TEACHING THE EXCHANGE RATE AND THE CURRENT ACCOUNT BALANCE IN A DYNAMIC MODEL WITH A NON-TRADED GOOD*

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ABSTRACT

This paper describes how a dynamic model with a non-traded good can be utilized to discuss the determination of prices, the exchange rate, and the current account balance in a senior undergraduate course in international macroeconomics. The model is a simplification of the dynamic, two-sector models in the academic literature. It is demonstrated that the main results can be explained with one core diagram and a few key equations. Students obtain a deeper understanding of the relationship between the current account balance and the exchange rate. A simple empirical application, at a level appropriate for undergraduates, reinforces the insights of the model.

Keywords: current account balance, exchange rate, net exports, undergraduate international macroeconomics.

JEL classifications: A22, F31, F32, F41.

1. INTRODUCTION

Non-traded goods and services constitute a large fraction of aggregate production in industrialized nations. The non-traded sector consists predominantly of service sectors, whereas the traded sector is comprised largely of the manufacturing, agriculture, and resource sectors. If aggregate production is decomposed into sectoral production, production in the non-traded sector is as large as, or larger than,
production in the traded sector (Stockman & Tesar 1995; and Lombardo & Ravenna 2012). While sectoral models like ‘the dependent economy model’ have been important elements in the toolkit of international macroeconomists for decades,¹ these analyses have not been given significant attention in undergraduate textbooks.

This paper describes how a dynamic model with a non-traded good can be utilized to discuss the determination of prices, the exchange rate, and the current account balance in a senior undergraduate course in international macroeconomics. Since the determination of the current account balance is an intertemporal phenomenon, the dynamic model permits an analysis of trade imbalances (see, for example, Sachs 1981; Obstfeld & Rogoff 1995; Corden 2007; and Craighead & Miller 2010). And the multi-sectoral nature of the model allows for an investigation of the determinants of the relative price of the non-traded good, a critical factor in the determination of real and nominal exchange rates (see, for example, Dornbusch 1983; Stockman 1983; and Corden 1994). The model can thus be used to explain both exchange rate movements and the relationship between changes in the exchange rate and the current account balance (or net exports).

The model is a simplification of the dynamic, two-sector models used in the academic literature. The seminal literature includes analyses by Dornbusch (1983), Stockman (1983) and Greenwood (1984), and these core models have been extended in various directions and applied in advanced empirical analyses (for example, Rogoff 1992; Stockman & Tesar 1995; Cova et al. 2008; Galstyan & Lane 2009; Devereux & Hnatkovska 2012; and Rees, Smith & Hall 2016). But even relatively simple versions have been applied beneficially to prominent macroeconomic issues, such as Blanchard’s (2007) discussion of current account imbalances in rich countries and Woodford’s (2008) commentary on the interpretation of empirical research on exchange rates and growth.

Existing textbooks discuss the importance of the non-traded sector in determining the real exchange rate, and outline the Harrod-Balassa-Samuelson effect as playing a role in its long-term level.² The analysis

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¹ On the historical background, including the significant contributions of Australian economists, see Viner (1937, Chapter VI), Oppenheimer (1974), Asea & Corden (1994), Turnovsky (2009, pp. 105-106), and Metaxas & Weber (2016).

in this paper carries matters significantly further, by utilizing the model to examine two core topics in the undergraduate course - exchange rate determination and current account imbalances. There are major benefits in terms of understanding the economy. Students obtain a deeper understanding of the relationship between the current account balance and the exchange rate. The theoretical analysis indicates that a depreciation of the domestic currency may or may not be associated with an improvement in the current account balance, and provides students with the tools to understand the real-world movements in these variables (for example, an increase in non-traded production causes changes in domestic prices and the exchange rate, but has no effect on the current account balance). In addition, the importance of sectoral factors in impacting the aggregate economy is highlighted (see, for example, the introductory comments in Rees, Smith & Hall 2016). Students learn, for example, that exogenous changes originating in the non-traded sector feed through the economy and impact traded-sector variables and the nominal exchange rate. These analyses reinforce the perception that sectoral disturbances can have a profound impact on the aggregate economy.

The analysis is conducted at a level appropriate for senior undergraduate students (and the discussion may also provide beneficial background reading for students in graduate-level courses). While the model, like the dependent economy model, abstracts from fluctuations in the terms of trade, the insights provided to students are significant (unlike the dependent economy model, the dynamic model regards sectoral output as exogenous). Experience has shown that students appreciate the realism of the two-sector model (relative to the traditional one-good structure) and are eager to apply the model to issues such as the joint determination of the current account and the exchange rate.3

The next three sections outline the model and examine various exogenous shocks. It is demonstrated that the main results can be explained with one core diagram and a few key equations. The penultimate section presents empirical evidence that can be presented in the classroom, using the Canadian economy as an example, and a final section concludes.

3 The author has been lecturing on this topic in an international macroeconomics course for the past four years.
2. A DYNAMIC MODEL WITH A NON-TRADED GOOD

Consumers maximize lifetime utility subject to an intertemporal budget constraint. There are two periods and two goods, a non-traded good and a traded good. The output of each good is exogenous, and domestic firms are owned by domestic residents. The domestic traded good is identical to the foreign traded good, so that a ‘law of one price condition’ holds. The domestic economy is small, with foreign variables taken to be exogenous.

The theoretical analysis focuses on the effects of exogenous changes in output and in the foreign real interest rate under a flexible exchange rate regime. It is assumed that goods prices are flexible, the government budget is always balanced, investment spending is equal to zero, and both central banks are following zero-inflation policies. With fixed aggregate price levels, any induced sectoral price change generates movements in both real and nominal exchange rates. Whether the current account balance is affected depends on the type of exogenous change impacting the economy.

Prices and the Real Exchange Rate

The price level (consumer price index), denoted $P$, is measured as (time subscripts ignored):

$$ P = P^T 0.5 P^N 0.5 $$

where $P^T$ is the price of the traded good, $P^N$ is the price of the non-traded good, and the weight 0.5 represents the (typical) share of expenditure on that good (for all relevant variables, the superscripts $T$ and $N$ refer, respectively, to traded and non-traded goods). The foreign price index, denoted $P^*$, is measured similarly, with equal expenditure weights (foreign variables are denoted with an * symbol). With identical traded goods and zero transport costs, the law of one price holds:

$$ P^T = s P^{*T} $$

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4 Abstracting from investment spending is a common practice when first presenting two-sector international macroeconomic models; see Dornbusch (1983) and Blanchard (2007). The flexibility of goods prices implies that the current period is taken to be longer than the ‘short run’ when some goods prices may be fixed. Corden (1994) provides an extensive discussion of short-run macroeconomic adjustment issues in two and three-sector models when the price of the good in the non-traded sector is fixed (or rigid downwards).
where $s$ is the nominal exchange rate (an increase in $s$ is a depreciation of the domestic currency).\(^5\) The real exchange rate, denoted $q$ and measured as $[sP^*/P]$, is a complex measure of the relative price of foreign to domestic goods. Using the law of one price, and with foreign prices assumed to equal 1 (for simplicity), the inverse of the real exchange rate equals:

$$\frac{1}{q} = \left[ \frac{P^N}{P^T} \right]^{0.5} \quad (3)$$

A real appreciation of the domestic currency (an increase in $1/q$) is associated with an increase in the relative price of the non-traded good. Under a flexible exchange rate with a zero-inflation policy, the real appreciation means that there is an increase in $P^N$, a decrease in $P^T$, and a nominal appreciation of the domestic currency (a decrease in $s$).

**Lifetime Utility and Lifetime After-tax Real Income**

Lifetime utility depends on current and future consumption of the traded and non-traded goods, with consumption denoted $c$ (the current and future periods are denoted $t$ and $t+1$, respectively). Future utility is discounted by a factor $[1/(1+\gamma)]$, where $\gamma$ represents the marginal rate of time preference.

Domestic residents generate income from the production of traded and non-traded goods (with production denoted $y$), and pay lump-sum income taxes (denoted $TX$). In the current period, consumers choose consumption of each good and the quantity of net foreign assets (denoted $J$).\(^6\) When $J_t$ is positive, domestic residents have acquired foreign bonds in the current period; when $J_t$ is negative, domestic residents have acquired a foreign loan (the interest rates on foreign bonds and foreign loans are the same). Consumers are forward looking, and base their consumption decisions on lifetime after-tax real income.

The intertemporal budget constraint is:

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\(^5\) If the domestic price of the traded good increases, making the foreign good cheaper, domestic residents demand foreign currency and cause a depreciation of the domestic currency. This process continues until the law of one price holds. For an empirical study on the law of one price, see Baldwin & Yan (2004).

\(^6\) The model abstracts from domestic bonds; the central bank is assumed to adjust the money supply to ensure a zero inflation rate. The variable $J$ is measured in foreign currency. To buy foreign bonds, for example, domestic residents must first purchase foreign currency at the exchange rate $s$. In some equations shown below, the exchange rate is eliminated using the law of one price condition.
where $z$ denotes the relative price of the non-traded good ($P_N/P_T$) and $r_t^{*T}$ is the foreign real interest rate (measured in terms of the traded good):

$$1 + r_t^{*T} = \frac{(1 + i_t^* \cdot P_t^{*T})}{P_t^{*T}}$$

This intertemporal constraint implies that the present value of lifetime consumption (the left-hand side) is constrained by, and in equilibrium is equal to, the present value of lifetime after-tax real income.

**Key Consumption Relationships**

Consumption is affected by lifetime after-tax real income and by intertemporal and intra-temporal relative prices. Desired traded-good consumption satisfies the Euler equation:

$$u'(c_t^T) = \frac{(1 + r_t^{*T})}{(1 + \gamma)} \cdot u'(c_{t+1}^T)$$

This intertemporal condition implies that consumers adjust current-period savings to achieve a relatively smooth path for traded-good consumption over time. When $r_t^{*T}$ equals $\gamma$, consumers ensure that current and future traded-good consumption are equal, meaning that there is ‘consumption smoothing’. And an exogenous increase in the foreign real interest rate (holding other factors fixed) induces

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7 This condition is a marginal benefit-marginal cost condition. If a consumer decreases current-period traded-good consumption (using the proceeds to purchase foreign bonds), the marginal cost is $u'(c_t^T)$, the current-period marginal utility. The marginal benefit is denoted by the right-hand side. The foreign bond pays $(1+r_t^{*T})$ in real terms in period $t+1$, generating a discounted gain in utility from the additional traded-good consumption.

8 Traded-good consumption can be smoothed, whereas non-traded consumption in any period is constrained by net supply in that period. Silva & Xabadia (2013) use a one good, two-period model of consumption, in conjunction with Excel-Solver, to provide interesting classroom exercises. In terms of the model in this paper, this tool could be applied to the traded good.
consumers to increase saving in the current period, so that traded-good consumption falls in the current period and rises in the future period.

In addition, domestic residents choose consumption of the traded and non-traded goods to satisfy an intra-temporal condition, where the marginal rate of substitution (the ratio of marginal utilities) equals the relative price:

$$\frac{u'(c_i^N)}{u'(c_i^T)} = \frac{P_i^N}{P_i^T}$$

The allocation of current-period spending between traded and non-traded goods is thus affected by movements in the current-period relative price of the non-traded good.

This intra-temporal condition is shown as the downward sloping curve in Figure 1 (the vertical line, representing net supply, is discussed below). The relative price of the non-traded good is on the vertical axis, and consumption of the non-traded good is on the horizontal axis. This marginal rate of substitution curve (MRS) is downward sloping because, as \(c_i^N\) increases, the marginal utility of non-traded consumption falls. When \(c_i^T\) changes and thereby changes the current-period marginal utility of traded-good consumption, the curve shifts (preferences are assumed to be separable, so that a change in \(c_i^T\) is the only factor that shifts this curve).

**Equilibrium Conditions and Constraints**

Equilibrium in the current-period market for the non-traded good implies that:

$$y_i^N = c_i^N + g_i^N$$

where \(g\) denotes government spending (likewise, the supply and demand of the non-traded good must be equal in the future period). The current-period household budget constraint, in conjunction with the conditions of a balanced government budget and equilibrium in the market for the non-traded good, implies the following current-period constraint on the economy:

$$y_i^T - g_i^T - c_i^T = \frac{J_i}{P_i^{eT}}$$
This equation also represents the balance of payments identity, where the left-hand side represents the current account surplus (denoted $CA_t$) and the right-hand side equals the net accumulation of foreign assets, all measured in terms of the traded good (the current account balance equals net exports, denoted $NX_t$, since ‘net foreign assets’ equal 0 at the start of period $t$). If the domestic economy produces more of the traded good than is purchased domestically by consumers and the government, the surplus is exported and leads to an accumulation of foreign currency, which is then converted to foreign bonds ($J_t$ is positive). The current account balance (net exports), with no investment spending and a balanced government budget, is equal to private saving.

The intertemporal budget constraint, in conjunction with the equilibrium conditions for the non-traded good and the balanced government budget conditions, yields the intertemporal constraint on the economy:

$$c_{t+1}^T = y_{t+1}^T - g_{t+1}^T + (1 + r_{t+1}^*) \cdot [y_t^T - c_t^T - g_t^T]$$

(9)

This intertemporal constraint implies that domestic residents can shift consumption of the traded good between periods. The term in square brackets is the current account balance in the current period, so that a surplus in the current period (relative to a balanced current account) allows for a higher level of future traded-good consumption.

3. A CORE DIAGRAM AND A FEW KEY EQUATIONS

Figure 1 represents current-period equilibrium in the market for the non-traded good. Production of the non-traded good and government spending on the non-traded good are exogenous. If production is 80
units and the government buys 20 units, there are 60 units of the non-traded good for sale to consumers. The vertical line representing the exogenous variable $y_t^N - g_t^N$ is called the net supply curve, denoted $NS_t$. The downward sloping curve, representing the marginal rate of substitution, is denoted MRS and called the MRS curve (or, for convenience, the demand curve for the non-traded good).\textsuperscript{9} The relative price adjusts to keep demand equal to supply in this domestic market. The relative price must adjust such that consumers are willing to buy 60 units of this good in the current period, where $y_t^N - g_t^N$ equals $c_t^N$.

Consumers ensure that the intra-temporal condition holds, meaning that consumption of the non-traded good is always at a point on the MRS curve. In the lectures, it is convenient to allow for a further simplification. With a logarithmic utility function, the intra-temporal condition simplifies to the ‘equal expenditure condition’:\textsuperscript{10}

$$\frac{P_t^N}{P_t^T} = \frac{u'(c_t^N)}{u'(c_t^T)} = \frac{c_t^T}{c_t^N} \quad \Rightarrow \quad P_t^N c_t^N = P_t^T c_t^T$$

(10)

The last equation, the equal expenditure condition, implies that consumers spend the same nominal amount on each good.

With respect to the traded good, consumers ensure that the Euler equation is satisfied. If the foreign real interest rate equals the marginal rate of time preference, there is consumption smoothing. The intertemporal constraint on the economy and the Euler equation, with $r_{*T}$ and $\gamma$ set equal to 0 for simplicity, together imply that consumption of the traded good is determined by the following equation (all right-hand side variables are exogenous):

$$c_t^T = \frac{y_t^T - g_t^T + y_{t+1}^T - g_{t+1}^T}{2}$$

(11)

In equilibrium, traded-good consumption is affected by current and future production of the traded good, and by current and future

\textsuperscript{9} The demand curve for the non-traded good would eliminate traded-good consumption from the equation using a budget constraint. This could be done, but it is convenient to leave traded-good consumption in the equation and then discuss how induced changes in traded-good consumption cause this MRS curve to shift.

\textsuperscript{10} It can simply be asserted in the lectures that, with a certain utility function, marginal utility equals the inverse of consumption. This simplification is convenient, and is especially useful in the classroom presentation.
government spending on the traded good (increased government spending, current or future, increases lifetime taxes and reduces consumption).

It is important to emphasize that the equilibrium conditions and the constraints imply that there is a dichotomy embedded within the model. Increases in output of the non-traded good increase lifetime after-tax real income and increase the demand for both traded and non-traded goods, but the income is spent entirely on the non-traded good (to maintain demand equal to supply in that market). There is no effect on traded-good consumption. Likewise, all income generated from traded-good production is spent on the traded good (see equation 11).

The diagram, along with the two equations above, forms the basis of the classroom discussion of the determinants of consumption and the relative price of the non-traded good. To provide the complete discussion of exogenous changes, one also needs the equations for the current account balance (net exports) and the current-period law of one price condition:

\[ CA_t = y_t^T - g_t^T - c_t^T = \frac{J_t}{P_{sT}} \]  
\[ P_t^T = s_t P_{sT} \]  

With the reminder that the central bank is following a zero-inflation policy, one can begin the discussion of the general-equilibrium effects of exogenous changes.

4. EXOGENOUS CHANGES
This section examines the effects of various exogenous changes on the current-period endogenous variables: consumption of the traded and non-traded goods, the price of the non-traded good, the price of the traded good, the exchange rate, and the current account balance (or net exports). For ease with numerical examples, it is assumed that the current account is initially balanced and the foreign real interest rate and the marginal rate of time preference both equal 0 (an exogenous increase in the foreign real rate is examined later on).

Temporary Increase in Output of the Traded Good
Suppose there is a temporary increase in traded-good production, so that \( y_t^T \) increases but \( y_{t+1}^T \) is unchanged. The increase in lifetime after-tax
real income causes the demand for both traded and non-traded goods to increase in both periods. With a temporary increase, consumers want to increase saving in the current period. This saving allows for an increase in future consumption of the traded good and thereby allows for consumption smoothing. If current output of the traded good increases by 20 units, current consumption of the traded good increases by 10 units and the remainder is exported. The current account balance increases from 0 to +10, with domestic residents accumulating foreign bonds and thereby allowing for the increase in future traded-good consumption.

In the market for the non-traded good, the increase in consumption of the current-period traded good shifts the MRS curve to the right in Figure 2 and causes the equilibrium relative price of the non-traded good to increase to point B (the increase in $c^T_t$ decreases $u'(c^T_t)$ and thereby increases MRS at each level of $c^N_t$). In effect, this shift represents the increase in demand for the non-traded good associated with the increase in lifetime after-tax real income. With fixed net supply, the result is an increase in the equilibrium relative price of the non-traded good.

With the central bank following a zero-inflation policy (the central bank acts to keep the consumer price index fixed), the price of the non-traded good rises and the price of the traded good falls.\(^\text{11}\) And given that the law of one price holds for the traded good, the decrease in the price of the traded good implies that there is an appreciation of the domestic currency (relative to the foreign currency) in the current period. Consumption of the non-traded good in the current period is unchanged. There is both a lifetime income effect and a relative price effect on the consumption of the non-traded good. The increase in lifetime real income increases the demand for the non-traded good, but the rise in the relative price of the non-traded good results in an exactly offsetting decrease in the quantity demanded of the non-traded good.

With the equal expenditure condition, the changes in nominal spending on each good must be the same. If there is a ten percent

\(^{11}\) While the actual adjustment process that occurs in response to shocks may be complicated, with the central bank making ongoing decisions regarding the appropriate policy response, the theoretical analysis assumes that the central bank ensures a zero inflation rate in the current period. In practice, central banks such as the Bank of Canada have been fairly successful in achieving their specified inflation targets.
increase in $c_t^T$, $P_t^N$ increases by 5% and $P_t^T$ decreases by 5 per cent (percentage changes are approximate). These changes are summarized in Figure 3.

\[ \uparrow P_t^N c_t^N = \downarrow P_t^T c_t^T \uparrow \]

**Figure 3: The Equal Expenditure Condition**

Since the increase in traded-good output is temporary, the current account balance increases. There is an increase in net exports even though the domestic currency appreciates (relative to the foreign currency) in the current period.\(^{12}\)

*Increase in ‘Expected’ Future Output of the Traded Good*

Consumers are forward looking, so that future changes can affect current-period variables.\(^{13}\) With a future increase in production of the traded good, the associated increase in lifetime after-tax real income causes the demand for goods to increase. For the traded good, there is consumption smoothing. With no change in the current production of the traded good, domestic residents must import traded goods to

\[^{12}\text{Any increase in traded-good output (permanent, temporary, or future) causes an appreciation of the domestic currency. Rogoff (1992) highlighted the result that temporary shocks to traded-good output have permanent effects on the real exchange rate.}\]

\[^{13}\text{Once an exogenous change occurs, consumers are assumed to have ‘perfect foresight’ with respect to future variables. The same approach is adopted by Blanchard (2007). Incorporating uncertainty into dynamic models adds considerable complexity - see, for example, Stockman (1983) and Pasula (2016).}\]
increase consumption. Consumers get a loan from foreigners to import these goods, and will repay the loan in the future period with the extra real income that arises from the future increase in output. In the current period, the current account balance falls, matching the foreign loan that domestic residents have received ($J_t$ is negative). The variables $y_t^T$ and $g_t^T$ are fixed, so the increase in current-period consumption of the traded good results in a decrease in the current account (net exports).

In the current period, the increase in traded-good consumption (due to the increase in lifetime after-tax real income) shifts the MRS curve to the right (the diagram for this case is the same as in Figure 2). With a zero-inflation policy, the increase in the relative price of the non-traded good means that there is an increase in the price of the non-traded good and a decrease in the price of the traded good. Again, there is both a lifetime income effect and a relative price effect on the consumption of the non-traded good, resulting in no change in consumption. And the equal expenditure condition holds, with the variables changing in the same way as shown in Figure 3.

With a lower price on the domestic traded good, the law of one price implies that there is an appreciation of the domestic currency. In this case, an appreciation of the domestic currency is associated with a decrease in the current account balance.\footnote{In this model, the current account deficit is not ‘bad’. The deficit is not due to a lack of competitiveness, and the increase in foreign debt is not a problem. Domestic consumers know that the future increase in real income will allow them to repay the debt and increase future consumption. With the current account deficit, domestic residents are able to obtain the highest possible level of lifetime utility. Craighead & Miller (2010) show how the gains from intertemporal trade can be explained in an undergraduate course. For a more detailed discussion related to current account imbalances and welfare, see Corden (1994, 2007) and Blanchard (2007).}

**Permanent Increase in Output of the Non-Traded Good**

With a permanent increase in production of the non-traded good, both $y_t^N$ and $y_{t+1}^N$ increase by the same amount (government spending and other exogenous variables are fixed). In the current-period market for the non-traded good depicted in Figure 4, the increase in production shifts the net supply curve to the right from $NS_0$ to $NS_1$. This exogenous increase in supply reduces the equilibrium relative price of the non-traded good.

Does consumption of the traded good increase and shift the MRS curve to the right? If consumers spend any part of the extra income on
the traded good, then not all of the non-traded good is purchased. There would then be an excess supply of the non-traded good, along with further downward pressure on the price of the non-traded good. In the new equilibrium, all the extra real income is spent on the non-traded good, consumption of the traded good is unchanged, and the MRS curve does not shift (the new equilibrium is at B).

![Figure 4: Increase in Non-traded Production](image)

With a zero-inflation policy, the fall in the price of the non-traded good is matched by an increase in the price of the traded good. From the law of one price, the domestic currency depreciates. This result is akin to the Harrod-Balassa-Samuelson effect, in that a permanent increase in non-traded production results in a real depreciation whereas a permanent increase in traded-good production results in a real appreciation. Since \( y_t^T \) and \( g_t^T \) are fixed, and \( c_t^T \) is unchanged, there is no effect on the current account balance. The domestic currency depreciates, but the current account is unchanged.

**Increase in the Foreign Real Interest Rate**

Suppose that, initially, \( r_t^* \) and \( \gamma \) both equal 0. An exogenous increase in \( r_t^* \) (holding the foreign prices of the traded good fixed) induces consumers to increase saving in the current period. Consumers therefore decrease traded-good consumption and acquire foreign bonds, thereby allowing future traded-good consumption to increase. With the other exogenous variables fixed, the current account balance increases.\(^{15}\) The increase in the foreign real interest rate also decreases the demand for the non-traded good in the current period, shifting the

\(^{15}\) In a model with investment spending, a higher real interest rate would also decrease investment spending.
MRS curve in the diagram (not shown) to the left. With a fixed net supply of the non-traded good, the current-period relative price of the non-traded good falls until a new equilibrium is established. With the central bank following the policy of zero inflation, there is a decrease in $P_t^N$, an increase in $P_t^T$, and an increase in the exchange rate $s_t$. The domestic currency therefore depreciates, and the current account balance improves.

5. RELATED EMPIRICAL EVIDENCE

Two empirical issues are now considered: sectoral production and the co-movement between net exports and the exchange rate.

**Sectoral Production**

The sectoral decomposition of the economy into traded and non-traded sectors is not always a straightforward exercise. In general, sectors that produce goods are often traded and sectors that produce services non-traded (but the construction sector is also regarded as non-traded). While empirical studies face various measurement issues, these matters are not of major importance here. The purpose is to provide general information on sectoral production, with an eye towards material that can be discussed in the classroom. As an example, data drawn from the Canadian economy are used.

Figure 5 provides measures of traded and non-traded production for Canada, using quarterly data between 1997 and 2016 (the data are measured at annual rates, in chained (2007) dollars). Using an approach similar to other studies, 6 sectors are regarded as traded and 14 sectors non-traded. With this decomposition, production in the non-traded sector ranges from 60% to 65% of the aggregate economy. And as evident in the figure, the non-traded sector has expanded considerably

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17 The CANSIM data are from Table 379-0031. The traded sectors (from largest to smallest) are manufacturing; mining, quarrying, and oil and gas extraction; wholesale trade; retail trade; transportation and warehousing; and agriculture, forestry, fishing, and hunting. The non-traded sectors are real estate and rental and leasing; finance and insurance; construction; health care and social assistance; public administration; professional, scientific and technical services; educational services; information and cultural industries; administrative and support, waste management and remediation services; utilities; accommodation and food services; other services; arts, entertainment and recreation; and management of companies and enterprises.
in this century (over the sample period, the average annual growth rates are 2.7% for the non-traded sector and 1.9% for the traded sector).

![Figure 5: Production of Traded and Non-Traded Goods and Services for Canada, 1997-2016](image1)

Source: Adapted from CANSIM Table 379-0031, North American Industry Classification System (NAICS) that has 20 sectors (this data series begins in 1997).

The model regards production in these sectors as being exogenous, or determined strictly by supply-side factors such as total factor productivity. Plotting the annual percentage changes in production, as in Figure 6, provides information on the extent of volatility. While production in the non-traded sector tends to grow at a relatively constant rate, the growth rate in the traded sector is volatile (the standard deviation of the growth rate of traded production is more than three times larger than that for non-traded production). In the 2008-2009 recession, production in the traded sector falls by over 10% whereas production in the non-traded sector falls by less than 1% (the correlation coefficient between the growth rates of traded and non-traded production is 0.65). These fluctuations in traded-good production would be one of the important factors in generating fluctuations in net exports (the current account balance) in Canada.

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18 In empirical work, it may be beneficial to decompose the economy into four sectors: two non-traded sectors, representing services and construction, and two traded sectors, representing manufacturing and the resource sector (including agriculture). Decomposing the traded-good sector into an export sector and an import-Competing sector, as in the standard three-sector model, allows for fluctuations in the terms of trade. In the undergraduate course, it is more beneficial to examine issues that arise in the three-sector model (terms-of-trade changes, the Dutch Disease, and so on) in a separate topic.
The Co-movement between Net Exports and the Exchange Rate

A depreciation of the domestic currency (holding foreign and domestic price levels fixed) is often regarded as generating an increase in net exports (or an improvement in the current account balance). But in a general-equilibrium setting, when various exogenous changes can occur, this relationship need not hold. In theory, the co-movement between the exchange rate and net exports can be positive or negative. Consider how various exogenous shocks generate co-movement between the two variables. The theoretical results from the various exogenous changes are summarized in Table 1. An appreciation of the domestic currency can be associated with an increase in net exports, a decrease in net exports, or no change in net exports.

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19 In a partial-equilibrium setting, a depreciation of the domestic currency (holding other factors fixed) results in an increase in net exports. The depreciation increases the traded-good price, decreases consumption of the traded good, and increases net exports. In a two-sector model with variable production (Dornbusch 1993), the increase in the price of the traded good (associated with the depreciation) results in an increase in traded-good production. This effect on production also acts to increase net exports.

20 Given the setup of the model, any ‘balanced budget’ decrease in government spending on the traded good—permanent, temporary, or future—has the same effects on the current account (net exports) and the exchange rate as the corresponding increase in traded-good production (and likewise for the non-traded good). With a balanced budget, any decrease in government spending is matched by an equivalent decrease in the lump-sum tax. Since government spending yields benefits to consumers, one could add government spending to the utility functions. With separability, the theoretical results are unchanged.
**Table 1: Net Exports and the Exchange Rate**

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<tr>
<th>Shock</th>
<th>$NX_t$</th>
<th>$s_t$</th>
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<tr>
<td>Temporary Increase in Output of the Traded Good</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Increase in Future Output of the Traded Good</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Permanent Increase in Output of the Non-Traded Good</td>
<td>↔</td>
<td>↑</td>
</tr>
<tr>
<td>Increase in the Foreign Real Interest Rate</td>
<td>↑</td>
<td>↑</td>
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</tbody>
</table>

Figure 7 provides evidence on this matter, using quarterly Canadian data over the period 1981:1 to 2015:4. The scatter plot depicts (a) the percentage change in the exchange rate, measured as $\Delta s/s$, on the vertical axis (if $\Delta s$ is positive, there is a depreciation of the domestic currency), and (b) the change in net exports relative to output, measured as $\Delta NX/y$, on the horizontal axis. There is no simple relationship between these two variables.\(^{21}\) If a linear regression analysis is conducted, the relationship is significantly positive. This result supports the case that a depreciation (appreciation) of the Canadian dollar tends to be associated with an improvement (deterioration) in the net export balance. But there are many data points for the other case. As suggested by the analysis, it is not uncommon to have an appreciation of the domestic currency and a rise in net exports (the points in the lower right-hand corner). And there are many periods when net exports fell even though there was a depreciation of the domestic currency (the points in the upper left-hand corner).\(^{22}\)

**6. CONCLUDING REMARKS**

This paper described how a dynamic model with a non-traded good can be presented in a senior undergraduate course in international macroeconomics. The effects of various exogenous shocks were examined using a core diagram and a few key equations. A significant

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\(^{21}\) Whether one uses the nominal or real exchange rate is not important empirically because they move together; the correlation coefficient is 0.986 for percentage changes. Likewise, in annual balance of payments data, the correlation coefficient between net exports and the current account is 0.98. The figure excludes 15 outliers to allow a better visual representation of the other points ($s$ and $NX$ move in the same direction in 12 of 15 cases).

\(^{22}\) For econometric evidence on the determination of real exchange rates, see Floyd (2010).
potential benefit to students is that the analysis would allow for a better understanding of the determinants of, and the relationships between, variables such as the exchange rate and the current account balance. An empirical application, at a level appropriate for undergraduates, reinforced the insights of the model.

The application of this framework to address critical international macroeconomic issues, by economists such as Blanchard (2007) and Woodford (2008), provides a strong indication of the usefulness of the approach. Likewise, the tradable/non-tradable dichotomy has been widely demonstrated to be beneficial at the academic level for both business-cycle and longer-term analyses. But a critical factor for instructors and textbook authors is whether the model and analysis can be formulated at a level that generates significant benefits to undergraduate students. This paper has attempted to demonstrate that this can be done. While decisions on course content are understandably influenced by a range of factors, the dynamic model with a non-traded good should be considered for inclusion in our undergraduate international macroeconomics courses and textbooks.
REFERENCES


