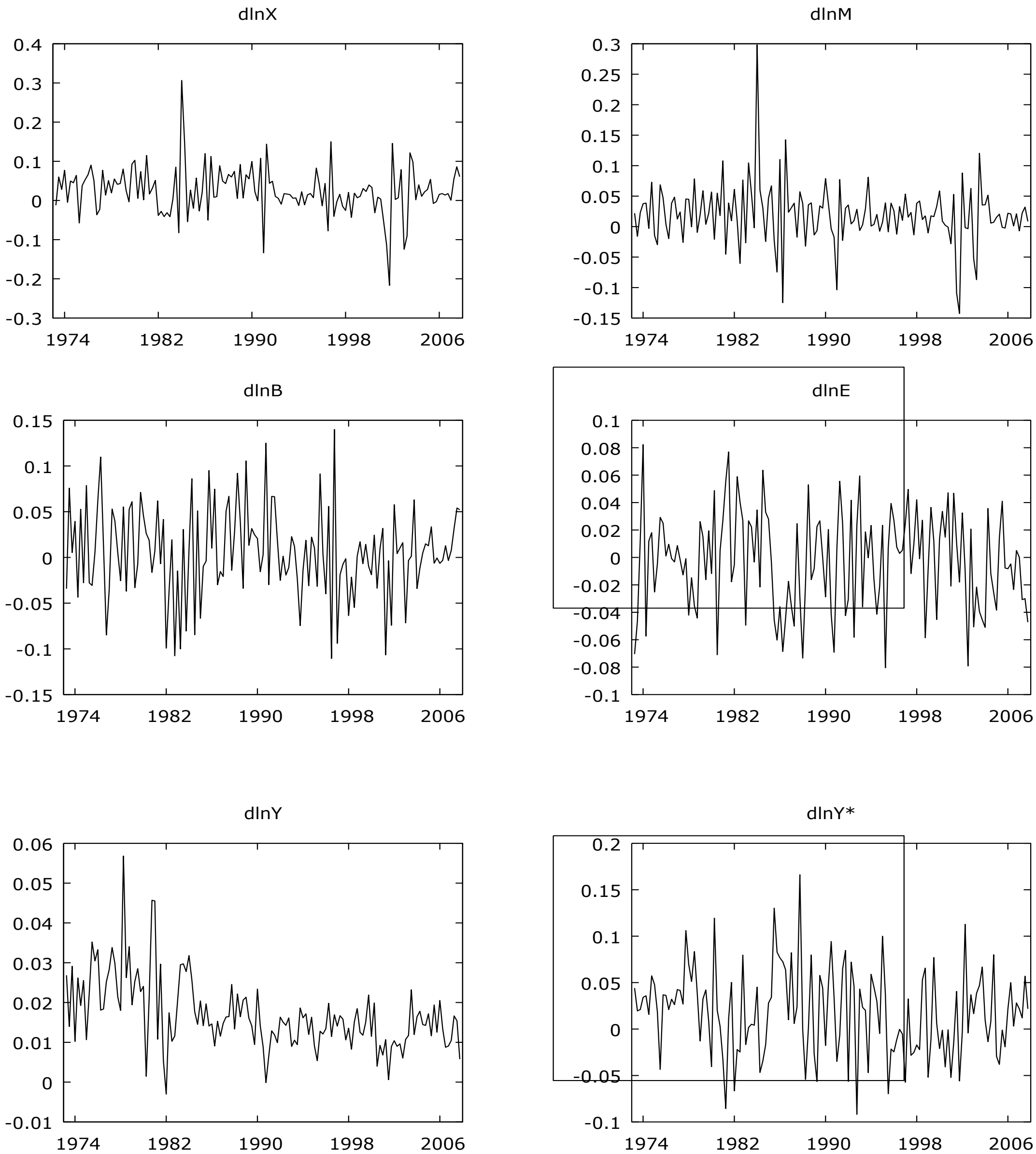
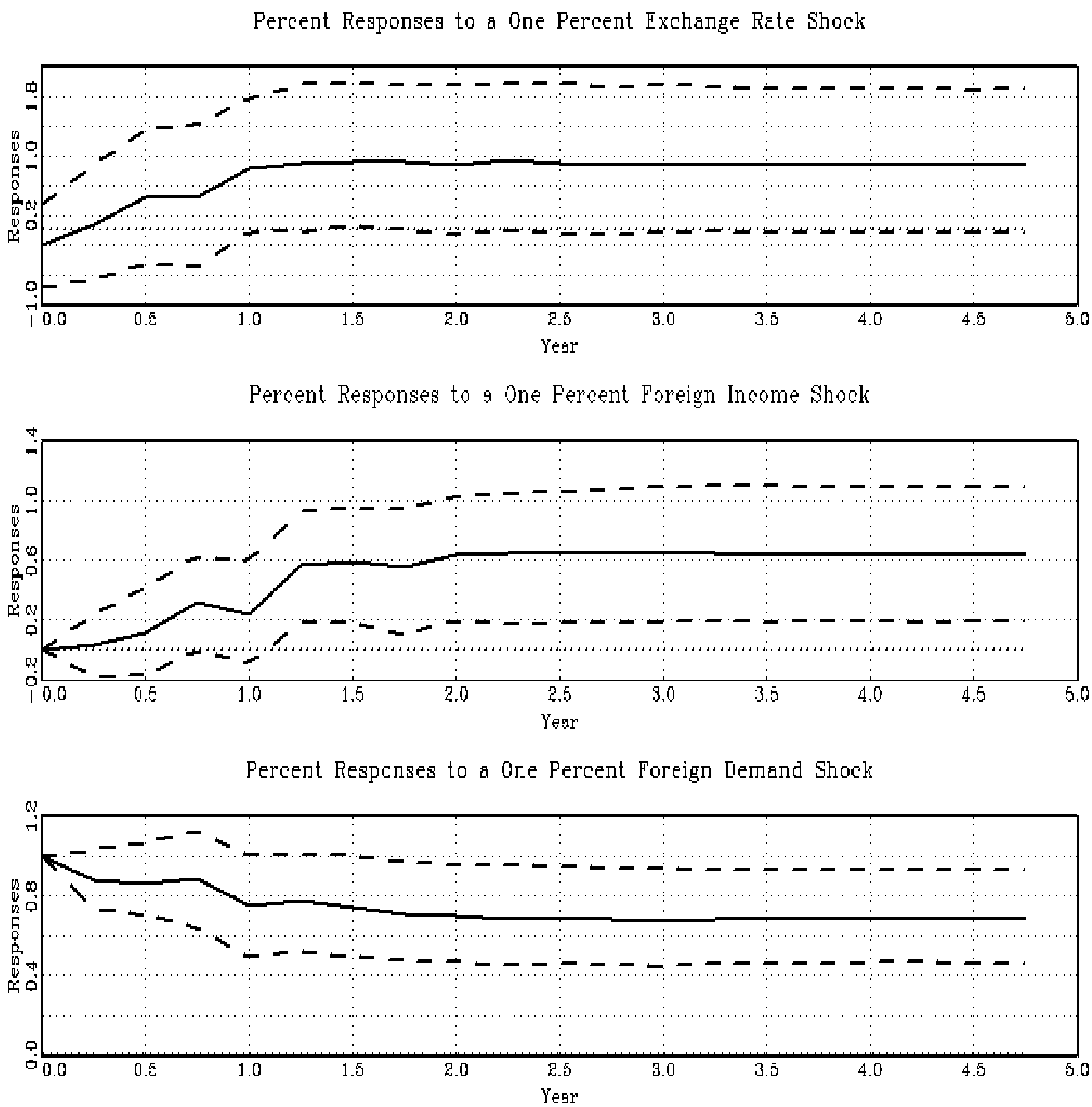
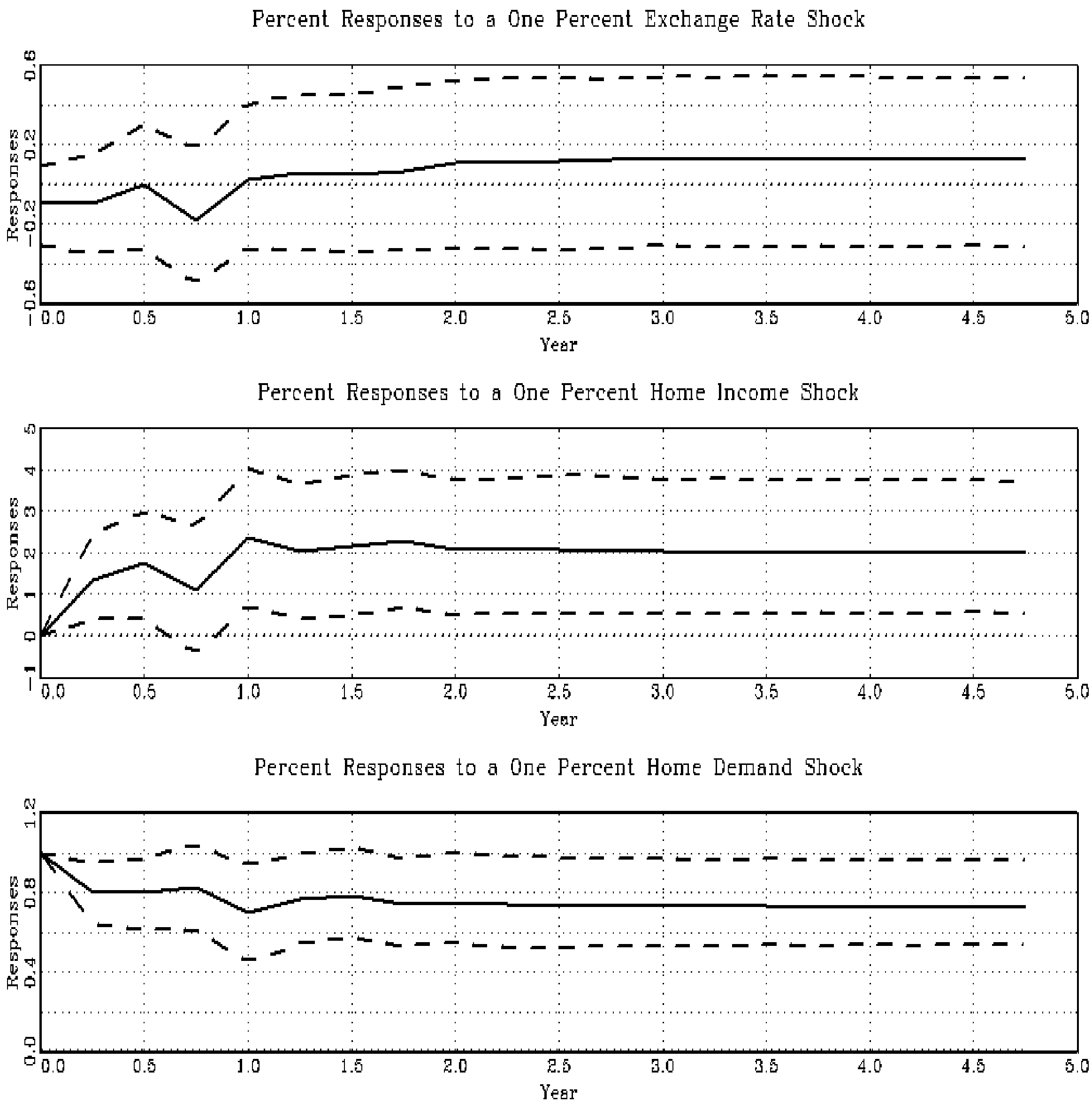


Figure 3. Impulse Response Function Estimates of Export Revenue



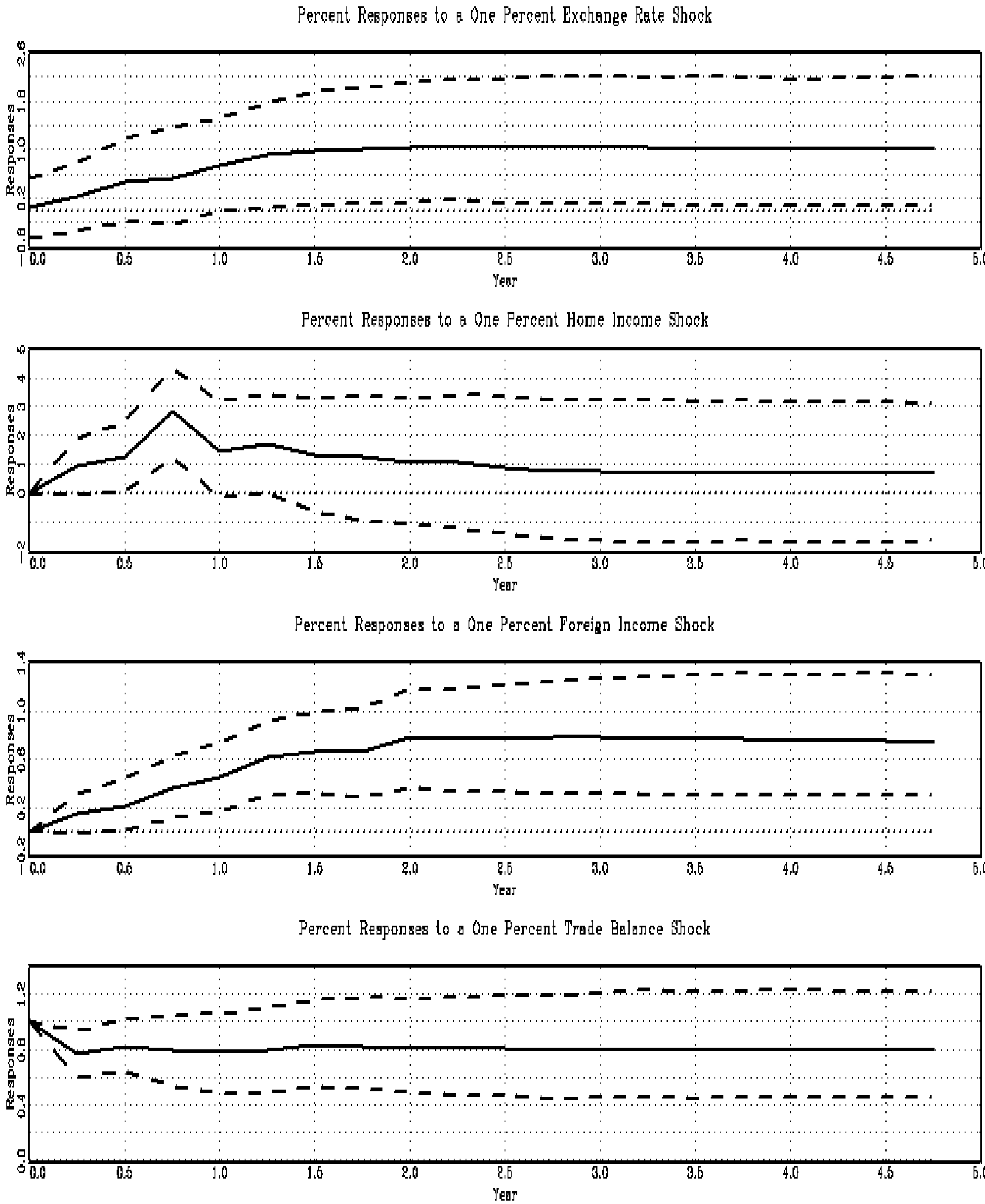
Note: 90% confidence intervals are obtained by taking 5% and 95% percentiles from 10,000 bootstrap simulations.

Figure 4. Impulse Response Function Estimates of Import Spending



Note: 90% confidence intervals are obtained by taking 5% and 95% percentiles from 10,000 bootstrap simulations.

Figure 5. Impulse Response Function Estimates of the Trade balance



Note: 90% confidence intervals are obtained by taking 5% and 95% percentiles from 10,000 bootstrap simulations.

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Appendix

Tourism export revenue X is the product of the quantity of export in tourism q_x and the price of domestic tourism p. Import spending on tourism M is the product of the quantity of import in tourism q_m and the price of international tourism in term of home currency Ep*.

Export revenue of the home country is

$$X = pq_x \tag{A1}$$

Import spending of the home country is

$$M = Ep^*q_m \tag{A2}$$

Totally differentiate (A1) and (A2) to find

$$dX = pdq_x + q_x dp \tag{A3}$$

$$dM = Ep^*dq_m + p^*q_m dE + Eq_m dp^* \tag{A4}$$

Assume supply prices p and p* of international tourism do not change given perfectly elastic supply curves over the range of quantity changes, dp = dp* = 0.

Elasticities of export and import demand are then

$$\eta_x = \frac{(dq_x/q_x)}{d(p/E)/(p/E)} \tag{A5}$$

$$\eta_m = \frac{(dq_m/q_m)}{d(Ep^*)/(Ep^*)} \tag{A6}$$

where (p /E) is the foreign price of US tourism and Ep* is the dollar price of international tourism.

Equation (A5) is expanded as

$$\eta_x = \frac{(dq_x/q_x)}{((Edp - pdE)/E^2)/(p/E)} = \eta_x = \frac{(dq_x/q_x)}{-(dE/E)} \tag{A7}$$

Rearranging (A7)

$$dq_x = -\left(\frac{dE}{E}\right)\eta_x q_x \tag{A8}$$

Substitute (A8) into (A3) to rewrite dX in terms of export demand elasticity η_x,

$$dX = -\left(\frac{dE}{E}\right)\eta_x pq_x = -\left(\frac{dE}{E}\right)\eta_x X \qquad \text{(A9)}$$

From (A9) the elasticity of export tourism revenue a_2 is related to the elasticity of export demand as

$$a_2 = \frac{(dX/X)}{(dE/E)} = -\eta_x \qquad \text{(A10)}$$

Similarly from (A6)

$$\eta_m = \frac{(dq_m/q_m)}{(dp^*E + p^*dE)/(Ep^*)} = \frac{(dq_m/q_m)}{(dE/E)} \qquad \text{(A11)}$$

and rearranging

$$dq_m = \left(\frac{dE}{E}\right)\eta_m q_m \qquad \text{(A12)}$$

Substitute (A12) into (A4) to rewrite dM in terms of import demand elasticity η_m, to find

$$dM = \left(\frac{dE}{E}\right)\eta_m Ep^* q_m + Ep^* q_m\left(\frac{dE}{E}\right) = \left(\frac{dE}{E}\right)M(\eta_m + 1) \qquad \text{(A13)}$$

From (A13), the elasticity of import tourism spending b_2 is related to the elasticity of import demand as

$$b_2 = \frac{(dM/M)}{(dE/E)} = \eta_m + 1 \qquad \text{(A14)}$$