Trade Flow Dynamics with Heterogeneous Firms

By Fabio Ghironi and Marc J. Melitz*

Recent work, both theoretical and empirical, has highlighted a fundamental property of international trade patterns. When trade flows vary, either across countries or within a country over time, so does the number of goods embodied in those trade flows (as well as the number of firms engaging in those international transactions). This recent work has further shown that this extensive margin of trade is not an inconsequential property of trade flows that can safely be ignored. Rather, it plays a crucial role in explaining several important international economic phenomena. Patrick J. Kehoe and Kim J. Ruhl (2002) show how large responses of trade flows to small but long-lasting reductions in trade costs (driven by trade liberalization) are driven by a substantial response in the extensive margin of trade (export of new goods). Ruhl (2003) theoretically shows how such differences in the extensive margin of trade responses, between transitory business cycle and long lasting trade liberalization shocks, can explain the very large differences observed in the elasticity of trade response at high versus low frequencies. Elhanan Helpman, Melitz, and Yona Rubinstein (2006) show how the incorporation of the extensive margin of trade can substantially improve the fit and predictive power of the standard bilateral trade gravity specifications.[1] Thomas Chaney (2006) shows theoretically and empirically how the extensive margin of trade reverses the (previously assumed) amplification effect of product substitutability on trade costs. Christian Broda and David E. Weinstein (2006a) and Broda, Joshua Greenfield, and Weinstein (2006) focus on the extensive margin for imports. They quantify the gains for US secular growth in its extensive margin of imports, resulting in additional product variety for US consumers. This extensive margin is not accounted for in US price indices (either for imports or the Consumer Price Index more generally) and entails substantial previously unmeasured welfare gains for US consumers. Broda, Greenfield, and Weinstein (2006), show that, across a wide sample of countries, the growth in the extensive margin of imports can also account for an important component of that country's productivity growth (this effect is amplified for developing countries). Andrew G. Atkeson and Ariel T. Burstein (2006) show how modeling of the extensive margin of trade, along with firm heterogeneity and oligopolistic pricing, can best explain the strong evidence on US pricing to market.

We document how the model developed in Ghironi and Melitz (2005) explicitly incorporates these key extensive margin empirical features into an international real business cycle model that further replicates other important empirical features of net and gross trade flows over the cycle. The endogenous response of the extensive margin of trade is driven by two crucial new features in our model. First, our model endogenizes the development and introduction of new varieties over the business cycle, subject to sunk costs. Second, not all introduced varieties are traded. Firms that produce these varieties face fixed export costs (as well as per-unit trade costs) and export a variety only when it is profitable. The extensive margin of trade at any given time is jointly determined by the endogenous total number of varieties introduced in the economy, along with the endogenous subset of those varieties that are exported. Both channels fluctuate over the business cycle as the economy and its trading partner experience a series of productivity shocks.

Recent empirical evidence for the United States has substantiated the endogenous fluctuations in available domestic varieties at the heart of our model. Previous literature documented

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[1] Jonathan Eaton and Samuel S. Kortum (2002) provide a very important precedent which first incorporates the extensive margin into a multicountry trade model that delivers a gravity specification for bilateral trade.

the strong pro-cyclical behavior of net producer entry (measured as incorporated firms or as production establishments).[2] Andrew B. Bernard, Stephen J. Redding, and Peter K. Schott (2006) document how existing firms devote a substantial portion of their production to goods they did not previously produce. Broda and Weinstein (2006b) and Kostas Axarloglou (2003) measure the introduction of new varieties in the US economy and document a strong correlation with the business cycle. Disproportionately more new varieties are introduced during US expansions. Our model replicates these important patterns of pro-cyclical entry for goods and producers.[3] Forward-looking, monopolistically competitive producers make endogenous product entry decisions subject to sunk development costs. In our general equilibrium framework, these are captured by real resources which must be expended to cover these costs (and represent resources that are unavailable for use in goods production). These sunk costs introduce substantial endogenous persistence to several key macroeconomic variables in our model, most directly via the sluggish response of the available number of products in the economy. We document the sluggish response of the number of US establishments and show how our model captures the key features of its comovements with GDP.

The endogenous export decision for each good produced generates a second channel that affects the extensive margin of trade. Goods are produced with heterogeneous technologies, leading to differences in productivity (which can be thought of as product quality differences). This implies that only a subset of relatively more productive goods are exported. This proportion of exported goods also fluctuates with the business cycle. These features match up well with the empirical firm-level evidence on productivity, export status, and export market entry and exit. Our model captures the key aggregate business cycle comovements between the number of traded varieties and the aggregate trade levels.

We embed these macroeconomic features into a two-country dynamic, stochastic, general equilibrium (DSGE) model of international real business cycles. Prices are fully flexible, and we allow for international trade in bonds (which provide a risk-free real rate of return). This allows us to investigate the dynamic responses of net and gross trade flows. We document how our model captures the key cross-correlations of these variables with domestic GDP over the business cycle.

I. Model Overview

The model we use is developed in Section VI of Ghironi and Melitz (2005). Due to space restrictions, we only briefly describe its key features and refer the reader to that article for details. This is a two-country model with monopolistic competition and flexible prices. Households maximize expected intertemporal utility from consumption and supply labor inelastically. At any given time, the consumption basket is defined as a CES aggregate over a continuum of varieties. Domestic and foreign varieties enter symmetrically in this consumption index. There is a continuum of firms in each country, each producing a different variety. Firms are heterogeneous as they produce with different technologies, reflected in differences in labor productivity (labor is the only factor of production). Overall firm productivity is subject to aggregate (country-specific) shocks.

Prior to entry, firms are identical and face a sunk entry cost (in the form of labor requirements). Upon entry, firms draw their relative productivity level from a known distribution, which we parametrize as Pareto. This relative productivity parameter remains fixed thereafter. There are no other fixed production costs, so all firms produce until they are with a death shock, which occurs with an exogenous probability.

Home and foreign firms can serve both their domestic and the foreign market. However, exporting is costly and involves both a per-unit 'iceberg' cost as well as a fixed cost (again in the form of labor inputs). Due to this fixed export cost, firms with relatively low productivity levels choose to only serve their domestic market,

[2] See Jeffrey R. Campbell (1998); Michael B. Devereux, Allen C. Head, and Beverly J. Lapham (1996a, 1996b); and Satyajit Chatterjee and Russell W. Cooper (1993).

[3] Our model does not address the distinction between firms and products. The key unit of production in our model is a production line for a particular good. We do not model how these production lines are distributed across firms. When we refer to a producer or firm, we mean the production line for an individual good.

and those varieties are thus not available abroad. There is an endogenously fluctuating firm productivity cutoff separating the exporters from the non-exporters. (The firm with the cutoff productivity level earns zero additional profits from its export sales.) Thus, there is an endogenously fluctuating set of traded and non-traded goods (the latter, produced by the non-exporters).

There is an unbounded pool of prospective, forward looking entrants who correctly anticipate their future expected profits. Entry occurs until the expected present discounted value of these future profits (subject to the consumer's subjective discount factor and the probability of exit associated with the death shock) is equalized with the sunk entry cost. We assume that macroeconomic shocks are small enough that there is positive entry in every period.

Households in each country hold shares in a mutual fund of domestic firms and domestic and foreign bonds. The mutual fund fully diversifies the idiosyncratic risk of firm death, and investment in share holdings finances the creation of new firms. International borrowing and lending result in current account fluctuations as households transfer resources across countries to smooth consumption and generate additional resources for firm creation. The model features well defined net and gross trade flows: The trade balance is obtained as the difference between aggregate exports and imports in each period. In turn, these flows embody the contributions to trade of both the extensive margin (the number of firms that export in each country) and the intensive margin (exported output per firm).

II. International Trade and Variety over the Business Cycle

We solve the model by log-linearization around the unique steady state with balanced trade. We assume that entry and trade costs remain constant at their steady-state values and posit a bivariate $AR(1)$ process for percent deviations of home and foreign aggregate productivities from the steady state. These fluctuations are the source of international business cycles. We calibrate our model using the same parameter values as in Ghironi and Melitz (2005). Whenever possible, we choose parameter values to concord with previous work on international business cycles.[4] Our firm-level parameters are chosen to match micro-level data on US exporting plants.

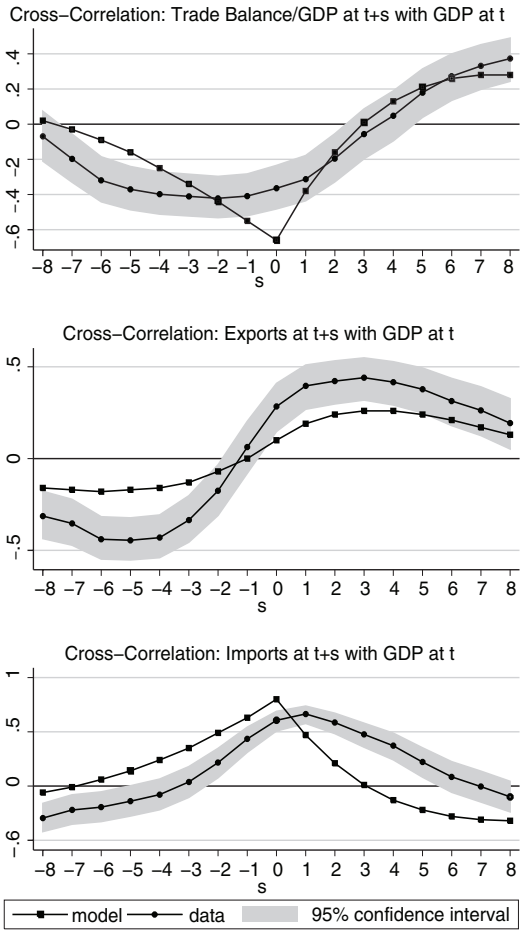

FIGURE 1. THE CYCLICALITY OF US TRADE

A. *Correlations*

Figure 1 presents evidence on the cyclical properties of US trade: the correlations between US GDP and the trade balance (as a ratio to GDP), exports, and imports at various leads and lags, and the counterparts to these moments

[4] For the autoregressive coefficient matrix of home and foreign productivities, we focus on the case of near unit root persistence and no spillovers in Ghironi and Melitz (2005).

generated by our model.[5] The figure shows an S-shaped pattern for the correlation between US GDP and the trade balance at various leads and lags. The trade balance is countercyclical (the contemporaneous correlation is negative) as documented by David K. Backus, Kehoe, and Finn E. Kydland (1992, 1994). The correlation between current GDP and future trade balances becomes positive. The correlations of gross trade flows with GDP explain this time profile of the cyclicality of net trade. While the correlation of exports with GDP displays an S-shaped profile, with the peak positive correlation happening several periods in the future, the correlation of imports with GDP is roughly tent-shaped, with the positive peak happening much earlier. This results in the contemporaneous countercyclicality of net trade and its expansion relative to GDP in the future.

Our model captures these qualitative patterns well. The intuition for the countercyclicality of the trade balance is analogous to that in the international real business cycle models of Backus, Kehoe, and Kydland (1992, 1994) and other studies. As we emphasized in Ghironi and Melitz (2005), creation of new production lines associated to new varieties is a form of capital accumulation in our model, financed through the saving decisions of households. When a favorable shock induces the economy to expand, agents borrow from abroad to finance faster entry of new production lines in the more attractive business environment, resulting in a countercyclical trade balance. While imports increase quickly as consumer demand expands, export expansion is slower, as the gradual increase in the number of home producers results in a gradual increase in the number of exporters.[6]

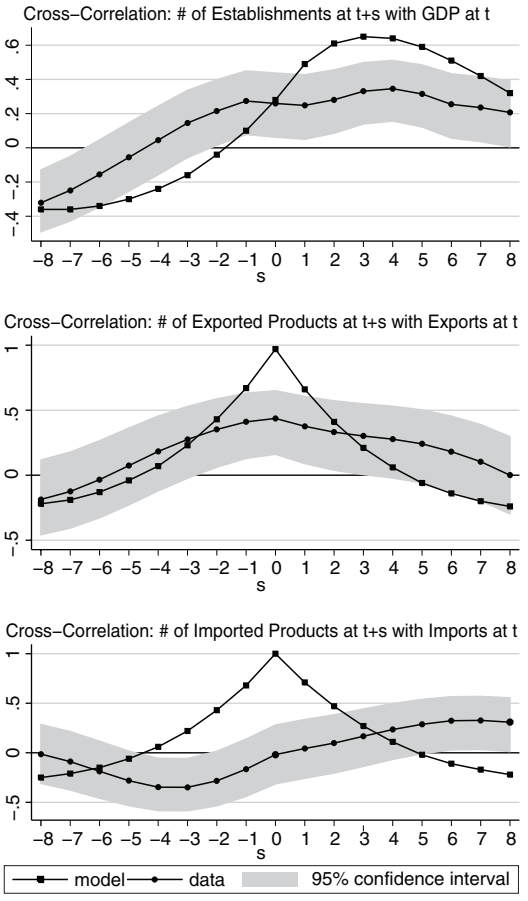

FIGURE 2. DOMESTIC AND TRADED VARIETY

Entry of new production lines associated with product creation and the dynamics of the extensive margin of trade are central for the ability of our model to reproduce the cyclical behavior of US trade. We reviewed some evidence on the significance of product creation and the extensive margin of trade over the business cycle earlier.[7] Figure 2 shows that our model comes close to matching the evidence on the cyclical variation in the number of establishments in US manufacturing.[8] The correlation function dis-

[5] The figure also shows the 95 percent confidence bands around the data correlations. These are based on logged, HP-filtered quarterly data, 1957:1-2006:2, except for the trade-balance-to-GDP ratio, which is not logged. Nominal data and the GDP deflator are from the International Monetary Fund (IMF). Data-consistent real variables in our model are obtained by deflating nominal variables by an average price index that removes the pure variety effect implicit in welfare-consistent price indexes (see Ghironi and Melitz, 2005, for details).

[6] As a discussion of impulse responses available on request substantiates, it is expansion along the extensive export margin that increases total home exports in our model, with lower output per exporter.

[7] See also Florin O. Bilbiie, Ghironi, and Melitz (2005) for more evidence on entry and product creation over the business cycle, and its role as capital accumulation.

[8] The quarterly series of the number of establishments, 1975:1–2000:4, is from the Quarterly Census of

plays negative correlation between the number of establishments in the past and current GDP, positive contemporaneous correlation, and positive correlation between current GDP and the number of future establishments. A higher GDP is associated with a relatively larger number of establishments that operate currently and in the future, as economic expansion stimulates business creation. The negative correlation between current GDP and the number of establishments in the past is equivalent to a negative correlation between the current number of establishments and GDP several quarters ahead, consistent with expansion in product variety taking place before GDP has reached the peak of a cycle. The S-shaped pattern generated by our model, in which entry takes place in anticipation of economic expansion, is not distant from the empirical correlation.

Figure 2 also illustrates the properties of our model in relation to data with respect to the extensive margin of international trade by presenting correlations between real exports (imports) and the number of exported (imported) varieties at various leads and lags.[9] Consistent with the data, the model predicts a tent-shaped correlation between exports and the number of exported varieties. The correlation is too strong relative to the data, but we conjecture this is a consequence of abstracting from sunk export market entry costs in the model. The model also predicts a tent-shaped correlation between imports and the number of imported varieties, with essentially perfect contemporaneous correlation. This is the predicted moment most different from the available US data, although the prediction of a strong correlation is qualitatively consistent with cross-country evidence. The available series on US exported and imported varieties are much shorter than the other data series in our exercise, making it hard to identify clear, statistically significant patterns, particularly on the import side. For this reason, and given the strong cross-country evidence, we do not view the inability of the model to replicate the absence of a significant contemporaneous correlation between imports and imported varieties suggested by this limited US data as a major setback.[10] Overall, the model does well at replicating several features of evidence on the cyclicality of US trade and changes along domestic and international extensive margins under a calibration that was not chosen to match any of these features.

III. Conclusions

We used a two-country, stochastic, general equilibrium model of international trade and macroeconomic dynamics with monopolistic competition and heterogeneous firms to explore the role of entry in the domestic economy and the extensive margin of international trade in the dynamics of US trade flows over the business cycle. There is substantial evidence of the association of producer entry, product introduction, and economic fluctuations in the United States, and strong evidence of the connection between trade flows and changes in the range of traded varieties across countries. We showed that our model can reproduce the evidence on the cyclicality of US trade and important features of the evidence on the extensive margins of domestic entry and international trade. Entry in the domestic economy and the implied differences in the timing of export and import expansions in response to favorable shocks provide the key mechanism for the model's ability to explain this range of stylized facts.

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Employment and Wages. The series is logged and HP-filtered before computing the correlation in Figure 2.

[9] The data on exported and imported varieties are 1989–2001 numbers of exported and imported HTS codes reported by the United States in Robert C. Feenstra, John Romalis, and Schott (2002). Quarterly series are interpolated from the annual data.

[10] It should also be noted that the correlation between import value and imported varieties at yearly frequency displays a tent shape, with statistically significant and positive contemporaneous correlation, between leads and lags of GDP from −2 to 2. The yearly frequency also increases the peak correlation between export value and exported varieties.

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