A NOTE ON THE VOLATILITY OF THE TRADEABLE AND NONTRADEABLE SECTORS

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This note evaluates whether a New Open Economy model can reproduce qualitatively the observed fluctuations of the tradeable and nontradeable sectors of the U.S. economy. The answer is positive: both in the model and in the data, the standard deviations of tradeable inflation, output, and employment are significantly higher than the standard deviations of the corresponding nontradeable sector variables. The key role in generating this result is played by the greater responsiveness of tradeable sector variables to monetary shocks.

Keywords: New Open Economy Macroeconomics, Tradeable and Nontradeable Sectors, Business Cycles

1. INTRODUCTION

In the field of international macroeconomics there are now many models that explicitly consider two sectors, one producing tradeable and the other producing nontradeable goods. However, the strategy of adding a tradeable and a nontradeable sector to an open economy model is not without problems. It is important, for example, to check whether the model-generated statistics are consistent with the sectoral data.1

The purpose of this note is to develop an open economy model with tradeables and nontradeables, estimate it by the generalized method of moments (GMM), and then check whether its implications for the tradeable and nontradeable sectors are reflected in the U.S. data. The model presented in this paper follows the “New Open Economy macroeconomics” (NOEM) paradigm, and the comparison between the data and the model is restricted to second-order moments.
After the initial contributions of Ghironi (2000), Bergin (2003), and Lubik and Schorfheide (2006), the literature on estimating NOEM models has grown considerably in recent years. More recent contributions include (with no claim of being exhaustive), Lubik and Schorfheide (2007), Justiniano and Preston (2010a and 2010b), and Rabanal and Tuesta (2010). This paper differs from other contributions not just because of the estimation methodology, but also because of the goal of the investigation, which is to compare the properties of the tradeable and nontradeable sectors in the model and in the U.S. data.

However, this sort of analysis is hampered by a measurement problem. The properties of the tradeable and nontradeable sectors can only be imperfectly measured, because virtually all sectors (as measured in the official statistics) have both tradeable and nontradeable goods. The strategy adopted here to deal with this problem is to restrict ourselves to qualitative, rather than quantitative, comparisons.

In spite of the measurement problem in the data, there is sufficient evidence to suggest that in the U.S. economy, business cycle fluctuations are more pronounced in the tradeable than in the nontradeable sector. When the estimated values are fed into NOEM model, it is successful in generating standard deviations of tradeable inflation, output, and employment that are considerably higher than the standard deviations of the corresponding nontradeable sector variables. This occurs because of the high responsiveness of tradeable sector variables to domestic monetary shocks, which are the most important source of fluctuations in the model.

The outline of the remainder of the note is as follows. Section 2 explains the model and its numerical solution. The estimation and calibration of the model are explained in Section 3. The model-implied statistics are presented in Section 4. Sensitivity checks are discussed in Section 5. Finally, Section 6 concludes.

2. THE MODEL

The model is similar to Benigno and Thoenissen’s (2003). Here I outline the main features of the model, and I specify the assumptions that are different from those of Benigno and Thoenissen’s model.

The world economy consists of two countries of equal size, named Home and Foreign. Each country has a tradeable and a nontradeable sector. Both sectors are populated by continua of monopolistic firms, each one of them producing a single differentiated good for final consumption.

Individuals cannot contemporaneously supply their labor to both the tradeable and nontradeable goods sectors, as they can only work in one sector at a time. Any individual who works incurs a fixed participation cost, as in Burnside et al. (1993).

Following Rogerson (1988), I add the probabilities of working in each sector to the individual maximization problem. That is, the utility of a representative
individual in the Home country is written as follows:

\[ U_0 = E_0 \sum_{t=0}^{\infty} \beta^t \left[ \frac{C_{\infty}^{1-\sigma} - 1}{1-\sigma} + \frac{\lambda}{1-\varepsilon} \left( \frac{M_t}{P_t} \right)^{1-\varepsilon} + n_{TH,t} \cdot \kappa (\Gamma - \psi - h_{TH,t}) 
+ n_{N,t} \cdot \kappa (\Gamma - \psi - h_{N,t}) 
+ (1 - n_{TH,t} - n_{N,t}) \cdot \kappa (\tau) \right] \]

where \( C \) is the aggregate consumption index, \( \frac{M}{P} \) are real money balances, \( n_{TH} \), \( n_N \) are the probabilities of working in the tradeable and nontradeable sector, respectively, \( \psi \) is a fixed cost of participation, the same for all individuals, and \( h_{TH} \) and \( h_N \) are the total hours that the individual supplies to the sectors \( TH \) and \( N \), respectively. Preferences over goods are described by CES aggregators.

At the international level, markets are incomplete: individuals trade in a one-period noncontingent real bond, denominated in units of the Home tradeable goods consumption index. Similarly to Benigno (2009), individuals must pay a small cost to undertake a position in the international asset market.

Nominal rigidities are introduced à la Calvo (1983). Tradeable goods firms in both countries set two different prices, one for the Home market and one for the Foreign market, denominated in the respective local currencies. A positive parameter governs the degree of exchange rate pass-through into import prices, as in Corsetti and Pesenti (2005). Output sold at Home and abroad is produced using a common plant or production function.

The model includes government expenditure shocks and specifies monetary policy in terms of the growth rate of money [as in Chari et al. (2002)]. I assume that the Home and Foreign governments purchase only nontradeable goods produced in their own country. The money growth rates, government expenditures, and the growth rates of technology for each country and sector follow AR(1) processes.

Preferences and functional forms used to describe the Home and Foreign countries are the same. Tables 1 and 2 illustrate which parameters are (and which ones are not) assumed to be the same for both countries.

The model is solved by log-linearizing the equations around a deterministic equilibrium or steady state in which net foreign asset positions are normalized at zero. The resulting system is then solved using Uhlig’s “Toolkit” algorithm (1999). The shocks to the AR(1) processes are all assumed to be temporary.

The unconditional means of the productivity processes are calibrated to ensure that the steady state of the model reproduces three facts in the data: the ratios of tradeable to nontradeable output in the two countries and the ratio of Home to Foreign tradeable output. These ratios are computed using year-2000 data from the Groningen 60-Industry Database.

An important feature of the solution is that hours are always endogenously constant. As a result, all the adjustment in the labour inputs takes place through the extensive margin, i.e. the participation rates or probabilities.
3. ESTIMATION

The sample period is 1980:1 to 2007:4. The Home country is represented by the United States, and the Foreign country by an aggregate of its major trading partners. The latter comprises Canada, France, Germany, Japan, Mexico, and the United Kingdom, which together represented 46% of U.S. total trade in goods in 2007. The combined GDP of these six countries was 104% of the U.S. GDP in the last quarter of 2007.

The tradeable sector is represented by manufacturing, and the nontradeable sector by services. This approximation is advantageous because quarterly observations on output, prices, and employment levels are available, and it is consistent with standard assumptions in the literature.

Not all of the model parameters could be estimated by GMM, as in some cases identification problems occurred during estimation. Table 1 shows the parameters that have not been estimated by GMM but instead have been chosen according to suggestions made in the literature. I check the robustness of the results of Section 4 to changes in all the parameters of Table 1. The most interesting of these sensitivity checks can be found in Section 5.

The preference weights \( \gamma \) and \( \delta \) are calibrated so that the steady-state import and service shares in consumption are consistent with the U.S. data, and \( \delta^* \) is set equal to \( 1 - \delta \). The benchmark value for the elasticity of substitution \( \theta \) between Home and Foreign tradeables is taken from Obstfeld and Rogoff (2005). The values for \( \eta_T \) and \( \eta_N \) are those suggested by Faruqee et al. (2005) for the U.S. economy. I use the short-run elasticities of exchange rate pass-through into import prices estimated by Campa and Goldberg (2005) to parameterize \( \zeta \) and \( \zeta^* \). Finally, \( \alpha_T \) and \( \alpha_N \) are chosen to match the labor shares in value added in the U.S. manufacturing and service sectors.
### Table 2. GMM estimates

| Description                                           | Estimate  |
|-------------------------------------------------------|-----------|
| $\varepsilon$ Elasticity of marginal utility of real money balances | 2.3044    |
| $\sigma$ Risk aversion for consumption                | 6.3679    |
| $\phi$ Elasticity of substitution tradeable-nontradeables | 0.6648    |

**Exogenous processes:** $\tilde{x}_{j,t} = \rho_j \cdot \tilde{x}_{j,t-1} + \epsilon_j$

| $\rho_j$    | AR coefficient Home nominal money growth | 0.4441 |
|             | AR coefficient Home tradeable technology | 0.8321 |
|             | AR coefficient Home nontradeable technology | 0.8045 |
|             | AR coefficient Home government expenditure | 0.6774 |
|             | AR coefficient Foreign nominal money growth | 0.3494 |
|             | AR coefficient Foreign tradeable technology | 0.8374 |
|             | AR coefficient Foreign nontradeable technology | 0.5852 |
|             | AR coefficient Foreign government expenditure | 0.6462 |

| $\text{Var}(\epsilon_j)$ | Variance Home nominal money growth | $8.50 \times 10^{-5}$ |
|                          | Variance Home tradeable technology | $6.52 \times 10^{-5}$ |
|                          | Variance Home nontradeable technology | $1.17 \times 10^{-5}$ |
|                          | Variance Home government expenditure | $1.55 \times 10^{-6}$ |
|                          | Variance Foreign nominal money growth | $6.36 \times 10^{-5}$ |
|                          | Variance Foreign tradeable technology | $9.24 \times 10^{-5}$ |
|                          | Variance Foreign nontradeable technology | $2.14 \times 10^{-5}$ |
|                          | Variance Foreign government expenditure | $2.20 \times 10^{-6}$ |

| $\text{Cov}(\epsilon_j, \epsilon_j')$ | Cov(Home nom. money growth, Home nontrad. prod.) | $1.21 \times 10^{-5}$ |
|                                       | Cov(Home nom. money growth, Home gov. exp.) | $2.29 \times 10^{-6}$ |
|                                       | Cov(Home nom. money growth, Foreign trad. prod.) | $-3.25 \times 10^{-5}$ |
|                                       | Cov(Home nom. money growth, Foreign gov. exp.) | $-2.19 \times 10^{-6}$ |
|                                       | Cov(Home trad. prod., Foreign trad. prod.) | $3.14 \times 10^{-5}$ |
|                                       | Cov(Home trad. prod., Foreign gov. exp.) | $2.52 \times 10^{-6}$ |
|                                       | Cov(Home nontrad. prod., Foreign trad. prod.) | $-8.59 \times 10^{-6}$ |
|                                       | Cov(Home nontrad. prod., Foreign gov. exp.) | $-2.46 \times 10^{-6}$ |
|                                       | Cov(Foreign trad. prod., Foreign nontrad. prod.) | $1.76 \times 10^{-5}$ |
|                                       | Cov(Foreign nontrad. prod., Foreign gov. exp.) | $-1.12 \times 10^{-6}$ |

The moment conditions\textsuperscript{16} are derived from the log-linearized solution (as in Ghironi 2000), and have been estimated using logged, seasonally adjusted, and HP-filtered data. The estimated parameters are presented in Table 2. Because of the small size of the sample, I estimate the parameters using an exactly identified system.\textsuperscript{17}

### 4. RESULTS

Table 3 reports the main business cycle statistics for the model. Tables 4 and 5 report the sectoral data moments and the sectoral model moments.
By identifying the tradeable sector with manufacturing we neglect agriculture or mining, and by identifying the nontradeable sector with the service sector we include also services that are actually traded.\textsuperscript{18} Because the measurement problem also affects the performance of the model with respect to the sectoral data, I restrict the comparison between the data and the model’s statistics to be qualitative in nature rather than quantitative.\textsuperscript{19}

**Table 4. Data moments**

|                  | % std dev | 1st AC | Correlogram |                  |                  |                  |                  |
|------------------|-----------|--------|-------------|------------------|------------------|------------------|------------------|
| $\pi_{TH}^{\text{Tot}}$—Home tradeable inflation | 0.83      | 0.14   | 1.00        | $\pi_{TH}^{\text{Tot}}$ | $\pi_N$           | $\hat{Y}_{TH}^{\text{Tot}}$ | $\hat{Y}_N$      |
| $\pi_N$—Home nontradeable inflation                | 0.45      | 0.32   | 0.14        | 1.00             |                  |                  |                  |
| $\hat{Y}_{TH}^{\text{Tot}}$—Home tradeable output | 2.50      | 0.86   | 0.32        | 0.44             | 1.00             |                  |                  |
| $\hat{Y}_N$—Home nontradeable output               | 0.50      | 0.80   | 0.14        | 0.15             | 0.34             | 1.00             |                  |
| $\hat{n}_{TH}$—Home tradeable employment           | 1.98      | 0.91   | 0.20        | 0.55             | 0.85             | 0.29             | 1.00             |
| $\hat{n}_N$—Home nontradeable employment           | 0.89      | 0.94   | 0.27        | 0.53             | 0.69             | 0.49             | 0.87             | 1.00 |

*Note:* Data sources and definitions are available from the author on request. Statistics were computed using logged and HP-filtered prices, output, and employment levels.
Overall, the estimated model generates standard deviations of tradeable inflation, output, and employment that are considerably higher than the standard deviations of the corresponding nontradeable sector variables. Moreover, the cross correlations are all positive, as in the data.

The main cause of the higher volatility in the tradeable sector is its higher sensitivity to Home monetary shocks. The model, prices, output, and employment levels all increase after a positive Home monetary shock, but they increase more in the tradeable sector than in the nontradeable sector. This happens because the same channels that ensure the international transmission of shocks also amplify the responses of tradeable sector variables to domestic monetary shocks.

Consider first sectoral output levels. A positive Home monetary shock causes a terms-of-trade deterioration, a fall in the real interest rate, and an increase in Home bond holdings. The terms-of-trade deterioration may or may not cause tradeable output to respond more, but the increase in bond holdings always causes tradeable output to increase more than nontradeable output after a monetary shock, thus explaining the higher volatility. The rationale is that borrowing allows the Foreign country to increase its consumption via the asset market; as a result, there is more demand for Home exports.

Next, let us consider sectoral inflation rates. Even if the degree of price stickiness is the same, tradeable inflation increases more than nontradeable output after a positive monetary shock. The key is the nominal exchange rate depreciation: because there is imperfect pass-through, the Foreign currency revenues of Home firms increase, so the tradeable price index increases.

### Table 5. Model moments

| Variable             | % st dev | 1st AC | Correlogram       |
|----------------------|----------|--------|-------------------|
| \(\pi^{\text{Tot}}_{TH}\) — Home tradeable inflation | 0.52     | 0.18   | 1.00              |
| \(\pi_N\) — Home nontradeable inflation   | 0.32     | 0.64   | 0.79 1.00         |
| \(\hat{Y}^{\text{Tot}}_{TH}\) — Home tradeable output | 0.88     | 0.67   | 0.75 0.89 1.00    |
| \(\hat{Y}_N\) — Home nontradeable output  | 0.39     | 0.62   | 0.73 0.88 0.85 1.00 |
| \(\hat{n}^{\text{Tot}}_{TH}\) — Home tradeable employment | 1.68     | 0.63   | 0.66 0.64 0.65 0.65 1.00 |
| \(\hat{n}_N\) — Home nontradeable employment | 0.50     | 0.63   | 0.42 0.63 0.51 0.43 0.41 1.00 |

Note: Statistics are averages over 100 simulations, each of length 111, after the first 1,000 observations were discarded. Statistics were computed using logged and HP-filtered variables. The model parameters are those of Tables 1 and 2.
Finally, because tradeable output responds more to Home monetary shocks, the firms’ demand for the labor input has to respond more too. Moreover, Home productivity shocks are significantly more volatile in the tradeable sector than in the nontradeable sector. This explains the higher volatility of employment in the tradeable sector.

5. SENSITIVITY ANALYSIS

By checking whether the results are sensitive to some of the parameterized values, we can further investigate the properties of the NOEM model. Table 6 shows the model-implied standard deviations obtained under three different parameterizations: a lower elasticity of substitution for Home–Foreign tradeables, a higher share of nondomestic goods in the tradeable consumption basket, and a lower degree of price rigidity in the tradeable sector. Under all these alternative assumptions, tradeable sector variables are still more volatile than nontradeable sector variables.

Table 6 also considers the two extreme assumptions of local currency pricing (LCP) and producer currency pricing (PCP). Under LCP, if the exchange rate depreciates following a monetary shock, Home firms get more domestic currency for each unit of output sold abroad. As a result, the tradeable price index responds more to domestic monetary shocks and the standard deviation of tradeable inflation is higher. Moreover, under LCP, if the nominal exchange rate depreciates, the terms of trade fall (appreciate) strongly. This depresses the Foreign demand for Home tradeable output, which therefore responds less after a monetary shock. At the other extreme, under PCP, if the exchange rate depreciates following a monetary shock, the terms of trade increase, boosting the Foreign demand for Home tradeable output. Moreover, under PCP, the exchange rate does not affect the price that Home firms get for each unit of output sold abroad.
To analyze the complete markets case, I have developed a separate version of the model, and I have conducted simulations using the same parameters as in the baseline parameterization. In Section 4, I explained that after a positive Home monetary shock, Foreign households increase their consumption via borrowing, so Home exports increase. This explains why tradeable output is more volatile than nontradeable output. This effect exists under complete markets, too, but it does not operate via debt, but via trade in state-contingent assets.

Finally, I have also checked whether the results from the model are robust to the introduction of aggregate productivity shocks. This scenario can be investigated by assuming that the tradeable and nontradeable productivity shocks are perfectly correlated. The last row of Table 6 shows that this assumption does not alter the main qualitative result, but there is an increase in the standard deviations of tradeable output and tradeable employment.

6. CONCLUSION

This note has developed and estimated by GMM a new open economy model, with the purpose of analyzing the fluctuations of the tradeable and nontradeable sectors.

The estimated model generates standard deviations that are compatible, from a qualitative point of view, with the pattern observed in the data. In the data, the standard deviations of inflation, output, and employment are higher in the tradeable sector than in the nontradeable sector. The model shows that this happens because of the greater responsiveness of tradeable sector variables to monetary shocks.

NOTES

1. For example, Barsky et al. (2007) note that durable goods feature prominently in discussions of monetary policy. Conventional sticky-price models with durables must be able to match not only the central features of the data, but also the empirical properties of the durable and nondurable goods sectors. Barsky et al. (2007) show that this is not the case and suggest adding additional features to conventional sticky-price models. A similar issue arises for nontradeable goods. They feature prominently in New Open Economy models and have been shown to increase the models’ ability to match central features of the data. But is a conventional NOEM model also able to match the basic properties of the tradeable and nontradeable sectors? This paper shows that the answer is yes.

2. Ghironi (2000) estimates a NOEM by nonlinear least squares at the single-equation level and full information maximum likelihood system-wide regressions. Bergin (2003) uses maximum likelihood techniques. Lubik and Schorfheide (2006 and 2007), Justiniano and Preston (2010a and 2010b), and Rabanal and Tuesta (2010) use Bayesian methods.

3. Conceptually it is possible to divide goods into tradeables and nontradeables, but disaggregated macroeconomic data, if available, are only for sectors as defined in the statistics.

4. Detailed derivations of all the equations are available from the author on request.

5. Total time available is different for the employed (Γ) and the unemployed (τ).

6. According to the Bureau of Economic Analysis’s “Guide to the National Income and Product Accounts of the United States,” government expenditure essentially consists of services provided to the public free of charge. Goods (and services) that are sold by the government are instead classified as personal consumption expenditure (if purchased by individuals) or intermediate inputs (if purchased by businesses).
7. Groningen Growth and Development Centre, 60-Industry Database, February 2005, http://www.ggdc.net. Because the year 2000 is the base year of the Groningen dataset, the data for the year 2000 does not depend on the computation of output deflators.

8. See Povoledo (2010) for a clarification on this point.

9. East Germany is not included in the time series up until 1990:4.

10. Notice that only goods can be durable or nondurable; services are neither durable nor nondurable.

11. The GMM estimation delivers the same estimates as OLS and SUR.

12. The specification of the functional form \( \kappa \) and the calibration of the parameters \( \chi, \Gamma, \tau \) and \( \psi \) are irrelevant for the solution.

13. That is, the ratio of imports of goods over total expenditure for goods (equal to 0.35), and the share of services in total (tradeable and nontradeable) consumption (equal to 0.56).

14. Specifically, \( \xi \) is their estimated value for the United States, and \( \xi^* \) is a weighted average of their estimates for Canada, France, Germany, Japan, and the United Kingdom.

15. These are equal to 0.64 and 0.56, respectively.

16. Detailed appendices illustrating the derivation of the moment conditions and the construction of the data variables are available from the author on request.

17. I compute the optimal weighting matrix using the Newey and West (1987) estimator with a Bartlett kernel. I have also verified that the estimates are not significantly affected by the choice of kernel or lag length.

18. For the United States, it is possible to obtain data on more sectors, but only at an annual frequency. In Povoledo (2010) I report standard deviations computed using such data, which confirm that the standard deviations in the tradeable sectors are higher than the standard deviations in the nontradeable sectors.

19. However, this measurement problem does not affect all the estimated values equally; for example, it does not affect the variance of the monetary shocks. This consideration confirms that the comparison between the data and the model-generated statistics cannot be strictly quantitative.

20. In Povoledo (2010) I perform a variance decomposition exercise and I show that Home monetary shocks are by far the most important source of fluctuations of sector-specific inflation rates and output levels. This is true also for sector-specific employment levels, but the latter are also significantly influenced by Home technology shocks.

21. This is a standard result, common to both the producer currency pricing model of Obstfeld and Rogoff (1995) and the local currency pricing model of Betts and Devereaux (2000). Impulse responses of all variables are available from the author on request.

22. In Povoledo (2010), I present a system of three equations that illustrates the key variables or channels of transmission of the exogenous shocks to the ratios of tradeable to nontradeable prices, output and employment. This system shows that the same channels which ensure the international transmission of shocks (the nominal exchange rate, the terms of trade, and the asset market) amplify the responses of tradeable sector variables to domestic monetary shocks.

23. This depends on the size of the elasticity of substitution between tradeable and nontradeable goods.

24. I define the price index for all Home tradeable goods as a weighted average of the price of output sold at Home and the price of output sold to Foreign consumers, converted in Home currency.

25. Under LCP, the pass-through elasticities \( \xi \) and \( \xi^* \) are equal to zero, and under PCP, the pass-through elasticities \( \xi \) and \( \xi^* \) are equal to one.

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