International Trade and Macroeconomic Dynamics with Labor Market Frictions*

(Job Market Paper)

Matteo Cacciatore†
Boston College

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Abstract

Do country-specific labor market frictions – hiring and firing restrictions and protection of unemployed workers – affect the consequences of trade integration? I address this question in a two-country model of trade and macroeconomic dynamics with heterogeneous firms, endogenous producer entry, and search and matching frictions in the labor market. I study the dynamic effects of trade integration on unemployment and economic activity and the business cycle implications of stronger trade linkages. The model introduces a novel source of amplification and propagation of domestic and international shocks, as fluctuations in job creation and destruction affect the profitability of producer entry into domestic and export markets. Structural differences in labor markets translate into asymmetric entry and export dynamics across countries. As trade barriers are reduced, unemployment initially rises (falls) in countries with more rigid (flexible) labor markets. In the long run, average productivity gains ensure positive employment effects in both countries. Trade is always beneficial for welfare, but the economy with a rigid labor market gains less. Integration has also important business cycle consequences. In contrast to benchmark international real business cycle models, but consistent with the data, the model predicts that trade integration leads to increased business cycle synchronization. Volatility increases in the country with a rigid labor market, but it falls for the flexible partner.

JEL classification: E32, F16, F41, J60.

Keywords: trade integration, search and matching, firm entry, heterogeneous firms, business cycle comovement, labor market policy.

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†matteo.cacciatore@bc.edu. Address: Boston College, Department of Economics, 140 Commonwealth Ave, Chestnut Hill, MA, 02467, USA.

1 Introduction

Do country-specific labor market frictions affect the consequences of trade integration? Several empirical studies have documented substantial cross-country heterogeneity in labor market characteristics and its importance for aggregate outcomes.[1] While theoretical contributions have analyzed the long run effects of trade on unemployment, little work has investigated how the functioning of labor markets affects overall outcomes of integration. This is the perspective adopted in this paper. Specifically, I study the dynamic consequences of trade integration on unemployment and economic activity and the business cycle implications of stronger trade linkages between countries with potentially heterogeneous labor markets. In so doing, I contribute to the trade literature, which typically focuses only on the long-run effects of trade integration and abstracts from its effects on fluctuations, and the international macroeconomic literature, by exploring the role of labor market frictions and trade in explaining international business cycle evidence.

To accomplish these goals, I develop a two-country, stochastic, general equilibrium model of trade and macroeconomic dynamics with heterogeneous firms, endogenous producer entry, and frictional labor markets. The model builds on Ghironi and Melitz (2005) in its determination of trade along the dynamics of the economy: Heterogeneous, monopolistically competitive firms face sunk entry costs in the domestic market and both fixed and per-unit export costs. Relatively more productive firms export, while the remaining, less productive producers only serve the domestic market.[2] To introduce equilibrium unemployment and study the role of alternative labor market structures, I assume the presence of search and matching frictions as in Mortensen and Pissarides (1994), with costs of job creation and destruction and unemployment benefits that can differ across countries.[3] Model tractability is preserved since I show that appropriately defined average productivities summarize all the relevant information for aggregate dynamics, as in the basic Melitz (2003) model.

The combination of product and labor market dynamics explains observed responses to trade integration: reallocation of production toward most productive firms (Trefler, 2004, and Bernard *et al.*, 2003) and within-industry job creation and destruction (Levinsohn, 1999 and Haltiwanger *et al.* 2004).[4] Heterogeneous labor markets imply asymmetric effects of global reductions of trade barriers, causing important differences in the short-run effects on unemployment across countries.[5]

[1] The World Bank (2007), following Botero et al. (2004), constructed a measure of the rigidity of employment laws across countries. For example, the index for the U.S. is 97 (out of 100, corresponding to maximum flexibility), while for France, Italy and Germany it is 34, 45 and 50 respectively. Moreover, labor market characteristics are found to be significant determinants of unemployment rates (Nickell and Nunziata, 2005), job flows (Haltiwanger, 2008), and the cyclical behavior of unemployment (Gomez, Vallanti and Messina, 2004, Messina and Vallanti , 2007).

[2] This paper focuses on within industry trade. The assumptions about the product market structure are justified by overwhelming empirical evidence indicating substantial productivity differentials across producers and the presence of barriers to entry into domestic and export markets.

[3] In this framework key parameters of the labor market have a clear counterpart in the data. As a result, the introduction of heterogeneity in labor markets across trading partners has a transparent empirical ground.

[4] While empirical work documented the presence of labor reallocation in response to trade integration between plants and within sectors, reallocation of workers across industries is found to be not significant (see Wacziarg and Wallace, 2004).

[5] For calibration purposes, I assume that the more rigid economy in the model features labor market characteristics

In the aftermath of integration, the economy with a more rigid labor market experiences an increase in unemployment, since larger hiring and firing costs dampen the reallocation of workers toward the most productive firms. In contrast, unemployment falls in the flexible economy. In the long run unemployment is lower in both economies, since the reallocation of market shares toward more productive producers increases the average return to a match in both countries. Thus, more workers are matched to firms in the new steady state. Importantly, there is no trade-off between short- and long-run unemployment outcomes in any country when labor markets are symmetric.

While the short-run unemployment effects of trade reforms differ (qualitatively and quantitatively) across heterogeneous labor markets, consumption increases everywhere, and so does welfare – both in the long run and along the transition. Favorable terms of trade boost consumption in the rigid country, while productivity and employment gains more than offset a negative terms of trade effect in the flexible trading partner. However, there are differences in the size of consumption and welfare gains across different labor markets: As employment and wages are higher, and competition from abroad is lower, the flexible economy becomes a relatively more profitable business environment, attracting more firms on the market. Thus, employment and consumption increase by more than in the rigid trading partner both during the transition and in the new steady state. Welfare gains are larger (smaller) the more rigid (flexible) the trading partner is.

The trade literature usually restricts the analysis of the consequences of trade integration to the long-run, "direct" consequences of the "integration shock".[6] However, trade integration affects economic outcomes and welfare also through its effects on the domestic and international propagation of business cycle shocks. The dynamic, stochastic, general equilibrium model of this paper allows me to address the full range of consequences of trade integration. In particular, the interaction of product and labor market dynamics that determines the direct consequences of trade integration is also at the heart of the propagation mechanism of business cycle shocks. Aggregate productivity disturbances generate spikes in job creation and destruction, with persistent effects on employment as a consequence of matching frictions. The profitability of producer entry into domestic and export markets responds to aggregate labor market conditions, and the sluggish adjustment in the number of producers over time feeds back into employment dynamics that magnify the future output effects of shocks. In turn, amplification of domestic responses implies that shocks originating in one country can trigger sizable and long lasting effects on its trading partner, increasing country interdependence.

In this context, structural differences in labor markets translate into different effects of shocks on profitability of job creation and destruction, resulting in different entry and export dynamics across countries. Aggregate fluctuations are dampened in the more rigid economy, but output and unemployment display higher persistence, consistent with the evidence in Michelacci and Balakhrishnan

similar to the Europe's Economic and Monetary Union (EMU) - Euro Area henceforth. The flexible economy represents the U.S. Hiring and firing restrictions and generosity of unemployment benefits are considered among the major contributors to the rigidity of continental European labor markets. See for instance Bentolila and Bertola (1998), Layard et al. (2005), and Ljungqvist and Sargent (2006).

[6] For instance, this is the approach of a recent paper by Helpman and Itskhoki (2008) that also features labor market frictions.

(2004) and Duval *et al.* (2007).

Trade integration affects this mechanism in two ways: When trade barriers are reduced, the magnification of domestic shocks induced by sunk entry costs and search and matching frictions translates into larger and more persistent effects on foreign output dynamics, with a positive effect on the comovement of business cycles across countries. Moreover, since the endogenous response of domestic and export market entry mitigates the terms of trade effects of shocks, the incentives to shift resources across countries over the cycle are dampened, with a further positive effect on comovement. Thus, the model predicts that business cycle synchronization increases with stronger trade linkages, as reported by Frankel and Rose (1998) and Clark and van Wincoop (2001). This result has often eluded standard international business cycle models that typically predict too small or negative effects of trade integration on output comovement – the so called trade-comovement puzzle (Kose and Yi, 2005).[7] Importantly, the mechanisms leading to increased synchronization do not depend on country-specific labor market features. Essential for the result is the endogenous interaction between product and labor market dynamics: the time consuming nature of the matching process combines with the presence of sunk entry costs, changing the propagation of shocks across countries with respect to standard international RBC models. Nevertheless, as asymmetries in labor markets become less pronounced, comovement is further strengthened.[8]

The consequences of trade integration on output volatility are instead conditional on the labor market characteristics of trading partners. As comovement increases, economic fluctuations become larger in the economy with a more rigid labor market and reduce in the flexible one. When labor markets are more similar these effects are milder.

The trade paper that is most closely related to my exercise is Helpman and Itskhoki (2008).[9] As in that paper, I focus on the role of labor market imperfections for the consequences of trade integration. Helpman and Itskhoki introduce search unemployment in a static two-sector model of trade with heterogeneous firms to study the effects of labor market rigidities and trade impediments on long-run welfare, trade flows, productivity, and unemployment. In contrast, I study the consequences of heterogeneity in labor market structures for the effects of trade integration from the short to the long run, and I consider the full range of effects of trade integration, including its impact on business cycle dynamics.[10]

[7] In standard international RBC models, larger trade costs – *i.e.* weaker trade linkages – increase output correlation by reducing the incentives to reallocate investment across countries in response to shocks. As a result, the positive effect of stronger demand linkages generated by lower trade barriers is more than offset. Importantly, even under financial autarky the predicted synchronization is less than one fourth compared to the data: domestic shocks generate too small and short lasting effects on foreign output fluctuations, despite the increase in product markets integration.

[8] This result has implications for the policy debates on economic integration and adoption of a common currency in the EMU. Frankel and Rose (1998) argued that lack of business cycle synchronization across countries should not necessarily be a concern when considering adoption of a common currency because the trade expansion from reduced trade frictions would result endogenously in increased comovement. The results of this paper show that this effect is stronger if trade integration is preceded by harmonization of labor market structures.

[9] Numerous papers have investigated the channels through which trade can affect long run unemployment abstracting from the role of country-specific labor market characteristics. See for instance Davidson et al. (1999), Davidson and Matisz (2004), Felbermayr, Prat, and Schmerer (2008), and Egger and Kreickemeier (2009).

[10] Furthermore, Helpman and Itskhoki disallow for forward-looking behavior of workers and firms on the labor market, which is a crucial feature of my model.

This paper is also related to a recent literature in international macroeconomics that, starting with Ghironi and Melitz (2005), shows how models with richer trade microfoundations than usually assumed can yield novel insights into macroeconomic dynamics and contribute to explaining international business cycle evidence.[11] I contribute to this literature by showing that labor market frictions play an important role for the endogenous propagation of shocks via trade.

Finally, the paper is related to a recent literature that focuses on the business cycle implications of trade integration. For example, Arkolakis (2008) builds a model of aggregate fluctuations and vertical specialization in international trade, showing that stronger vertical trade linkages between countries can enhance the synchronization of business cycles. Drodz and Nosal (2008) address the link between trade and comovement in a model with low short-run price elasticity of trade and high long-run elasticity. Differently from these papers, I focus on the role of labor market frictions in a model with endogenous product market dynamics.[12]

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 discusses the calibration. Section 4 presents steady-state and dynamic effects of trade integration. Sections 5 and 6 focus on business cycle implications of trade integration and labor market structure. Section 6 concludes.

2 The Model

I begin developing a version of the model under financial autarky.

2.1 Household Preferences and Intratemporal Choices

The world consists of two countries, home and foreign. Foreign variables are denoted with a superscript star. Each economy is populated by a unit mass of atomistic households. All contracts and prices are written in nominal terms and prices are flexible.[13] Each household is thought of as a large extended family containing a continuum of members along a unit interval. In equilibrium some members will be unemployed while some others will be producing. Household members perfectly ensure each other against variation in labor income due to employment or unemployment. There is no ex post heterogeneity across individuals.

[11] See, for instance, Bergin and Glick (2003), Corsetti, Martin and Pesenti. (2006), Contessi (2006) and Zlate (2008).

[12] A few other papers have introduced search and matching frictions of the form used here in otherwise standard international business cycle models, but none of these papers focused on the consequences of trade integration. For instance, Hairault (2004) studies the effects of search and matching frictions in a two-country real business cycle model, showing that labor market frictions improve the ability of the model to generate comovement in labor inputs and investment across countries. Campolmi and Faia (2008) develop a DSGE model of a currency area with sticky prices and labor market frictions to study whether cyclical inflation differentials observed for EMU countries can be explained by differences in labor market institutions.

[13] For this reason I do not model demand for currency and resort to a cashless economy as in Woodford (2003).

The representative household maximizes the following utility function:

$$u(C) = E_t \left\{ \sum_{s=t}^{\infty} \beta^{s-t} \frac{C_s^{1-\upsilon}}{1-\upsilon} \right\}, \tag{1}$$

where $\beta \in (0,1)$ is the subjective discount factor and $\nu > 0$ is the inverse of the intertemporal elasticity of substitution. At time t the household consumes a basket of goods C_t defined over a continuum Ω :

$$C_t = (\int_{\omega \in \Omega} c_t(\omega)^{\frac{\gamma-1}{\gamma}} d\omega)^{\frac{\gamma}{\gamma-1}},$$

where $\gamma > 1$ is the symmetric elasticity of substitution across goods.

At any given point in time only a subset of goods $\Omega_t \in \Omega$ is available. Let $p_t(\omega)$ be the home nominal price for the good $\omega \in \Omega_t$. The consumption-based price index for the home economy is

$$P_t = [\int_{\omega \in \Omega} p_t(\omega)^{1-\gamma} d\omega]^{\frac{1}{1-\gamma}},$$

and home's demand for each individual variety ω is:

$$c_t(\omega) = (\frac{p_t(\omega)}{P_t})^{-\gamma} Y_t,$$

where Y_t is the aggregate demand in the home country.

The foreign household maximizes a similar utility function, with identical parameters. The foreign consumption basket is:

$$C_t^* = (\int_{\omega \in \Omega} c_t^*(\omega)^{\frac{\gamma-1}{\gamma}} d\omega)^{\frac{\gamma}{\gamma-1}}.$$

Importantly, the subset of goods available for consumption in the foreign economy during period t is $\Omega_t^* \in \Omega$ and can differ from the subset of goods that are available in the home economy. Similar to the home economy, the foreign consumption based price index is $P_t^* = [\int_{\omega \in \Omega} p_t^*(\omega)^{1-\gamma} d\omega]^{\frac{1}{1-\gamma}}$ and foreign demand for an individual good ω is $c_t^*(\omega) = (\frac{p_t^*(\omega)}{P_t^*})^{-\gamma} Y_t^*$.

2.2 Firms and the Labor Market

In each country there is a continuum of monopolistically competitive firms, each producing a different variety ω. Production requires only labor and it is characterized by constant returns to scale. Firms are heterogenous as they produce with different technologies indexed by relative productivity z. From now on, to save notation, I will abuse language by identifying a firm with its productivity z, omitting the variety index ω.[14]

[14] In this continuum setting, the number of firms with a productivity z is $g(z)dz$, the density at z. So potentially, there is "more than one" single firm with such a productivity. Formally, each of these firms has a different identity (each of them produces a unique differentiated variety ω). However, as I will show later, they all behave in exactly the same way. They are indistinguishable from their actions. For this reason I can safely omit the variety label ω. I also use the same index z for both Home and Foreign firms as this variable only captures firm productivity relative

Firms are subject to aggregate and idiosyncratic productivity shocks. Z_t is the stochastic aggregate productivity, common to all firms. In addition, within each firm, there are idiosyncratic job specific productivity shocks.[15] Those are *i.i.d.* draws from a time invariant distribution with *cdf* $H(\cdot)$, assumed to be independent of firms productivity z and identical across countries. To summarize: the filled job i at firm z produces $zZ_t a_{i,t}$ units of output at time t. The timing of the model is described in Table 1.

I model labor market frictions within the context of a large firm set up, in order to allow both size and number of producing firms to vary in response to aggregate shocks. Each firm employs a continuum of workers. Within each firm, the stock of labor varies because of the variation in hiring (job creation) and firing (job destruction).

To hire a new worker each firm has to post a vacancy, incurring in a cost κ - expressed in units of the aggregate consumption basket C_t and, most importantly, independent of z. The probability of finding a worker depends on a constant return to scale matching technology, which converts aggregate unemployed workers U_t and aggregate vacancies V_t into aggregate matches M_t:

$$M(U_t, V_t) = \chi U_t^{\varepsilon} V_t^{1-\varepsilon}, 0 < \varepsilon < 1.$$

Defining labor market tightness as $\theta_t \equiv \frac{V_t}{U_t}$, each firm meets unemployed workers at a rate $q(\theta_t) = \frac{M(U_t,V_t)}{V_t}$. I assume that newly created matches become immediately productive. For an individual firm, the inflow of new hires in t is therefore $q(\theta_t)v_{z,t}$, where $v_{z,t}$ is the number of vacancies posted by an incumbent with productivity z.

Firms and workers can separate for exogenous and endogenous motives. When the firm finds a match to be no longer profitable, it can dismiss the worker but it has to incur a constant firing tax F, also independent of firm's specific productivity z.[16]

Firm output is determined by the measure $l_{z,t}$ of jobs, the firm specific productivity z, the aggregate productivity Z_t and the aggregate over job specific idiosyncratic shocks $\bar{a}_{z,t} = \int_{a_{z,t}}^{\infty} a \frac{dH(a)}{1-H(a_{z,t}^c)}$:

$$y_{z,t} = zZ_t \overline{a}_{z,t} l_{z,t}, \tag{2}$$

where $a_{z,t}^c$ is the (endogenous) critical threshold below which a firm z destroys non profitable jobs with a realization $a_t(i) < a_{z,t}^c$. This results in an endogenous within-firm job destruction rate $H(a_{z,t}^c)$.

Within firm separation has also an exogenous component $\overline{\varrho}$. This represents the fraction of jobs that are exogenously separated at the beginning of each period, identical across all producers.[17]

to the distribution of firms in the country.

[15] I introduce job-specific idiosyncratic shocks to induce endogenous job destruction in the model. The latter is required to make effective the role of firing costs in the model.

[16] As in Thomas (2006), firing costs take the form of a pure firing tax. Severance transfers from the firm to the worker have no allocative effects in the standard model with Nash wage bargaining.

[17] This assumption ensures that, in presence of small aggregate shocks, there are no corner solution with zero hiring in the firm's maximization problem. I assume that when the separation is exogenous, no firing costs are paid.

The law of motion of employment for the producer z is given by :

$$l_{z,t} = [1 - H(a^c_{z,t})][(1 - \overline{\varrho})l_{z,t-1} + q(\theta_t)v_{z,t}]. \tag{3}$$

Endogenous entry of producers is modelled as in Ghironi and Melitz (2005). Prior to entry, firms are identical and face an entry cost $f_{E,t}$, to be specified later on. Upon entry, home firms draw their productivity level z from a common distribution $G(z)$ with support on $[z_{\min}; \infty)$. Foreign firms draw their productivity level from an identical distribution. This relative productivity level remains fixed thereafter. There are no fixed costs of production. Hence, all firms that enter the economy produce in every period until they are hit by a "death" shock, which occurs with probability $\delta \in (0, 1)$ in every period.[18] When a firm leaves the market, its entire stock of workers becomes unemployed, joining the pool of searchers in the next period. I assume that exiting firms bear no costs associated with the workers' layoff.

Home and foreign firms can serve both their domestic market as well as the export market. Exporting is costly and it involves both a per unit iceberg trade cost $\tau_t > 1$ ($\tau^*_t > 1$) and a per-period fixed cost $f_{X,t}$ ($f^*_{X,t}$).[19] I assume that the fixed export cost is paid in units of consumption: to serve the foreign market each exporting firm needs to purchase a bundle of materials that has the same composition of the domestic consumption basket.[20]

2.2.1 Incumbent Firms

An incumbent with productivity z minimizes the following cost function:

$$Cost_t(z) = E_t \sum_{s=0}^{\infty} \beta_{t+s}\{\bar{w}_{z,s}l_{z,s} + \kappa v_{z,s} + H(a^c_{z,t})F\},$$

where $\beta_{t+1} = \beta(1 - \delta)(\frac{C_{t+1}}{C_t})^{-\gamma}$ is the household's discount factor adjusted for the exogenous exit probability. The first term of the cost function reflects the wage bill of the firm. Wages are not identical across workers, but they depend on the idiosyncratic productivities of jobs. Therefore, $\bar{w}_{z,t}$ is the aggregate of individual wages paid by the incumbent z, taken as given by the producer. The second and third terms reflect vacancy and firing costs respectively. The two constraints are (2) and (3).

Combining the first-order conditions for $l_{z,t}$, $v_{z,t}$ and $a^c_{z,t}$ it is possible to derive job creation (JC) and job destruction (JD) curves for a producer with relative productivity z:

[18] I abstract from the endogenous decision of firms to leave the market to preserve model tractability.

[19] Empirically, there is substantial evidence that a big portion of export costs are indeed sunk. The presence of sunk export costs would significantly complicate the model's solution. Qualitatively, the assumption of fixed rather than sunk export costs is harmless. Their quantitative relevance is left for further investigation.

[20] I assume that the fixed export cost is paid in units of consumption for simplicity. Alternatively, $f_{X,t}$ could be denominated in units of labor, as in GM. Assuming that workers can be employed either in production of final goods or in the production of export services would complicate the model due to the presence of labor market fricitons. A version of the model with the export cost denominated in units of labor is available upon request.

$$\frac{\kappa}{q_t} = \varphi_{z,t} z Z_t \int_{a^c_{z,t}}^{\infty} (a - a^c_{z,t}) dH(a) - \int_{a^c_{z,t}}^{\infty} (w(a) - w(a^c_{z,t})) dH(a) - F, \tag{4}$$

$$\varphi_{z,t} z Z_t a^c_{z,t} + F + E_t \beta_{t,t+1} \frac{\kappa}{q_{t+1}} = w^c_{z,t}, \tag{5}$$

where $\varphi_{z,t}$ is the Lagrange multipliers attached to the output constraint, representing the firm's real marginal revenue.

The job creation equation states that the expected marginal cost of posting a vacancy - $\frac{\kappa}{q(\theta_t)}$ - has to be equal to the expected marginal benefit. The job destruction equation defines the job-specific productivity threshold $a^c_{z,t}$: each producer has to be indifferent between keeping and firing the marginal worker. The marginal benefit of that match is given by its marginal revenue product augmented by the saving from paying firing costs and posting a new vacancy in the next period. The marginal cost is the wage bill.

The behavior of each producer z on the labor market can be summarized by mean of job creation, job destruction and aggregate wage equations. The wage schedule is obtained through the solution of an individual Nash bargaining process. The bargaining solution splits the surplus of the match between the firm's and the worker's outside option. The analytical derivation of the wage scheduled is presented in Appendix A, here I report the equilibrium wage resulting from the bargaining between a worker with a generic idiosyncratic productivity a and a producer with productivity z:

$$w_{z,t}(a) = \eta(\varphi_{z,t} z Z_t a + \kappa\theta_t + (1 - E_t\zeta_{t+1})F) + (1 - \eta)B, \tag{6}$$

where $\zeta_{t+1} = (1 - p_{t+1})(1 - \overline{\varrho}) E_t \beta_{t+1}$ and B is the unemployment benefit received by the worker if unemployed.

The match specific wage rate is increasing in the real marginal value product - $\varphi_{z,t} z Z_t a_t$, labor market tightness and size of unemployment benefits. A higher expected probability of firing the worker instead lowers $w_{z,t}(a)$.

The aggregate real wage is the average of the individual wages, weighted according to the distribution of the idiosyncratic productivities:

$$\bar{w}_{z,t} = \int_{a^c_{z,t}}^{\infty} w_{z,t}(a) \frac{dH(a)}{1 - H(a^c_{z,t})}. \tag{7}$$

Substituting equations (6) and (7) in (4) and (5) the job creation and destruction equations can be restated as:

$$\frac{k}{q_t} = \varphi_{z,t} z Z_t (\bar{a}_{z,t} - a^c_{z,t})(1 - H(a^c_{z,t})) - F, \tag{8}$$

$$\varphi_{z,t} z Z_t a^c_{z,t} = [B + \frac{1}{1 - \eta}(\eta\kappa\theta_t - \frac{\kappa}{q(\theta_t)} - (1 + \eta E_t \zeta_{t+1})F]. \tag{9}$$

Similarly, in the foreign country:

$$\frac{k^*}{q_t^*} = \varphi_{z,t}^* z Z_t^* (\bar{a}_{z,t}^* - a_{z,t}^{*c})(1 - H(a_{z,t}^{*c})) - F^*, \tag{10}$$

$$\varphi_{z,t}^* z Z_t^* a_{z,t}^{*c} = [B^* + \frac{1}{1-\eta^*}(\eta^* \kappa^* \theta_t^* - \frac{\kappa^*}{q^*(\theta_t^*)} - (1 + \eta^* E_t \zeta_{t+1}^*) F^*], \tag{11}$$

where it is understood that all the labor market parameters are (potentially) asymmetric across home and foreign countries.

2.2.2 Profit Maximization

All firms face a residual demand curve with constant elasticity of substitution γ in both markets and set fully flexible prices that reflects the same proportional markup $\frac{\gamma}{\gamma-1}$ over the real marginal cost $\varphi_{z,t}$. Let $p_{D,t}(z)$ and $p_{X,t}(z)$ ($p_{D,t}^*(z)$ and $p_{X,t}^*(z)$) denote the nominal domestic and export prices of a home (foreign) firm. I assume that export prices are denominated in the currency of export market. Prices, in real terms relative to the price index in the destination market, are given by:

$$\rho_{D,t}(z) \equiv \frac{p_{D,t}(z)}{P_t} = \frac{\gamma}{\gamma-1}\varphi_{z,t}, \quad \rho_{X,t}(z) \equiv \frac{p_{X,t}(z)}{P_t^*} = \frac{\tau_t}{Q_t}\rho_{D,t}(z),$$

$$\rho_{D,t}^*(z) \equiv \frac{p_{D,t}^*(z)}{P_t^*} = \frac{\gamma}{\gamma-1}\varphi_{z,t}^*, \quad \rho_{X,t}^*(z) \equiv \frac{p_{X,t}^*(z)}{P_t} = Q_t \tau_t^* \rho_{D,t}^*(z),$$

where $Q_t \equiv \frac{\varepsilon_t P_t^*}{P_t}$ is the consumption-based real exchange rate (units of consumption per units of foreign consumption; ε_t is the nominal exchange rate, units of home currency per units foreign).

Due to the presence of fixed export costs, $f_{X,t}$, a firm may decide not to export in any given period since expected profits cannot cover $f_{X,t}$. When making this decision a firm decompose its total real profit $d_t(z)$ into portions earned from domestic sales $d_{D,t}(z)$ and from potential export sales $d_{X,t}(z)$:

$$d_t(z) = d_{D,t}(z) + d_{X,t}(z),$$

where all the profits are expressed in units of the consumption basket in the firm's location. In particular:

$$d_{D,t}(z) = \frac{1}{\gamma}(\rho_{D,t}(z))^{1-\gamma} Y_t$$

$$d_{X,t}(z) = \begin{cases} \frac{Q_t}{\gamma}(\rho_{X,t}(z))^{1-\gamma} Y_t^* - f_{X,t} & \text{if firm } z \text{ exports} \\ 0 & \text{otherwise} \end{cases}.$$

A firm will export if and only if the expected profit from exporting is non-negative. There exists a home (foreign) cut-off productivity $z_{X,t}$ ($z_{X,t}^*$) such that: $z_{X,t} = \inf\{z : d_{X,t}(z) > 0\}$. I assume that the lower bound cost $z_{\min}$ is low enough to have $z_{X,t}$ ($z_{X,t}^*$) $> z_{\min}$. This ensures the existence of an endogenously determined non-traded sector: firms with a productivity draw z below $z_{X,t}(z_{X,t}^*)$ only produce for their domestic market in period t. The set of exporting firms fluctuates over time with changes in profitability of export.

2.3 Aggregation

As in Melitz (2003) I define two special "average" productivity levels (proportional to the relative output shares): an average $\widetilde{z}_D$ for all producing firms in each country, and an average $\widetilde{z}_{X,t}(\widetilde{z}^*_{X,t})$ for all home (foreign) exporters:

$$\tilde{z}_d = \tilde{z}^*_d = [\int_{z_{\min}}^{\infty} z^{\gamma-1} dG(z)]^{\frac{1}{\gamma-1}},$$

$$\tilde{z}_{x,t} = [\frac{1}{1-G(z_{x,t})}]\int_{z_{x,t}}^{\infty} z^{\gamma-1} dG(z)]^{\frac{1}{\gamma-1}},\ \tilde{z}^*_{x,t} = [\frac{1}{1-G(z^*_{x,t})}]\int_{z^*_{x,t}}^{\infty} z^{\gamma-1} dG(z)]^{\frac{1}{\gamma-1}}.$$

Melitz (2003) shows that all aggregate variables can be summarized by mean of these productivity averages. This paper extends Melitz's result in a dynamic model with search and matching frictions in the labor market. Two sufficient conditions for the result are: (a) production function is linear in labor; (b) hiring and firing costs are linear and identical across plants (*i.e.* independent of firm's specific productivity z).[21] Melitz's aggregation survives because these two assumptions ensure that the firm's real marginal cost can still be written in the form:

$$\varphi_{z,t} = \frac{\overline{\varphi}_t}{z},$$

where $\overline{\varphi}_t$, still to be defined, is a component of the firm real marginal cost identical across plants.[22]

In Appendix B and C, I show that such a representation exists. Conditions (a) and (b) imply that the wage rate and the within firm job destruction cut off $a^c_{z,t}$ are independent of the firm's specific productivity z. From (9) it follows immediately that $\varphi_{z,t}$ can be written as $\varphi_{z,t} = \frac{\overline{\varphi}_t}{z}$. Intuitively, since both hiring and firing costs are independent of z, the outside option of each producer - not being matched with a particular worker - is identical across producers and it depends only on aggregate outcomes. As a result, labor market frictions affect the firm real marginal cost symmetrically up to differentials in the specific productivity z. For this reason, the relative productivity z uniquely differentiates the impact of labor market frictions across producers and average productivities can still summarize all the relevant macroeconomic outcomes as in the original Melitz's model.[23]

The term $\overline{\varphi}_t$ - which I will call "average" real marginal revenue henceforth - is identical across all producers and summarizes all the relevant information about aggregate labor market conditions,

[21] The model has no capital. The number of firms in the economy can be interpreted as the capital stock of the economy since entry is indeed financed by households' investment.

[22] In a model with Walrasian labor we would have: $\varphi^{Melitz}_{z,t} = \frac{\overline{\varphi}_t}{z} = \frac{w_t}{zZ_t}$.

[23] Technically, in order to show that such a representation exists, I first need to prove that all the firms with relative technology z are identical regardless of their timing of entry. The issue arises due to the presence of labor market frictions. Among producers with a productivity draw z, firms will be identical at any point in time if new entrants find optimal to target the same workforce of incumbents. In this case when new plants begin production the only difference with any other incumbent z will be that they are producing a different variety and there is no need to keep track of all the cohorts of entrants (for each realization of z). In Appendix B I show that (a) and (b) are sufficient conditions for the result.

including the symmetric wage rate. The average marginal cost $\overline{\varphi}_t$ can be expressed as:

$$\overline{\varphi}_t = \frac{\tilde{w}_t}{Z_t} + \frac{1}{Z_t}\{\frac{\frac{k}{q_t} + F}{(1 - H(a_t^c))(\bar{a}_t - a_t^c)}\}.^{24} \tag{12}$$

It follows that :

$$\varphi_{z,t} = \frac{\tilde{w}_t}{zZ_t} + \frac{1}{zZ_t}\{\frac{\frac{k}{q_t} + F}{(1 - H(a_t^c))(\bar{a}_t - a_t^c)}\}, \tag{13}$$

$$\varphi^*_{z,t} = \frac{\tilde{w}^*_t}{zZ^*_t} + \frac{1}{zZ^*_t}\{\frac{\frac{k^*}{q^*_t} + F^*}{(1 - H(a_t^{*c}))(\bar{a}^*_t - a_t^{*c})}\}, \tag{14}$$

The presence of search and matching frictions in the labor market shows up in the real marginal cost for a producer z as an extra component with respect to a model with Walrasian labor markets. Labor market frictions, by affecting the firm's marginal cost, influence the profitability of entry and export decisions following aggregate shocks. As a result, differences in the labor market structure like the size of hiring and firing costs or the generosity of unemployment benefits, can imply asymmetric responses of the marginal cost across countries, affecting country interdependence.

As the productivity averages $\tilde{z}_D$ and $\tilde{z}_{X,t}$ summarize all the relevant information for aggregate outcomes, the model is isomorphic to one where $N_{D,t}$ ($N^*_{D,t}$) firms with productivity level z_D and workforce $l_{D,t}$ ($l^*_{D,t}$) produce to serve the domestic market and $N_{X,t}$ ($N^*_{X,t}$) firms with productivity $z_{X,t}$ ($z^*_{X,t}$) and stock of labor $l_{X,t}(l^*_{X,t})$ export to the foreign (home) market. In particular:

$$\begin{array}{l} l_{D,t} = [1 - H(a_t^c)][(1 - \bar{\varrho})l_{D,t-1} + q(\theta_t)v_{D,t}] \\ l_{X,t} = [1 - H(a_t^c)][(1 - \bar{\varrho})l_{X,t-1} + q(\theta_t)v_{X,t}] \end{array},$$

where $v_{D,t}$ and $v_{X,t}$ are respectively the vacancies posted by firms producing for the domestic and export market.

The average relative price of domestic goods is then:

$$\tilde{\rho}_{D,t} \equiv \rho_{D,t}(\tilde{z}_D) = \frac{\gamma}{\gamma - 1}\frac{\bar{\varphi}_t}{\tilde{z}_D} \quad (\rho^*_{D,t} \equiv \tilde{\rho}^*_{D,t}(\tilde{z}_D) = \frac{\gamma}{\gamma - 1}\frac{\bar{\varphi}^*_t}{\tilde{z}_D}),$$

while the average export price is:

$$\tilde{\rho}_{X,t} \equiv \rho_{X,t}(\tilde{z}_{X,t}) = \frac{\gamma}{\gamma - 1}\frac{\tau_t}{Q_t}\frac{\bar{\varphi}_t}{\tilde{z}_{X,t}} \quad (\tilde{\rho}^*_{X,t} \equiv \rho^*_{X,t}(\tilde{z}^*_{X,t}) = \frac{\gamma}{\gamma - 1}Q_t\tau^*_t\frac{\bar{\varphi}_t}{\tilde{z}^*_{X,t}}).$$

The nominal price indexes P_t and P^*_t can be written as:[25]

[24] Notice that $\tilde{w}_t = \int_{a^c_{z,t}}^{\infty} (w(a) - w(a^c_t))\frac{dH(a)}{1 - G(a^c_t)}$, while $\bar{w}_t = \int_{a^c_{z,t}}^{\infty} w(a)\frac{dH(a)}{1 - G(a^c_t)}$.

[25] This follows from:

$$\begin{array}{rcl} P_t & = & N_{D,t}(\tilde{p}_{D,t})^{1-\gamma} + N^*_{X,t}(\tilde{p}^*_{X,t})^{1-\gamma}, \\ P^*_t & = & N^*_{D,t}(\tilde{p}^*_{D,t})^{1-\gamma} + N_{X,t}(\tilde{p}_{X,t})^{1-\gamma}. \end{array}$$

$$
\begin{aligned}
1 &= N_{D,t}(\tilde{\rho}_{D,t})^{1-\gamma} + N^*_{X,t}(\tilde{\rho}^*_{X,t})^{1-\gamma}, \\
1 &= N^*_{D,t}(\tilde{\rho}^*_{D,t})^{1-\gamma} + N_{X,t}(\tilde{\rho}_{X,t})^{1-\gamma}.
\end{aligned}
$$

2.4 Parametrization

Following Melitz (2003) and Ghironi and Melitz (2005) I parametrize the distribution of firm productivity draws $G(z)$ assuming that z is drawn from a Pareto with lower bound $z_{\min}$ and shape parameter $k > (\gamma - 1)$.[26]

The average productivities $\tilde{z}_D$, $\tilde{z}_{X,t}$ and $\tilde{z}^*_{X,t}$ are given by:

$$
\begin{aligned}
\tilde{z}_D &= [\frac{k}{k-(\gamma-1)}]^{\frac{1}{\gamma-1}} \\
\tilde{z}_{X,t} &= [\frac{k}{k-(\gamma-1)}]^{\frac{1}{\gamma-1}} z_{X,t}, \quad \tilde{z}^*_{X,t} = [\frac{k}{k-(\gamma-1)}]^{\frac{1}{\gamma-1}} z^*_{X,t}.
\end{aligned}
$$

The shares of exporting firms in each period are:

$$
\begin{aligned}
\frac{N_{X,t}}{N_{D,t}} &= 1 - G(z_{X,t}) = (\frac{z_{\min}}{\tilde{z}_{X,t}})^{-k} (\frac{k}{k-(\gamma-1)})^{\frac{k}{\theta-1}} \\
\frac{N^*_{X,t}}{N^*_{D,t}} &= 1 - G(z^*_{X,t}) = (\frac{z_{\min}}{\tilde{z}^*_{X,t}})^{-k} (\frac{k}{k-(\gamma-1)})^{\frac{k}{\theta-1}}.
\end{aligned}
$$

Finally the zero profit conditions to determine the cutoff imply that $z_{X,t}$ and $z^*_{X,t}$ must satisfy:

$$
\tilde{d}_{X,t} = \tfrac{\gamma-1}{k-(\gamma-1)} f_{X,t} \quad \tilde{d}^*_{X,t} = \tfrac{\gamma-1}{k-(\gamma-1)} f^*_{X,t}.
$$

2.4.1 Firm Entry and Exit

In every period there is an unbounded mass of perspective entrants in both countries. Potential entrants are forward looking and correctly anticipate their future profits $d_s(z)$ in any period $s > t$ as well as the exogenous probability δ of incurring in the exit-inducing shock. Entrants at time t will start producing only from $t + 1$.

Perspective entrants compute their expected post-entry value - $\tilde{e}_t$ - defined as the present discounted value of the expected stream of per period profits d_s:

$$
\tilde{e}_t = E_t \Sigma^{\infty}_{s=t+1} \beta_s d_s. \tag{15}
$$

Prior to entry, firms face a sunk entry cost:

$$
f_{E,t} = f_{R,t} + \kappa \frac{l_{d,t} + [1 - G(z_{x,t})] l_{x,t}}{q_t}, \tag{16}
$$

[26] The assumption of a Pareto distribution induces a size distribution of firms that is also Pareto.

to be paid in order to serve the market. The entry cost $f_{E,t}$ consists of two components. The first term, $f_{R,t}$, represents the cost associated to regulation and barriers to entry. It's exogenous and potentially subject to shocks. As the fixed export cost, it is expressed in units of the aggregate consumption basket C_t. The second term in equation (16) instead reflects the fact that, upon entry, new entrants need to build their stock of labor to begin production.[27]

Entry occurs until firm value is equalized to the entry cost, leading to the free entry condition:[28]

$$\tilde{e}_t = f_{E,t}$$

Similar conditions hold in the foreign country:

$$f^*_{E,t} = f^*_{R,t} + \kappa^* \frac{l^*_{D,t} + [1 - G(z^*_{X,t})] l^*_{X,t}}{q^*_t}$$

$$\tilde{e}^*_t = f^*_{E,t}.$$

The labor recruitment cost it is endogenous and it responds to aggregate labor market conditions. In particular, it is procyclical: as the labor market is tighter - *ceteris paribus* - entry is more costly due to a congestion externality generated by the presence of search and matching frictions in the labor market (θ_t is higher and hence the expected cost of filling a vacancy $\frac{\kappa}{q(\theta_t)}$ is higher).

Given the time to build assumption, the law of motion of firms is given by $N_t = (1-\delta)(N_{t-1} + N_{E,t-1})$. The number of producing firms represents the stock of capital of the economy. It behaves much like physical capital in a standard RBC model, but it has an endogenously fluctuating price given by (15). In particular, the key interaction between labor and product market dynamics is captured by the stock market price of investment $\widetilde{e}_t$: it endogenously fluctuates in response to aggregate shocks and it summarizes the interdependence between product and labor market dynamics.

2.5 Household Budget Constraint and First Stage Budgeting

The representative household can invest in two types of assets: shares in a mutual fund of domestic firms[29] and domestic risk-free bonds. Let x_t be the share in the mutual fund of domestic firms held by the representative household entering period t. The mutual fund includes all the domestic firms existing at time t - $N_{D,t} + N_{E,t}$ - even though only a fraction $(1-\delta)$ of those will be producing in $t+1$. The price of one share at time t is equal to the price of claims to future firms real profits $\tilde{e}_t$. The per period household's budget constraint can be written as:

$$B_{t+1} + C_t + \tilde{e}_t(N_{D,t} + N_{E,t})x_{t+1} = (1 + r_t)B_t + (\tilde{d}_t + \tilde{e}_t)N_{D,t}x_t + \bar{w}_t L_t + B(1 - L_t) + T_t, \quad (17)$$

[27] The first component - $\frac{\kappa}{q_{t+1}}\, l_{D,t}$ - is the cost associated to the labor input required to begin domestic production. The second one - $\frac{\kappa}{q_t}[1 - G(z_{X,t})] l_{X,t}$ - is instead the stock of labor required to export to the foreign country (weighted by the probability of being an exporter).

[28] This condition holds as long as the mass of new entrants $N_{E,t}$ is positive. I assume that macroeconomic shocks are small enough for this condition to hold in each period.

[29] New entrants finance entry on the stock market in this model.

where r_t is the real interest rate on bond holdings (known with certainty as of $t-1$), $B(1-L_t)$ represents the total amount of unemployment benefits and T_t are lump sum taxes. The household maximizes (1) subject to (17). The Euler equations for bond and share holdings are respectively:

$$1 = (1+r_t)E_t\beta(\frac{C_{t+1}}{C_t})^{-\gamma} \text{ and } \tilde{e}_t = (1-\delta)E_t\beta(\frac{C_{t+1}}{C_t})^{-\gamma}(\tilde{d}_{t+1}+\tilde{e}_{t+1}).$$

2.6 Equilibrium

We are now able to characterize the equilibrium of the model. First, I derive aggregate variables in the labor market. Aggregate employment - L_t - can be expressed as the sum of total employment in domestic production ($L_{D,t}$) and export production ($L_{X,t}$):

$$L_t \equiv L_{D,t} + L_{X,t} = N_{D,t}l_{D,t} + N_{X,t}l_{X,t},$$

Total vacancies V_t are the sum of total vacancies posted by incumbents for domestic and export production and the vacancies posted by new entrants to build their initial stock of labor:

$$V_t = N_{D,t}v_{D,t} + N_{X,t}v_{X,t} + N_{E,t}[\frac{l_{D,t} + [1-G(z_{X,t})]l_{X,t}}{q_t}].$$

The partition of workers between domestic and export sector satisfies:

$$L_{X,t} = \phi_{X,t}L_{D,t},$$

where $\phi_{X,t} = (\frac{z_{\min}}{z_{X,t}})^{-k}(\frac{k}{k-\theta+1})^{\frac{k}{\theta-1}}Q_t^{\theta}(\frac{\tau_t z_D}{z_{X,t}})^{1-\theta}\frac{Y_t^*}{Y_t}$. The current stock of unemployed workers is given by $U_t = (1-L_t)$.

Aggregate demand in the domestic market is given by:

$$Y_t = C_t + N_{E,t}f_{R,t} + N_{X,t}f_{X,t} + \kappa V_t,$$

while in the foreign economy it is given by:

$$Y_t^* = C_t^* + N_{E,t}^* f_{R,t}^* + N_{X,t}^* f_{X,t}^* + \kappa^* V_t^*.$$

The aggregate resource constraint for the economy can be obtained by imposing the equilibrium conditions $B_t = B_{t+1} = 0$, $x_t = x_{t+1} = 1$ and $B(1-L_t) = T_t$,.

We obtain:

$$C_t + N_{E,t}\tilde{e}_t = N_{D,t}\tilde{d}_t + \bar{w}_t L_t.$$

Total consumption plus investment has to be equal to total income (labor income plus dividends).

To close the model, observe that financial autarky implies balanced trade. The value of home

exports must equal the value of foreign exports:

$$Q_t N_{X,t}(\tilde{\rho}_{X,t})^{1-\gamma} Y_t^* = N_{X,t}^*(\tilde{\rho}_{X,t}^*)^{1-\gamma} Y_t.$$

Table 2 summarizes the model equations.

2.7 International Trade in Bonds

To perform quantitative exercises I will relax the assumption of financial autarky, by introducing incomplete financial markets. The relevant model equations are presented in Table 3. International assets markets are incomplete. Agents can trade bonds domestically and internationally. Home (foreign) households issue home (foreign) bonds, denominated in home (foreign) currency. Bonds issued by each country provide a risk-free real return in units of that country's consumption basket. To avoid indeterminacy of the steady state net foreign assets and nonstationary model dynamics I assume that agents must pay fees to domestic financial intermediaries when adjusting their bond holdings (see Ghironi, 2006).[30] The change in asset holdings between t and $t+1$ is the country's current account.

There are now three Euler equations in each country: the Euler equations for domestic and foreign bond holdings and the Euler equation for share holdings (unchanged). Since there is no longer balanced trade under international bond trading, I also replace the balanced current account condition from the model with financial autarky with the expression for the balance of international payments.

To conclude, for future references, it is useful to define the following variables:

- $\widetilde{TOL}_t = \frac{Q_t \bar{\varphi}_t^*}{\bar{\varphi}_t}$ is the average terms of labor: the ratio between the cost of production abroad and the cost of production at home. This variables summarizes the relative impact of labor market frictions (and labor market regulation) in the two countries.

- $\widetilde{TOT}_t = \frac{Q_t \tilde{\rho}_{X,t}}{\tilde{\rho}_{X,t}^*}$ represent the average terms of trade, the ratio between the average price of home exports to the average price of home imports (or the average quantity of foreign exports per one unit of home exports).

- $\tilde{P}_t = N_t^{\frac{1}{\gamma-1}} P_t$ and $\tilde{P}_t^* = N_t^{*\frac{1}{\gamma-1}} P_t^*$ (where $N_t = N_{D,t} + N_{X,t}^*$ and $N_t^* = N_{D,t}^* + N_{X,t}$) denote home and foreign average prices. In a model where the number of goods available for consumption is endogenous and preferences exhibit love for variety, there is a disconnection between consumption based price indexes and their data counterpart.[31] It is possible to decompose the price indexes into component reflecting the average prices and the product

[30] These fees are quadratic functions of the stock of bonds. Financial intermediaries rebate the revenues from bond-adjustment fees to domestic households.

[31] Price indexes change over time both because of changes in the average prices as well as for the variety effect implied by entry of new firms and availability of new goods in the economy. CPI data instead are based on average prices and they are not constantly adjusted for availability of new varieties.

variety: the average prices $\tilde{P}_t$ and $\tilde{P}_t^*$ corresponds much more closely to the empirical measure such as the CPI.

- $\tilde{Q}_t = (\frac{N_t}{N_t^*})^{\frac{1}{\gamma-1}} Q_t$ is the theoretical counterpart to the empirical real exchange rate.[32]

[32] See Ghironi and Melitz (2005) for a discussion.

3 Calibration

3.1 Symmetric Countries

I interpret periods as quarters and calibrate the model to match selected targets of the U.S. economy.

As standard practice for quarterly business cycle models I set the discount factor $\beta = .99$ implying an annual real interest rate of 4%. The value of the risk aversion coefficient ν is equal to 2. I set the symmetric elasticity of substitution across varieties $\gamma = 3.8$ to fit U.S. plant and macro trade data (see Bernard *et al.*, 2003).[33] The shape parameter k in the Pareto distribution is chosen to match the standard deviation of log U.S. plant sales, which in the data is equal to 1.67. The lower bound of the distribution $z_{\min}$ is normalized to 1. The fixed export cost f_X is chosen to match the share of exporting plants, equal to 21%. I assume $\tau = 1.3$, in line with Ghironi and Melitz (2005) and Obstfeld and Rogoff (2000a).

Pissarides (2003) compiles an index for entry delay as the number of business days that it takes (on average) to fulfill entry requirements. I follow Ebell and Haefke (2009) to convert this index in months of lost output to get a value of the regulation cost f_R. The index for the U.S. is 8.5, corresponding to 0.15 quarters of lost output (based on 220 business days in a year).

As concerns the labor market, I set the elasticity of the matching function $\varepsilon = 0.5$ (consistent with empirical evidence reported in Blanchard, 1999).

In order to calibrate the exogenous within firm separation - $\bar{\varrho}$ - and the exogenous exit of plants - δ - I target the portion of job destruction due to the exit of plants and the ratio between job destruction and employment observed in the data. Davis, Haltiwanger, and Schuh (1996) report a plant exit rate of 20% in the U.S.; they also find that the ratio between job destruction and employment is equal to 0.052. Appendix D describes the procedure in more detail.

Unemployment benefits take the form: $B = h_P + \psi_R w^{SS}$. The replacement rate is $\psi_R = 0.54$, taken from the OECD (2004) "*Benefits and Wages*" publication. As standard in the literature, I assume that firing taxes in the United States are zero. Since $F = \psi_F w^{SS}$, I set $\psi_F = 0$.

In absence of empirical guidance, the bargaining power of workers is set to a conventional value of $\eta = 0.5$.

Three labor market parameters are left to calibration. The cost of posting a vacancy κ, the flow value of home production h_P, the efficiency of the matching function χ. As common practice in the literature, I choose κ, h_P and χ in order to match the steady state unemployment rate U^{SS}, the probability of filling a vacancy q^{SS} and the total separation rate ρ^T. I set $U^{SS} = 7\%$, computed from quarterly data on U.S unemployment. Total separation ρ^T is set to 7%, an average of the values reported by Shimer (2005) and Fujita and Ramey (2007). The probability of filling a vacancy is $q^{SS} = 0.7$, as in Shimer (2005) and Fujita and Ramey (2007).

[33] A value of $\gamma = 3.8$ implies a mark-up of 35.7% relative to marginal costs, which is in the range of 3% to 70% of different empirical studies as documented by Schmitt-Grohe (1997). The standard choice in the international literature is a mark up lower than 20%. As pointed out by Ghironi and Melitz (2005), in models with a fixed number of varieties a firms don't pay sunk entry costs, which creates a gap between average and marginal costs. Thus, although $\gamma = 3.8$ implies a fairly high markup over marginal cost, this parametrization delivers reasonable markups over average costs.

The idiosyncratic job specific productivity shocks a are lognormally distributed with mean μ and standard deviation σ_A. The parametrization follows den Haan, Ramey, and Watson (2000)*:* I normalize μ to 0, calibrating σ_A to match the relative volatility of unemployment with respect to GDP. The benchmark symmetric calibration is summarized in Table 4.

3.2 Asymmetric Labor Markets

I assume that the rigid economy (home) corresponds to the Euro Area, while the relatively more flexible country (foreign) is represented by U.S.[34]

In a model with search and matching frictions *a la* Mortensen and Pissarides (1994) there are parameters for which no data are readily available: κ (cost of posting a vacancy), h_P (home production), $\varkappa$ (matching efficiency), and σ_A (variance of idiosyncratic shocks). As already discussed, the standard approach is to calibrate those parameters to match selected first and second moments of the labor market in the data. Countries usually considered rigid like the Euro Area tend to be quite different in terms of those targets.

In the benchmark calibration I set such parameters to match country specific targets, using U.S. and Euro Area data as a targets.[35] U.S. targets are identical as before. Instead I choose κ, h_P and $\varkappa$ to match unemployment rate, total separation and probability of filling a vacancy observed in the European labor market. Steady state unemployment is $U_{eu}^{SS} = 9.2\%$, computed from quarterly data. Total separation $\rho_{eu}^{T}$is set to 3%, an average value of the evidence collected for the Euro Area - see Christoffel, Kuester, and Linzert (2009); q_{eu}^{SS} is equal to 0.7, which is in line with estimates reported by ECB (2002) and Weber (2000). The replacement rate is $\psi_R = 0.65$, an average of values reported in OECD (2004) "Benefits and Wages" publication. To calibrate firing costs $F = \psi_F w^{SS}$, I follow Thomas and Zanetti (2008) by setting $\psi_F = .2$.

Another way to proceed would be instead to let only B and F differ across the two countries, imposing symmetry on all the other parameters.[36] As a robustness check I have also re-calibrated the model following the latter strategy.

Table 5 summarizes the calibration under the assumption of asymmetric labor markets. All the other parameters in the model are assumed to be identical across countries in order to focus on the role of different labor market structures.

[34] The model abstracts from cross country asymmetries in factor endowments and the role of comparative advantage. At the same time though, Djankov, Porta, de Silane, Shleifer, and Botero (2003) and OECD (2004) report substantial differences in terms of labor market characteristics across the two economies. Hence, the choice of the Euro Area as a benchmark rigid trading partner is quite natural in this context.

[35] The only exception is the variance of idiosyncratic job specific productivity. Given the assumption of full symmetry in the structure of shocks across countries, I will impose that $\sigma_A = \sigma_A^*$.

[36] In this case κ^*, hP^* and χ^* would be choosen to match standard moments of the U.S. labor market, imposing symmetry between the rigid and flexible economy: $\kappa = \kappa^*$, $hP = hP^*$ and $\chi = \chi^*$. In this case U, ϱ^T and q in the rigid economy would be freely detemined.

4 Steady State and Dynamic Implications of Trade Integration

In this section I study the gradual adjustment to a symmetric reduction in iceberg trade costs τ_t and τ_t^*.[37] The novel feature with respect to previous studies is the characterization of the dynamic adjustment in the labor markets in presence of different frictions across trading partners. Importantly, I restrict the analysis to a perfect foresight exercise, assuming that no other aggregate shock hits the economy after the unexpected, permanent symmetric change in τ_t and τ_t^*.

4.1 Trade and Unemployment Outcomes in the Long Run

Before discussing the dynamic adjustment following trade integration, I focus on the long run labor market effects of lower trade barriers. In so doing, I compare the predictions of the model with existing studies in the trade literature.

Despite the presence of firm heterogeneity, the long run behavior of aggregate job creation and destruction summarizes all the effects of trade integration on unemployment. Consider first a simplified version of the model which abstract from endogenous separation - *i.e.* matches are destroyed only for exogenous reasons (within and across firms) and assume full symmetry across trading partners.

The change in the steady state unemployment rate U can be written as:

$$\frac{dU}{d\tau} = \underbrace{-\Omega_{\theta}^{EXO}\frac{d\theta}{d\tau}}_{\Delta U \text{ duration}} = -\Omega_{\varphi}^{EXO}\underbrace{\frac{d\overline{\varphi}}{d\tau}}_{<0} > 0,$$

where $\Omega_{\varphi}^{EXO} = \frac{(1-\psi_R)}{\eta\beta\kappa+(1-\psi_R)(1-\beta)\chi\kappa} > 0$. In this case the change in U is completely summarized by the variation of labor market tightness θ (interpreted as the change in unemployment duration) - see Figure 1. Combining job creation and wage equations, it is possible to see that the response of θ depends on the change in the average real marginal revenue $\bar{\varphi}$. Using the price index equation and the definition of domestic and export prices, we have:

$$\overline{\varphi} = \frac{\theta-1}{\theta}\underbrace{N^{T\frac{1}{\theta-1}}}_{\text{Variety}}\underbrace{\widetilde{z}}_{\text{TFP}},$$

where $N^T = N_D + N_X$ and $\tilde{z}$ is the average productivity across all firms:

$$\tilde{z} = \{\frac{1}{N^T}[N_D(\tilde{z}_D)^{1-\gamma} + N_X(\frac{\tilde{z}_X}{\tau})^{1-\gamma}]\}^{\frac{1}{1-\gamma}}.$$

Notice that N^T represents the total mass of varieties available to consumers in any country (or alternatively, the total mass of firms competing in the country).[38]

[37] It should be noticed that trade opennes in the model could also be interpreted as a reduction in fixed costs. Qualitatively a reduction in $f_{X,t}$ and $f_{X,t}^*$ generates similar patterns with respect to falling trade costs. The impact is smaller in terms of magnitude, since a reduction in fixed export costs mainly affects firms that were not exporting before trade integration. Results are available upon request.

[38] N_D denotes the equilibrium mass of incumbent firms in any country. $N_X = [1 - G(z_X)]N_D$ is the mass of

The average marginal revenue is increasing both in the total mass of varieties available to consumers N^T and in the average productivity $\tilde{z}$. Since households derive more welfare from spending a given nominal amount when N^T is higher, *ceteris paribus*, the relative price of each individual good increases (since the price index decreases). This variety effect increases the expected average marginal value of a match $\overline{\varphi}$. At the same time, the increase in the average productivity $\tilde{z}$ makes workers on average more productive, rising $\bar{\varphi}$. For a reasonable parametrization of the model, (symmetric) trade openness increases both N^T and $\tilde{z}$. In particular, as τ falls, the reallocation of market shares toward exporting firms is enough to generate an increase in average productivity, despite the absence of endogenous exit of least productive plants.[39] As a result, the average marginal revenue $\bar{\varphi}$ increases and so does labor market tightness θ, lowering unemployment. Intuitively, the reduction in trade barriers lowers search unemployment since the cost of vacancy posting relative to the productivity of the average firm decreases and employers intensify recruitment efforts. The long run average return to a match rises and more matches are created following openness.

When both job creation and destruction are endogenous the analysis is slightly more complicated. In this case the steady state change of the unemployment rate can be written as:

$$dU = \underbrace{\Omega_a da^c}_{\text{Flows into U}} - \underbrace{\Omega_\theta d\theta}_{\Delta U \text{ duration}}$$

where Ω_a and Ω_θ are again two constant terms. The first term reflects the change in job flows and it is summarized by the reservation productivity a^c; the second term again refers to changes in unemployment duration. Unemployment is increasing in both terms. The effects of openness on equilibrium unemployment depend now on the impact of a reduction of τ on θ and a^c, *i.e.* on the relative shifts of job creation and job destruction curves - see Figure 2. The two curves can be written as:

$$\text{JC curve}: \frac{k\theta^{-\varepsilon}+F}{(1-H(a^c))} = \underbrace{\overline{\varphi}}_{\text{TFP+VARIETY}} Z(\bar{a}-a^c)$$

$$\text{JD curve}: a^c = \underbrace{\frac{1}{\overline{\varphi}}}_{\text{TFP+VARIETY}} \{\beta(1-\delta)[(1-\eta)k\theta - k\theta^{1-\varepsilon}] + \eta B - (\eta+(1-\eta)\zeta)F\}$$

Also in this case international trade triggers variations in $\bar{\varphi}$ which in turn affects both θ and a^c. *Ceteris paribus*, θ is increasing in $\bar{\varphi}$, while a^c falls. As before, tightness θ increases if the average marginal revenue of a new match is higher because the expected return to vacancies gets bigger. At the same time the value of low productive matches is boosted by a higher $\bar{\varphi}$. Both unemployment duration and flows into unemployment tends to be reduced when $\bar{\varphi}$ rises, unambiguously lowering

exporting firms among domestic producers.

[39] $\tilde{z}$ is a weighted average of domestic and exporting firms' productivity. As trade barriers move around, some among the most productive non-exporters begin to export and the market shares of the domestic producers shrink due to increased foreign competition. This in turns implies that in the definition of $\tilde{z}$ more efficient firms have a bigger weight. Even if the average productivity of exporters $\tilde{z}_X$ is falling after openness (new exporters are less productive than already existing ones), the gain in market shares of new exporting firms is enough to guarantee that $\tilde{z}$ increases.

the unemployment rate. The additional difficulty is that in general equilibrium, variations in θ and a^c affect each other and $\bar{\varphi}$ no longer summarizes the effects on unemployment. As a^c falls, job creation further increases since now the expected probability of destroying low productive matches is reduced (further increasing θ). At the same time though, as the labor market gets tighter, the aggregate wage increases: marginal workers become less attractive, since they are now relatively more expensive than before. This tends to reverse the drop in a^c - increasing flows into unemployment. On net, θ unambiguously increases while a^c can go in both direction. For a reasonable calibration of the model a^c would fall, meaning that more low productive matches survive in the new steady state and the overall flows into unemployment are reduced.

A growing number of studies in the trade literature focuses on the long run relationship between trade integration and unemployment. Those contributions differentiate themselves with respect to the assumptions about the trade structure or the mechanisms leading to equilibrium unemployment. Papers focusing on the role of firm heterogeneity in presence of frictional unemployment yield different predictions.[40] In contrast to the present paper, Helpman and Itskhoki (2007) find that unemployment is not unambiguously lowered by trade openness. The symmetric version of their model can feature a negative trade-unemployment link under some parameterization. Differently from the present model, they assume a two country - two sector setup: trade boosts average productivity in the differentiated goods sector, making employment more attractive in that sector. This yields a reallocation of labor from the distortion-free numeraire sector into the friction-ridden differentiated good sector. Importantly, the impact of trade on unemployment operates only through the reallocation of labor across sectors, because *sectoral* unemployment rates do not change in their model in response to trade.[41] Felbermayr, Prat, and Schmerer (2008) instead find a negative long run relationship between trade integration and unemployment in a static model similar to the present one (but they abstract from endogenous job destruction).

4.2 Transition Dynamics of Trade Reforms

Figure 3 and 4 plot the dynamic adjustment to a 1 percent drop in iceberg trade costs τ and τ^*. In Figure 3 trading partners are fully symmetric and flexible, while in Figure 4 the home economy has a relatively more rigid labor market, with characteristics similar to the Euro Area.

The interaction between product and labor market dynamics is at the heart of the transitional adjustment. As trade barriers are lowered, the incentives to create and destroy jobs across producers change together with profitability of entry into domestic and export markets. The response of the labor market affects product market dynamics, and the endogenous adjustment in the number of producers feeds back into labor market outcomes. Regardless of the labor market structure (flexible

[40] An exaustive review is beyond the scope of this paper. Other contributions abstracting from the role of firm heterogeneity or making alternative assumptions about the labor market structure (fair wages) are Davidson, Matusz, and Shevchenko (2008), Matusz (1996), Egger and Kreickemeier (2009) and Davis and Harrigan (2007).

[41] More workers search for jobs in the differentiated sector when trade costs decline and therefore aggregate unemployment rises when the differentiated sector has higher sectoral unemployment and aggregate unemployment falls when the differentiated sector has lower sectoral unemployment.

or rigid), the slow reallocation of workers and the sluggish variation in the number of producers in the economy induce a long lasting transition: it takes time for employment, consumption and GDP to reach their new (high) long run levels.

In the aftermath of trade integration, there are substantial gross job flows: import-competing, domestic plants are downsizing while employment rises among exporters. Entry of producers drops as the effect of fiercer domestic competition prevails. Labor market characteristics determine the initial response of unemployment as they impact on profitability of job creation and destruction. Figure 3 shows that when the trading partners are fully symmetric and "flexible", the compositional shift of employment towards exporters does not trigger sizable net effects on unemployment in the aftermath of the shock. At the opposite, unemployment spikes in the rigid economy in presence of asymmetric labor markets - see Figure 4. The intuition is as follows. As the expected cost of firing and hiring workers is larger in the rigid economy, exporters (and those who could potentially become exporters) have less incentive to hire new workers compared to the flexible country. At the same time, due to fiercer competition from abroad, domestic incumbents are downsizing more heavily. The net effect is that unemployment rises in the rigid country. In the flexible economy instead, unemployment is unambiguously reduced. Importantly, as terms of trade ameliorate for the rigid country - the price of home (rigid) exports rises with respect to the price of (foreign) imports - consumption increases despite the negative initial unemployment response.

Employment rises slowly in both countries. As time passes by, producers in the export sector can match with more workers and production of domestic (non traded) goods partially recovers as higher aggregate demand spreads out on all existing domestic and foreign varieties. As employment and wages are higher and competition from abroad is lower, the foreign, flexible, economy is now a more attractive business environment. Entry profitability recovers more compared to the rigid country and production shifts towards foreign goods. This translates in different unemployment dynamics across countries, with the flexible economy benefiting relatively more. The consumption differential between the rigid and flexible economy is steadily increasing: the latter gains relatively more at any at any point in time during the transition.

By allowing for international trade in bonds, asymmetries in labor markets induce movements in the current accounts. Given the permanent nature of the shock, there are no consumption smoothing motives affecting their dynamics. The flexible country is a relatively more attractive economy after the trade shock and the return on holding of shares is relatively higher there. Since the return on bond holdings is tied to the return on holdings of shares by no arbitrage reasons, households in the rigid home economy invest in foreign bonds in the aftermath of the reform. By mean of financial integration, home consumers can partially share the higher benefits arising from trade integration in the foreign country.

4.3 Welfare Consequences

The dynamic nature of the model allows me to calculate the welfare implications of trade integration taking into account long run outcomes as well as the transitional adjustment. Since the model

features perfect risk sharing among family members and no ex post heterogeneity between employed and unemployed workers, welfare calculations here are meant to capture only aggregate implications of globalization. The presence of distributional conflicts between consumers in the economy cannot be addressed in the present framework.

I calculate the fraction of aggregate consumption that would make the representative household indifferent between the absence of trade integration (consuming $\bar{C}^{OLD}$ in each period) and lowering trade barriers (consuming C_t - time varying until the economy reaches the new steady state). For the home economy:

$$\sum_{s=t}^{\infty} \beta^{s-t} \frac{[\bar{C}^{OLD}(1+\Delta)]^{(1-\gamma)}}{1-\gamma} = \sum_{s=t}^{\infty} \beta^{s-t} \frac{[C_t]^{(1-\gamma)}}{1-\gamma}, \tag{18}$$

where Δ is the percentage increase in steady state (pre-openness) consumption level that would make the household indifferent.

Assuming full symmetry in the labor markets, calculations show that for each point reduction in τ (τ^*) the household would require an increase in consumption of $\Delta = \Delta^* = 4.82\%$. In presence of asymmetric labor markets also the compensation would be asymmetric. In particular: $\Delta = 3.69\%$ and $\Delta^* = 5.91\%$.

These numbers conveys two important messages. First, as expected, the rigid labor market experiences a lower gains in terms of welfare. Secondly, flexible countries benefit from the rigidity of the trading partners: the welfare gain is higher than in presence of symmetric (flexible) labor markets.

5 International Trade and Macroeconomic Dynamics

So far I have studied the direct effects of trade integration on unemployment and economic activity, investigating whether the dynamic adjustment to the new steady state can be affected by country specific labor market characteristics. However, trade integration can affect economic outcomes and welfare also through its effects on the domestic and international propagation of business cycle shocks. In this section instead, I focus on the effects of stronger long run trade linkages for business cycle dynamics.

I first show that the interaction of product and labor market dynamics that determines the direct consequences of trade integration is also at the heart of the propagation of business cycle shocks. This novel transmission mechanism helps the model to successfully account for key domestic and international business cycles facts. I then turn to the implications of lowering trade barriers for aggregate fluctuations and the consequences of heterogeneous labor markets in this context.

5.1 Impulse Responses

The model includes only one source of fluctuations, the shocks to aggregate productivities Z_t and Z_t^*. I begin by describing the domestic and international adjustment to a country specific productivity shock assuming full symmetry across countries. Then, to illustrate the role of heterogeneity in labor

market frictions for aggregate fluctuations, I consider the effects of a temporary, global, increase in productivity.

Symmetric Labor Markets

I assume that productivity is described by the univariate process $\ln Z_{t+1} = \phi_{ZZ} \ln Z_t + \xi_t$, with the persistence parameter $\phi_{ZZ} = 0.9$. Figure 7 describes the aggregate dynamics under financial autarky. On impact, higher Z_t increases profitability of existing matches at home and incumbents reduce job destruction and post new vacancies. Domestic unemployment falls. The number of producers able to cover the fixed export cost $f_{X,t}$ increases: the productivity cutoff $z_{X,t}$ falls and the number of exporters $N_{X,t}$ rises, further increasing vacancy posting and employment.

Employment and output unambiguously increase in the foreign economy on impact. There are two mechanisms at work. First, aggregate demand at home increases for all existing goods, domestic and foreign. Producers abroad anticipate that the increase in demand will be persistently higher in the future. The expected profitability of existing and future matches rises inducing incumbents to post new vacancies and save more low productive workers on impact. The presence of a rent sharing mechanism, which tends to dampen the increase in wages further contributes to the increase in employment.

Second, contrary to a standard international RBC model, the initial TOT deterioration is dampened by the presence of endogenous producer entry and firm heterogeneity. As the home economy becomes a more attractive business environment, a larger number of firms enter the domestic market and post vacancies to recruit workers for production in the next period. The home labor market gets tighter and hiring costs increase (recruiting labor is more costly for all the producers since the probability of filling a vacancy is lower). Other things equal, this rises the average marginal cost and the average price of exported goods $\tilde{\rho}_{X,t}$. Furthermore the reduction in the average export productivity $\tilde{z}_{X,t}$ pushes $\tilde{\rho}_{X,t}$ further up. As a result, the expenditure switching towards home goods is dampened. Producers entry adjusts slowly due to the presence of search and matching friction in the labor market. Output and employment dynamics also display hump shaped patterns because of the sluggish adjustment in the product and labor market. The slow variation in the number of producers feeds back into employment dynamics, amplifying the initial effects of the shock. Since labor market tightness increased disproportionately more at home, hiring new workers become relatively cheaper in the foreign country (the terms of labor, TOL, appreciate). The pattern of entry in the home economy reverts, while the number of foreign firms entering the economy continue to rise, increasing the number of exporters and further reducing foreign unemployment.

As Figure 8 reveals, opening the economy to trade in financial assets does not change the propagation mechanism. The main difference with respect to the autarky case is the initial negative response of entry in the foreign country. As the home economy becomes more productive, domestic households borrow from abroad to finance entry of new firms, running a current account deficit.[42]

[42] Current account dynamics revert during the transition to the steady state since domestic households want to

As a result, financing of new foreign firms drops. Initially, even in presence of financial integration, employment and GDP rises in both countries in the aftermath of the productivity shock. In the model the incentives to shift resources towards the more productive economy do not induce an asymmetric response of output across countries.

To summarize, the impulse responses highlight the central role of product and labor market frictions for the domestic and international propagation of shocks. Aggregate disturbances generate spikes in job creation and destruction and employment remains persistently higher on account of matching frictions. Profitability of entry responds to aggregate labor market conditions and the sluggish adjustment in the number of producers on the market feeds back into employment dynamics magnifying the future output effects of the shock. This internal amplification implies that shocks originating in one country can trigger sizable and long lasting effects in the trading partner. Persistent dynamics of aggregate demand induce persistent effects abroad, substantially increasing country interdependence.

5.1.1 Asymmetric Labor Markets

Empirical work has shown that differences in labor market regulation can affect domestic labor market fluctuations. For instance Micco and Pagés (2006), Messina and Vallanti (2007) and Gomez-Salvador, Messina, and Vallanti (2004) find that more stringent labor laws affects job flows over the business cycle - higher employment protection leads to lower labor reallocation. To what extent the model is consistent with such findings? Do different labor market characteristics affect country interdependence and product market dynamics? To simplify the analysis, consider the response of the home (rigid) and foreign (flexible) economy to a global, temporary, productivity shock.[43] As before, the home economy features a relatively more rigid labor market while the foreign country is maintained flexible. Figure 8 shows that key macroeconomic variables react differently across countries: heterogenous labor market characteristics traduce in asymmetric dynamics of unemployment and output across countries. Specifically, the rigid country is less responsive in the aftermath of the shock but its dynamics are more persistent. Larger hiring and firing costs slow down the decrease in unemployment. Job creation and destruction are, *ceteris paribus*, less sensitive to the shock on impact, as the expected cost of a temporary increase in the stock of labor is relatively higher compared to the flexible country. Home incumbents experience a smaller increase in employment and entry of new firms in the aftermath of the shock. International financial linkages amplify the impact of labor market differentials as resources are shifted towards the more flexible country.[44]The smaller response of producers entry at home feeds back into labor market outcomes, further dampening the initial reduction in unemployment. At the same time, larger unemployment benefits tend to increase propagation by making the wage rate to absorb less of the aggregate shock. Unemployment dynamics display more persistence in the more regulated economy.

smooth out the consequences of the favorable productivity shock by lending to foreign households.

[43] I assume $\ln Z^*_{t+1} = \phi_{Z^*Z^*} \ln Z^*_t + \xi^*_t$ with $\phi_{Z^*Z^*} = \phi_{ZZ} = .9$.

[44] Households in the rigid economy find profitable to lend to the flexible country to take advantage of the more profitable business conditions abroad. The rigid economy runs a current account surplus on impact.

This result is in line with the VAR analysis provided by Balakrishnan and Michelacci (2001), who find that unemployment is slower in adjusting to technology shocks in countries belonging to the Euro Area with respect to the U.S. More persistent unemployment dynamics translates into larger output persistence with respect to the foreign country. This is consistent with the findings in Duval, Elmeskov, and Vogel (2007).

5.2 International Business Cycle

I assume that the percentage deviations of Z_t and Z_t^* from the steady state follow the bivariate process:

$$\begin{bmatrix} Z_t \\ Z_t^* \end{bmatrix} = \begin{bmatrix} \phi_{ZZ} & \phi_{ZZ^*} \\ \phi_{Z^*Z} & \phi_{Z^*Z^*} \end{bmatrix} \begin{bmatrix} Z_{t-1} \\ Z_{t-1}^* \end{bmatrix} + \begin{bmatrix} \xi_t \\ \xi_t^* \end{bmatrix},$$

For purposes of comparison with Backus, Kehoe, and Kydland (1992) (BKK henceforth) and Ghironi and Melitz (2005) I use the symmetrized estimate of the bivariate productivity process presented in BKK:

$$\begin{bmatrix} \phi_{ZZ} & \phi_{ZZ^*} \\ \phi_{Z^*Z} & \phi_{Z^*Z^*} \end{bmatrix} = \begin{bmatrix} .906 & .088 \\ .088 & .906 \end{bmatrix}.$$

Innovations are zero-mean and normally distributed, with standard deviation set to 0.00852 and the correlation to 0.258 as estimated by BKK.

Regardless of the underlying labor market structure, I will assume the same bivariate process for the percentage deviations of Z_t and Z_t^* and the same symmetric variance and covariance matrix for productivity innovations.[45] Moreover, since the empirical price deflators are best represented by the average prices $\tilde{P}_t$ and $\tilde{P}_t^*$ in the model (as opposed to the welfare based price indexes), I report second moments of real variables deflated by $\tilde{P}_t$ and $\tilde{P}_t^*$.[46]

As shown in Tables 5 - 7, the standard deviations of aggregate output and investment are very close to the data.[47] Standard deviation of consumption, relative to GDP, is over-predicted even though the model generates less volatile consumption than GDP.

Unemployment volatility is matched by construction. Relative volatilities of wages, job creation and job destruciton are in the range of what observed in the data. The volatility of vacancies and labor market tightness is too small, but higher than the values generated by a standard search and matching model with no sunk entry costs. The model is also successful in matching the contemporaneous correlation between output and unemployment but it does not deliver a sufficiently negative Beveridge curve - the correlation between vacancies and unemployment.

Turning to the international business cycle, the cross country correlations of output and labor inputs are positive. This is a significant improvement with respect to a standard international RBC.[48] Product and labor market frictions are crucial to generate the result since they induce inter-

[45] I do so to insulate the role of labor market asymmetries.

[46] To obtain such a measure, for any variable X_t in units of consumption, I define its corresponding real variable deflated by the average price index: $X_{R,t} = \frac{P_t X_t}{\tilde{P}_t}$.

[47] I define aggregate investment as $N_{E,t}\tilde{e}_t$.

[48] In Ghironi and Melitz (2005), cross country GDPs correlation is positive, but smaller in absolute terms than the

nal amplification and dampen the TOT deterioration following positive domestic shocks, inducing sizable and long lasting effects on the trading partner. As already pointed out by Hairault (2002), productivity spillovers across countries amplify the role of search frictions, since existing and future matches become more productive everywhere in response to asymmetric TFP shocks: producers post more vacancies and save more low-productive matches also in the country not directly hit by the productivity boost.

The model is also able to generate a negative - but too large in absolute terms - correlation between relative consumption spending and the real exchange rate. As the original BKK model, the cross country correlation of consumption is larger than the correlation across GDPs.[49] The real exchange rate displays substantial persistence, slightly higher than the one observed in the data.

To verify robustness I have also considered an alternative parametrization of the productivity process consistent with Baxter and Crucini (1995). In this case:

$$\begin{bmatrix} \phi_{ZZ} & \phi_{ZZ^*} \\ \phi_{Z^*Z} & \phi_{Z^*Z^*} \end{bmatrix} = \begin{bmatrix} .999 & 0 \\ 0 & .999 \end{bmatrix},$$

using the same variance-covariance matrix of the productivity innovations as in BKK.

Results are not significantly affected, with two important exceptions.[50] First, cross-country correlation of consumption is now equal to 0.53, much lower than before . In presence of productivity spillovers, the response of foreign consumption to a home shock is larger as foreign households anticipate that foreign productivity will raise too. Second, also the cross-country correlations in output and labor inputs are lowered, being now respectively .298 and .302.

Overall, I interpret the results from the stochastic exercise as successful. The performance of a standard international RBC model is improved with respect to some key domestic and international business cycle dimensions. Furthermore, the model is quite successful in accounting for important aspects of the cyclical behavior of the labor market.

When labor markets are assumed to be asymmetric across countries, both domestic and international business cycle properties are affected.[51] Confirming previous impulse response analysis, output tends to be less volatile in absolute terms in the rigid economy - volatility is 20% lower compared to the flexible country. Moreover, the asymmetric behavior of the labor markets, by triggering asymmetric effects in product market dynamics, lowers the cross-country correlations of output and consumption.[52]

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one generated by this model (which is closer to the average correlations observed in the data). Their model is also silent with respect to comovement of labor inputs, since they assume inelastic labor supply.

[49] As I will show, this result depends on the assumed parametrization of productivity.

[50] Results are not reported here for brevity. They are available upon request.

[51] Remember that the structure of shocks and any other feature of the model other than labor markets is assumed to be symmetric across countries.

[52] Fonseca and Patureau (2008) provide empirical support for the prediciton that heterogeneity in labor market characteristics is associated to a smaller degree of syncronization.

6 Labor Markets and Business Cycle Implications of Trade Integration

What are the implications of stronger trade linkages for business cycle fluctuations? Do country specific labor market characteristics have an impact on the cyclical behavior of integrating trading partners? These are the types of questions I want to address in this section.

A robust conclusion from empirical work is that, among industrialized economies, business cycles become more synchronized when trade linkages are stronger. In particular, by running cross country regressions, Frankel and Rose (1998) and Clark and van Wincoop (2001) find that countries with 3.5 times larger trade have a correlation that is 0.089 and 0.125 higher. Kose and Yi (2005) - reestimating the Frankel and Rose (1998) regression with updated data - find that a doubling of the median (across all country pairs) bilateral trade intensity is associated with an increase in the country pair's GDP correlation of about 0.06.

I first explore whether the model can account for the observed increase in comovement following trade integration and discuss the role of labor market frictions in such context. Then I analyze the model predictions for output volatility.

6.1 Output Comovement

Panel A in Figure 9 plots the effects of lower trade barriers on cross-country output correlation. I change the steady state values of trade costs τ and τ^* to generate variations in bilateral trade volumes comparable with those reported in empirical studies. Under financial autarky, when steady state trade volumes increase by a factor of 3.5 the model generates an increase in synchronization close to the values reported by Clark and van Wincoop (2001). The mechanism behind the result is simple and it is illustrated in Figure 8. First, as trade barriers are lowered, the magnification effect induced by sunk entry costs and labor market frictions translates into larger and more persistent effects of domestic shocks on foreign output dynamics. Consider again the effects of a domestic productivity boost. As the endogenous response of employment and entry amplifies the domestic effect of the shock, aggregate demand is high for a prolonged amount of time. When trade barriers are lower, *i.e.* when the steady state trade volumes are higher, the dynamics of home demand induce sizable and longer lasting effects in the foreign economy (via demand complementarities). Foreign output dynamics are affected for a longer spell of time and comovement increases.

Furthermore, as discussed before, the presence of firm heterogeneity and endogenous entry mitigates terms of trade effects and the reduction in trade barriers does not automatically amplify the importance of expenditure switching effects.

Importantly, the result survives in presence of financial integration. As pointed out by Kose and Yi (2001), when countries can trade in financial assets, lower trade costs increase the incentives to shift resources in response to aggregate disturbances. It's more convenient to let production take place in the country where resources are temporary more productive, thereby reducing international output correlation. This resource shifting motive is still present but quantitatively less important:

synchronization is lower compared to financial autarky, but still in the range of the average values observed in the data. The result is not only due to the dampening of TOT effects due to the endogenous response of producer entry. Since the price of investment e_t is linked to labor market conditions by the free entry condition, foreign households anticipate that the price of investment will be higher in the future as financing entry of foreign firms will become relatively more expensive when labor market tightness will be higher. When trade barriers are lower the incentives to anticipate investment in new firms are more pronounced, partially mitigating the outflow of resources towards the trading partner.

The ability of the model to account for the synchronization observed in the data has often eluded standard international business cycle models that typically predict too small or negative comovement in response to trade integration - the so called trade-comovent puzzle.[53] For example, Kose and Yi (2001) show that in a standard model of international macroeconomics - the Backus, Kehoe, and Kydland (1994) model augmented with transportation costs - lower trade barriers can yield the counterfactual prediction of a smaller cross-country output correlation. The reason is twofold. First, in that model the resource shifting motive is stronger. Second, demand complementarities generated by plausible reductions of trade barriers are too weak. Under financial autarky - where the resource shifting motive is absent - the predicted synchronization is less than one fourth compared to the data. In other words, as τ falls, country-interdependence is not significantly affected. The model lacks of sufficient internal amplification: regardless of lower trade barriers, domestic shocks generate too small and short lasting effects on foreign output fluctuations.[54]

To illustrate the mutually reinforcing role of search frictions and sunk entry costs, I consider three alternative versions of the model in which I abstract from: (i) labor market frictions *and* endogenous variations in the number of firms (a version of the model which I call BKK); (ii) labor market frictions (the original Ghironi and Melitz model); (iii) endogenous variations in the number of producers (a version which I call MP).[55] All these alternative versions fail to generate the comovement observed in the data. Taken in isolation, both endogenous entry and labor market frictions help the model to get closer to the data, but they fall short of generating plausible quantitative predictions.[56]

[53] This puzzle is distinct from the puzzles that Obstfeld and Rogoff (2000b) document; in particular, it is different from the consumption correlation-puzzle. The trade-comovement puzzle is about the inability of the standard international RBC models to generate a strong change in output correlations from changes in bilateral trade intensity.

[54] Output dynamics are primarily driven by the underlying aggrgeate disturbances and economic mechanisms play a small role in propagating shocks.

[55] I impose financial autarky to mute the resource shifting motive. Hence I'm implicitely considering the more favorable scenario for those models. When I assume financial integration, the predicted change in correlation is signficantly lowered.

[56] Other papers have tried to reverse the counterfactual prediction of the standard international RBC model about the relationship between trade and comovement. Burstein, Kurz, and Tesar (2008) show that allowing for production sharing among countries can deliver tighter business cycle synchronization. Arkolakis and Ramanarayanan (2008) build a model of vertical specialization in international trade and aggregate fluctuations. In their model the degree of vertical specialization varies with trade barriers and higher vertical trade linkages between countries *can* induce higher synchronization of business cycles. Drozdy and Nosalz (2008) deviate from the standard neoclassical framework and address the link between trade and comovement in a model featuring a low short-run price elasticity of trade coexisting with a high long-run price elasticity.

Panel B of Figure 9 shows that asymmetries in labor markets can dampen the increase in output comovement, but they do not change the positive effect of trade on business cycle synchronization: the sign of the result does not depend on the country-specific labor market characteristics. What is essential is the endogenous interaction between product and labor market dynamics, *i.e.* the time consuming nature of the matching process combines with the presence of sunk entry costs, changing the propagation of shocks via trade with respect to a standard international RBC model. Labor market features of trading partners affect the intensity of the change in comovement. The reason is twofold. First, when trade opens up between countries with asymmetric labor markets, there is an asymmetric propagation of external shocks which is absent in the symmetric case. Second, the resource shifting motive is stronger when countries have asymmetric labor markets. Lower trade barriers increase the incentives to shift resources towards the more flexible (rigid) economy in good (bad) times. During worldwide expansions households in the rigid economy invest abroad, attracted by the relatively higher returns in the flexible economy which exploits its quickly and costlessly ability to reallocate labor (reflected in higher entry profitability). On the contrary, during worldwide downturns, incentives are reverted and resources tend to shift toward the more rigid economy which is somehow more protected in the aftermath of the negative aggregate shock - firing is more costly and employment and aggregate demand do not fall abruptly.

6.2 Domestic Volatility

Traditional arguments linking output volatility and trade refer either to the increased importance of external shocks or to changes in the degree of diversification of production across sectors.[57] This model highlights three other channels through which trade integration can (potentially) affect the size of domestic fluctuations. First, as in the original Melitz (2003) model, in presence of heterogenous firms and fixed export costs a reduction of trade barriers lowers the export productivity cutoff z_X and the economy fluctuates around a steady state in which a bigger number of firms is exporting. Under the Pareto parametrization, the density of firms with productivity z_X is bigger - a larger number of firms are in the neighborhood of the marginal exporter. As a consequence, any given shock triggers a bigger variation in the number of exporting firms, which, *ceteris paribus* - tends to increase output volatility.[58]

Second as trade opens up, labor market tightness rises and within firm job destruction falls, reducing the sensitivity of job creation and destruciton to aggregate disturbances, which, *ceteris*

[57] For instance, aggregate volatility could increase if production specializes in sectors characterized by more elastic product demand and factor supply as in Kraay and Ventura (2002) or in sectors characterized by higher idiosyncratic volatility Cuñat and Melitz (2007). At the same time, if trade changes the comovement properties of the trading sectors with the rest of the economy, volatility might decrease. In the model there is no scope for sectorial specialization since the focus is on within industry trade. Hence only the first channel is potentially at work here.

[58] di Giovanni and Levchenko (2009) discuss another channel through which long run effects of trade opennes can affect volatility. In presence of firm heterogeneity and resource reallocation toward more productive firms the economy might display granula features: idiosyncratic shocks to individual firms might no longer average out, increasing volatility. In my model, idiosyncratic job-specific shocks, by construction, affect firms symmetrically and so they completely average out.

paribus, triggers a smaller variation of job flows[59].

Third, in presence of heterogenous labor markets, differences in cross-country output dynamics might spillover abroad as trade barriers are reduced.

Figure 11 illustrates the variation in GDP volatility for progressive reductions of trade costs from high values to the benchmark calibration level. As before, at the extreme points, the difference in trade costs implies differences in trade volumes of a factor of 3.5. Trade integration under full symmetry has very small effects on output volatility. The steady effects in product and labor markets tend to offset each other and the change in volatility is quantitatively negligible.

Panel B instead reveals that lowering trade barriers between countries with asymmetric labor markets can induce quite sizable effects. In particular, the rigid home country experiences an increase in output volatility of almost 10%.[60] As the comovement between the rigid and flexible trading partners increases, this result is not surprising. Since the flexible economy is more responsive to shocks, stronger trade linkages imply that domestic demand in the rigid country becomes relatively more volatile. Furthermore, lower trade barriers amplify the resource shifting motive, further increasing output volatility. In the flexible economy volatility instead falls, even if the absolute change is smaller than what observed in the rigid country.[61] The result is quite suggestive given the fact that I'm considering two large economies and assuming a fully symmetric structure of shocks. In particular, if the more flexible trading partner would also experience relatively higher volatility of innovations the impact of labor market rigidity for domestic volatility could be even larger.

As a robustness check I have recomputed the predicted change in comovement using the parametrization in Baxter and Crucini (1995). Figure 10 show that results are robust to different specification of the productivity process.

7 Conclusions

In this paper I have developed a two country, stochastic, general equilibrium model of trade and macroeconomic dynamics with search and matching frictions in the labor market. I have used this model to study the effects of trade integration between countries with potentially heterogeneous labor market characteristics. I have focused on the dynamic effects of trade reforms and on the business cycles implications of stronger trade linkages. The paper contributes to the trade literature,

[59] This is true both for rigid and flexible labor markets. In a rigid economy, though, the reduction of labor market tightness and threshold cut off is smaller compared to a flexible economy.

[60] Notice that this result does not imply that the Home rigid economy becomes more volatile than its flexible trading partner.

[61] This happens since the larger incentives to shift resources over the cycle tend to increase volatility everywhere, other things equal. For this reason, even if aggregate demand in the flexible country is less volatile after intergration because of the rigidity of the trading partner, the decrease in volatility is not so pronounced . This seem to suggest that the role played by international financial markets is quantitatively important when countries have asymmetric labor markets.

which typically focuses only on the long-run effects of trade integration and abstracts from its effects on fluctuations, and the international macroeconomic literature, by exploring the role of labor market frictions and trade in explaining international business cycle evidence.

The results indicate that search and matching frictions and their heterogeneity across trading partners play an important role for the short to medium run effects of trade integration. Following aggregate shocks, fluctuations in job creation and destruction affect profitability of producer entry into domestic and export markets which in turn feed back into labor market outcomes. The interaction of product and labor market dynamics that determines the transitional adjustment to trade integration is also at the heart of the propagation mechanism of business cycle shocks via trade. Country specific labor market characteristics, by affecting the behavior of job creation and destruction, impact on entry and export decisions, inducing asymmetric dynamics between trading partners.

The model predicts that more flexible labor markets are a source of competitive advantage following reductions of trade barriers and gains from trade are dampened in more rigid trading partners. Nevertheless, concerns about the presence of short-run negative welfare effects of globalization do not find confirmation in the model. Trade, in fact, is found to be beneficial at any point in time, even if labor market outcomes can be negatively affected in the aftermath of integration. Business cycle implications of stronger trade linkages suggest that the trade expansion from reduced trade frictions increases comovement across countries. Results indicate that this effect is stronger if trade integration is preceded by harmonization of labor market structures. On the other hand, the prediction of increased aggregate volatility for countries with relatively more rigid labor markets might disincentive labor market deregulation in such economies.

From a theoretical point of view this paper makes two contributions. First, the model introduces a source of amplification and propagation of shocks not investigated before, as typical model of international macroeconomics assume Walrasian labor markets and they abstract from the endogenous determination of the number of firms serving domestic and foreign markets. The interaction between product and labor market dynamics in presence of sunk entry costs and search and matching frictions turns out to be very important in explaining the effects of stronger trade linkages across countries. Second, I have derived sufficient conditions to extend the original Melitz (2003) aggregation in a dynamic model with labor markets characterized by search and matching frictions (with both job creation and destruction endogenously determined).

The model abstracts from a number of important features which are left for future research. For example, the role of comparative advantage is ignored, as the focus is restricted to within industry trade. If trade promotes production specialization across countries, relative labor market characteristics might contribute to shape the nature of comparative advantage. As a consequence, there could be additional consequences for sectoral and aggregate unemployment and implications for business cycle dynamics not captured by a one sector model. Moreover, given the recent interest about the effects of trade integration for inflation dynamics, the model could be extended to include nominal rigidities in order to address this issue.

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Appendix A: Wage Equation

I assume a Nash bargaining between each firm and each worker. Without loss of generality consider a worker with idiosyncratic productivity a_t and a domestic producer with productivity z. The bargaining solution splits the surplus of their match in shares determined by an exogenous bargaining weight η. The sharing rule is such that:

$$\eta\Gamma_{z,t}(a) = (1-\eta)(W_t(a) - U_t).$$

where $\Gamma_{z,t}(a)$ is the value of the matched worker for the firm, $W_t(a)$ represents the worker's asset value of being matched to a job and U_t is the value of unemployment.[62] We have:

$$\Gamma_{z,t}(a) = \varphi_{z,t} z Z_t a_t - w_t(a) + E_t\beta_{t,t+1}(\bar{\Gamma}_{z,t+1} - H(a^c_{z,t+1})F),$$

where $\beta_{t,t+1} = \beta(1-\delta)(\frac{C_{t+1}}{C_t})^{-\gamma}$ is the stochastic discount factor adjusted for the exit probability. The value of a job depends on current real revenue minus the real wage, plus the discounted continuation value, where $\bar{\Gamma}_{z,t+1} = \int_{a^c_{t+1}}^{\infty} \Gamma_{z,t+1}(a)dH(a)$. Provided the firms is still on the market and the worker is not separated, in $t+1$ the match draws a new idiosyncratic productivity a. If $a > a^c_{z,t+1}$ the worker contributes $\Gamma_{z,t+1}(a)$; otherwise the job is destroyed and the firm must pay firing costs, F.

For W_t and U_t:

$$W_t(a) = w_t(a) + E_t\beta_{t,t+1}((1-\overline{\varrho})\bar{W}_{t+1} + \varrho^F_{t+1}U$$

$$U_t = B + E_t\beta_{t,t+1}(p_t(1-\varrho^F_{t+1})\bar{W}_{t+1} + (1-(p_t(1-\varrho^F_{t+1}))U_{t+1}),$$

where $\bar{W}_{t+1} = \int_{a^c_{z,t+1}}^{\infty} W_{t+1}(a)dH(a)$. An unemployed worker receives the unemployment benefit B, the discounted continuation value and the option value of future employment (weighted by the respective probabilities).

Inserting the value functions in the bargaining rule yields the equation for the individual real wage:

$$w_{z,t}(a) = \eta(\varphi_{z,t} z Z_t a + \kappa\theta_t + (1 - E_t\zeta_{z,t+1})F) + (1-\eta)B \tag{19}$$

where $\zeta_{t+1} = (1-p_t)E_t\beta_{t,t+1}\varrho^f_{t+1}$.

[62] Notice that workers anticipate that the wage rate is symmetric across all the incumbents.

Appendix B: Symmetric Job Destruction Cutoff

Here I show that each incumbent has the same marginal workers regardless of the specific productivity z. The proof is done for the home economy but it is understood that it applies also to the foreign country.

From the JC equation:

$$\underbrace{\frac{\kappa}{\eta q_t Z_t} + F}_{\Lambda_t^{JC}} = \varphi_{z,t} z \int_{a_{z,t}^c}^{\infty} (a - a_t^c) dH(a). \tag{20}$$

From JD equation:

$$\varphi_{z,t} z a_{z,t}^c = \underbrace{E_t \beta_{t+1} \{(1-\eta)\kappa\theta_{t+1} - \frac{\kappa}{q_{t+1}}\} + \eta B + (1 + (1-\eta) E_t \zeta_{t+1}) F}_{\Lambda_t^{JD}}, \tag{21}$$

where Λ_t^{JC} and Λ_t^{JD} depends only on aggregate variables - independent of firm's specific productivity.

From (21):

$$\varphi_{z,t} z = \frac{\Lambda_t^{JD}}{a_{z,t}^c}. \tag{22}$$

Plugging the last expression into (20):

$$F(a_{z,t}^c) \equiv \frac{1}{a_{z,t}^c} \int_{a_{z,t}^c}^{\infty} (a - a_t^c) dH(a) = \underbrace{\frac{\Lambda_t^{JC}}{\Lambda_t^{JD}}}_{\text{Identical for Each Firm}}.$$

To show that $a_{z,t}^c = a_t^c$ I need to show that $F(a_{z,t}^c) = \frac{\Lambda_t^{JC}}{\Lambda_t^{JD}}$ has a unique solution - *i.e.* $F(a_{z,t}^c)$ is monotonic in $a_{z,t}^c$.

Assume $a \sim \log N(0, \sigma_A^2)$. We can rewrite:

$$F(a_{z,t}^c) = \frac{1}{a_{z,t}^c \sigma_A \sqrt{2\pi}} \int_{a_{z,t}^c}^{\infty} e^{-\frac{(\ln(a))^2}{2\sigma_A^2}} da - \frac{1}{\sigma_A \sqrt{2\pi}} \int_{a_{z,t}^c}^{\infty} \frac{e^{-\frac{(\ln(a))^2}{2\sigma_A^2}}}{a} da.$$

Applying the Leibniz rule it is possible to show that: $\frac{dF(a_{z,t}^c)}{a_{z,t}^c} < 0$. Hence there is a unique solution: $a_{z,t}^c = a_t^c$.

Symmetric Wage Rate

Take:

$$w_{z,t}(a) = \eta(\varphi_{z,t} z Z_t a + \kappa\theta_t - E_t \zeta_{z,t+1} F) + (1-\eta) B.$$

From (22) and using $a_{z,t}^c = a_t^c$:

$$w_{z,t}(a) \equiv w_t(a) = \underbrace{\eta(\frac{\Lambda_t^{JD}}{a_t^c} Z_t a + \kappa\theta_t - E_t\zeta_{z,t+1}F) + (1-\eta)B.}_{\text{Only Aggregates}}$$

It follows that each worker with a given productivity draw a is identical across all producers. As a consequences:

$$\bar{w}_{z,t} \equiv \bar{w}_t = \int_{a_t^c}^{\infty} w_t(a) \frac{dH(a)}{1 - G(a_t^c)}.$$

Appendix C: Symmetry Between Incumbents with Productivity z

Here I show that: (i) all incumbent firms with a draw z are symmetric, regardless of their time of entry; (ii) the optimal hiring policy for a new entrant with a draw z is to post vacancies to target the size of existing incumbents with the same productivity z.

Again, without loss of generality I focus on incumbents and new entrants with a productivity draw z. I proceed backwards. First I show that for a new entrant in t is optimal to target the workforce size of existing incumbents if the entrant will have the same marginal cost of current incumbents in $t+1$ (when it will begin production).Then I complete the proof showing that the real marginal cost is effectively identical for all the producing firm with productivity z in a given period of time, regardless of whether or not the firm is a new producer.

Assume that all the producing firm in t with relative technology z - no matter their timing of entry - have the same marginal cost $\varphi_{z,t}$. This implies that each incumbents is charging the same domestic relative price $\rho_{D,t}(z)$ and - if exporting - the same export price $\rho_{X,t}(z)$ since $\rho_{D,t}(z) = \frac{\gamma}{\gamma-1}\varphi_{z,t}$ and $\rho_{X,t}(z) \equiv \frac{p_{X,t}(z)}{P_t^*} = \frac{\tau_t}{Q_t}\rho_{D,t}(z)$. It follows that each producer faces the same domestic and foreign demand schedules: $y_{D,t}(z) = (\rho_{D,t}(z))^{1-\gamma} Y_t$ and $y_{X,t}(z) = (\rho_{X,t}(z))^{1-\gamma} Y_t^*$. The output produced by each incumbent - expressed in units of the consumption basket C_t - is $y_{D,t}(z) = \rho_{D,t}(z)(zZ_t\overline{a_t}l_{D,t}(z))$ and $y_{X,t}(z) = Q_t\tau_t\rho_{X,t}(z)(zZ_t\overline{a_t}l_{X,t}(z))$. Hence it must be that each firm with productivity z producing at time t has the same stock of labor.

To complete the proof I show that each incumbent with relative technology z has indeed the same marginal cost $\varphi_{z,t}$ regardless of the timing of entry. To see this it is enough to rewrite (21) as:

$$\varphi_{z,t} = \frac{1}{z a_t^c} \Lambda_t^{JD}.$$

All the terms on the RHS are independent of the time of entry. Once again the result follows from the fact that a_t^c and the wage rate are identical across producers.

The same reasoning can be applied to any other producer with a different productivity $z^{'}$ and it extends to the foreign country.

Appendix D:Calibration

An important aspect of the model is the distinction between within and across firm worker separation, a feature absent in a standard "large firm" model of search and matching frictions. To pin down δ and ϱ^x I use the following procedure. First notice that total job destruction in steady state is given by $jd = \varrho^T L - (1-\delta)\varrho^x qL$. The amount of the overall job destruction induced by the exit of plants is $jd^{EXIT} = \delta L$.

Davis, Haltiwanger, and Schuh (1996) report $\frac{jd}{L} = 0.052$ and $\frac{jd^{EXIT}}{jd} = .2$.

By assuming a total separation rate ϱ^T of 7%, we can compute δ and ϱ^x as follows:

$$\delta = \frac{jd^{EXIT}}{L}\frac{jd}{L}, \qquad \varrho^x = \frac{\varrho^T - \frac{jd}{L}}{(1-\delta)q}.$$

TABLE 1: TIMING OF THE MODEL

	Event
1.	Exogenous job destruction ($\bar{\varrho}$); Z_t is realized;
2.	Entry decision
3.	New entrants and incumbent firms post vacancies
4.	Idiosyncratic shocks $a_{i,t}$ and job destruction;
5.	Individual wage bargaining
6.	Production with L_t workers
7.	Firms exit (δ)

TABLE 2: MODEL SUMMARY - FINANCIAL AUTARKY

1.	Discount Factor	$\beta_{t,t+1} = \beta(1-\delta)(\frac{C_{t+1}}{C_t})^{-\gamma}$
2.	F Discount Factor	$\zeta_{t+1}= (1-p_t)E_t\beta_{t+1}$
3.	Employment	$L_t= N_{D,t}l_{D,t}+N_{X,t}l_{X,t}$
4.	Domestic Employment	$l_{D,t} = [1-H(a_t^c)][(1-\bar{\varrho})l_{D,t-1} + q(\theta_t)v_{D,t}]$
5.	Export Employment	$l_{X,t} = [1-H(a_t^c)][(1-\bar{\varrho})l_{X,t-1} + q(\theta_t)v_{X,t}]$
6.	Domestic/Export Labor	$l_{X,t} = Q_t^{\theta}(\frac{\tau_t z_D}{z_{X,t}})^{1-\theta}\frac{Y_t^*}{Y_t}l_{D,t}$
7.	Vacancies	$V_t= N_{D,t}v_{D,t}+N_{X,t}v_{X,t}+N_{E,t}[\frac{l_{D,t}+[1-G(z_{X,t})]l_{X,t}}{q_t}]$
8.	Unemployment	$U_t= (1-L_t)$
9..	Matching F.	$M(U_t,V_t) = \chi U_t^{\varepsilon}V_t^{1-\varepsilon}$
10.	Tightness	$\theta_t=\frac{V_t}{U_t}$
11.	Job Finding	$p(\theta_t) =\frac{M(U_t,V_t)}{U_t}$
12.	Vacancy Filling	$q(\theta_t) =\frac{M(U_t,V_t)}{V_t}$
13.	Aggregate Wage	$\bar{w}_t= \eta(\bar{\varphi}_t Z_t\bar{a}_t+\kappa\theta_t-E_t\zeta_{z,t+1}F) + (1-\eta)B$
14.	Aggregate JC	$\frac{k}{q_t}= \bar{\varphi}_t Z_t(\bar{a}_t-a_t^c)(1-H(a_t^c)) - F$
15.	Aggregate JD	$\bar{\varphi}_t Z_t a_t^c= [B+\frac{1}{1-\eta}(\eta\kappa\theta_t-\frac{\kappa}{q(\theta_t)}-(1+\eta E_t\zeta_{t+1})F].$
16.	Price Indexes	$1 = N_{D,t}(\tilde{\rho}_{D,t})^{1-\gamma}+N_{X,t}^*(\tilde{\rho}_{X,t}^*)^{1-\gamma}$
17.	Profits	$\tilde{d}_t= \tilde{d}_{D,t}+\frac{N_{X,t}}{N_{D,t}}\tilde{d}_{X,t}$
18.	Domestic Price	$\tilde{\rho}_{D,t}=\frac{\gamma}{\gamma-1}\frac{\bar{\varphi}_t}{\tilde{z}_D}$
19.	Export Price	$\tilde{\rho}_{X,t}=\frac{\gamma}{\gamma-1}\frac{\tau_t}{Q_t}\frac{\bar{\varphi}_t}{z_{X,t}}$
20.	Domestic dividends	$\tilde{d}_{D,t}=\frac{1}{\gamma}(\tilde{\rho}_{D,t})^{1-\gamma}Y_t$
21.	Export Dividends	$\tilde{d}_{X,t}=\frac{Q_t}{\gamma}(\tilde{\rho}_{X,t})^{1-\gamma}Y_t^*-f_{X,t}$
22.	Zero Profit Export	$\tilde{d}_{X,t}=\frac{\gamma-1}{k-(\gamma-1)}f_{X,t}$
23.	Free Entry	$e_t= f_{E,t}$
24.	Entry Cost	$f_{E,t} = f_{R,t}+\kappa\frac{l_{d,t}+[1-G(z_{x,t})]l_{x,t}}{q_t}$
25.	Number of Firms	$\frac{N_{X,t}}{N_{D,t}}= 1-G(z_{X,t}) = (\frac{z_{\min}}{\tilde{z}_{X,t}})^{-k}(\frac{k}{k-(\gamma-1)})^{\frac{k}{\theta-1}}$
26.	Euler eq. (bonds)	$1 = (1+r_t)E_t\beta(\frac{C_{t+1}}{C_t})^{-\upsilon}$
27.	Euler eq. (shares)	$\tilde{e}_t= (1-\delta)E_t\beta(\frac{C_{t+1}}{C_t})^{-\upsilon}(\tilde{d}_{t+1}+\tilde{e}_{t+1})$
28.	Demand	$Y_t= C_t+N_{E,t}f_{R,t}+\kappa V_t.$
29.	Accounting	$C_t+N_{E,t}\tilde{e}_t= N_{d,t}\tilde{d}_t+\bar{w}_t L_t.$
30	Balanced Trade	$Q_t N_{X,t}(\tilde{\rho}_{X,t})^{1-\gamma}Y_t^*= N_{X,t}^*(\tilde{\rho}_{X,t}^*)^{1-\gamma}Y_t$

Note: I omit equations for the foreign economy. Equations 1-28 hold true for the foreign country (with a superscript star). Notice that equations (17) and (21) become: $\tilde{\rho}_{X,t}^*=\frac{\gamma}{\gamma-1}Q_t\tau_t^*\frac{\bar{\varphi}_t^*}{\tilde{z}_{X,t}^*}$ and $\tilde{d}_{X,t}^*=\frac{1}{\gamma Q_t}(\tilde{\rho}_{X,t}^*)^{1-\gamma}Y_t^*-f_{X,t}^*$.

TABLE 3: MODEL SUMMARY - BOND TRADING

Home Euler equation (home bonds)	$C_t^{-\upsilon}(1+\xi B_{t+1}) = \beta(1+r_{t+1})E_t[(C_{t+1})^{-\upsilon}]$
Home Euler equation (foreign bonds)	$C_t^{-\upsilon}(1+\xi B_{*,t+1}) = \beta(1+r^*_{t+1})E_t[\frac{Q_{t+1}}{Q_t}(C_{t+1})^{-\upsilon}]$
Foreign Euler equation (home bonds)	$C_t^{*-\upsilon}(1+\xi B^*_{t+1}) = \beta(1+r_{t+1})E_t[\frac{Q_t}{Q_{t+1}}(C^*_{t+1})^{-\upsilon}]$
Foreign Euler equation (foreign bonds)	$C_t^{*-\upsilon}(1+\xi B^*_{*,t+1}) = \beta(1+r^*_{t+1})E_t[(C^*_{t+1})^{-\upsilon}]$
Home Accounting	$C_t+N_{E,t}\tilde{e}_t+B_{t+1}+Q_tB_{*,t+1}= (1+r_t)B_t+Q_t(1+r^*_t)B_{*,t}+N_{D,t}\tilde{d}_t+\bar{w}_tL_t.$
Horeign Accounting	$C^*_t+N^*_{E,t}\tilde{e}^*_t+B^*_{t+1}+Q_tB^*_{*,t+1}=\frac{1}{Q_t}(1+r_t)B^*_t+(1+r^*_t)B^*_{*,t}+N^*_{D,t}\tilde{d}^*_t+\bar{w}^*_tL^*_t.$
Home Current Account	$CA_t= (B_{t+1}-B_t) + Q_t(B_{*,t+1}-B_{*,t})$
Foreign Current Account	$CA^*_t=\frac{(B^*_{t+1}-B^*_t)}{Q_t}+(B^*_{*,t+1}-B^*_{*,t})$
International Payments	$[Q_tN_{X,t}(\tilde{\rho}_{X,t})^{1-\gamma}Y^*_t-N^*_{X,t}(\tilde{\rho}^*_{X,t})^{1-\gamma}Y_t] + r_tB_t+r^*_tB_{*,t}= CA_t$

TABLE 4: SYMMETRIC CALIBRATION

	Parameter	Value	Target/Source
Int. Elasticity Sub.	υ	2	*Lit*
Elasticity Varieties	γ	3.8	*Lit*
Discount Factor	β	.99	*Lit*
Entry Cost	f_E	1.60	$.Data$
Export Cost	f_X	0.013	$\frac{N_x}{N_d} = .21$
Iceberg trade Cost	τ	1.3	*Lit*
Pareto Support	$z_{\min}$	1	*Norm*
Pareto Shape	κ	3.4	σ_{sales}
Bargaining Power	η	.5	*Lit*
Elasticity Matching	ξ	.5	*Lit*
Firing Costs	ψ_F	0	*Lit*
Replacement Rate	ψ_B	.54	*Lit*
Firm Exit rate	δ	.02	$\frac{JD^{EXIT}}{jD} = .20$
Exogenous Separation	$\overline{\rho}$	.012	$\frac{JD}{L} = .052$
home Production	h_P	1.47	$U^{SS} = .07$
Matching efficiency	χ	.67	$q^{SS} = .7$
Vacancy Cost	k	.52	$\rho^{Tot} = .07$
stD iid Job shocks	σ_a	.15	$\frac{\sigma_u}{\sigma_Y}$

TABLE 5: ASYMMETRIC CALIBRATION

	Parameter	Value (Rigid)	Sources/Target	Value (Flexible)	Sources/Target
Firing Costs	ρ_F	.20	Data	0	Data
Rep. Rate	ρ_B	.65	*Data*	.54	Data
Matching Efficiency	$\varkappa$	.44	q_{eu}= .7	.52	q_{usa}= .7
Vacancy Cost	k	.62	ρ_{eu}^{TOT}= .03	.44	ρ_{usa}^{TOT}= .07
home Production	h_P	1.49	U_{eu}= 0.092	1.47	U_{usa}= .07

TABLE 6: STANDARD DEVIATIONS

	U.S. Data	Symmetric	Rigid	Flexible
		$\frac{\sigma_X}{\sigma_Y}$	$\frac{\sigma_X}{\sigma_Y}$	$\frac{\sigma_X}{\sigma_Y}$
Y_R	1.71	1.64	1.42	1.60
C_R	0.49	0.68	.58	.67
I_R	3.15	3.34	2.84	3.16
U	6.90	6.90	6.2	6.82
V	8.27	4.13	4.45	3.98
θ	14.06	6.20	5.58	6.34
JC	2.52	2.55	2.45	2.68
JD	3.73	4.10	3.25	3.90
			Symmetric	**Asymmetric**
TB_R	0.26		.35	.46
Q	4.81		.05	.07

TABLE 7: AUTOCORRELATIONS

	U.S. Data	Symmetric Flexible	H Rigid	F Flexible
$Y_{R,t}, Y_{R,t-1}$	.85	.78	.83	.77
U_t, U_{t-1}	.87	.81	.89	.80
V_t, V_{t-1}	.90	.41	.52	.39
		Symmetric		**Asymmetric**
Q_t, Q_{t-1}	.89	.91		.92

TABLE 8: CONTEMPORANEOUS CORRELATIONS

	International					Within Country			
	$Y_{R,t}, Y^*_{R,t}$	$C_{R,t}, C^*_{R,t}$	L_t, L^*_t	$\frac{C_{R,t}}{C^*_{R,t}}, Q_t$		U_t, V_t	U_t, Y_t	C_t, Y_t	I_t, Y_t
US Data	.351	.207	.360	−.35	**US Data**	−.91	−.923	.76	.90
Symmetric	.321	.881	.376	−.84	**Symmetric**	−.06	−.71	.88	.80
Asymmetric	.298	.788	.320	−.80	**Rigid**	−.21	−.79	.89	.71
					Flexible	−.04	−.71	.88	.78

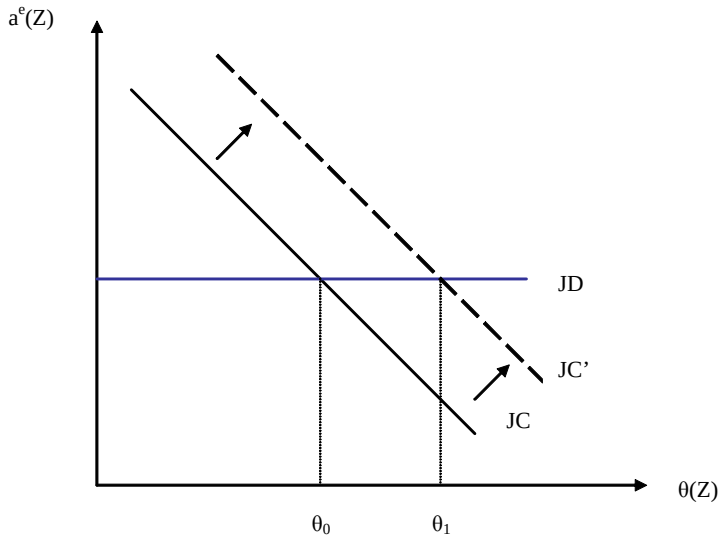

Figure 1. Equilibrium in the Labor Market - Exogenous Separation

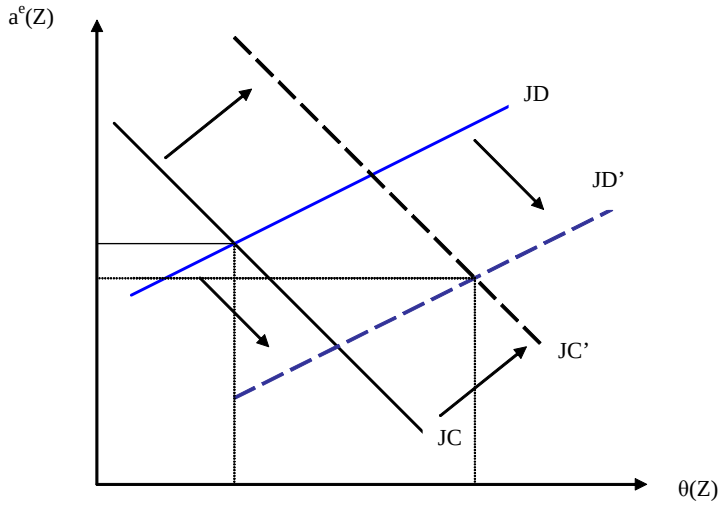

Figure 2. Equilibrium in the Labor Market - Endogenous Separation

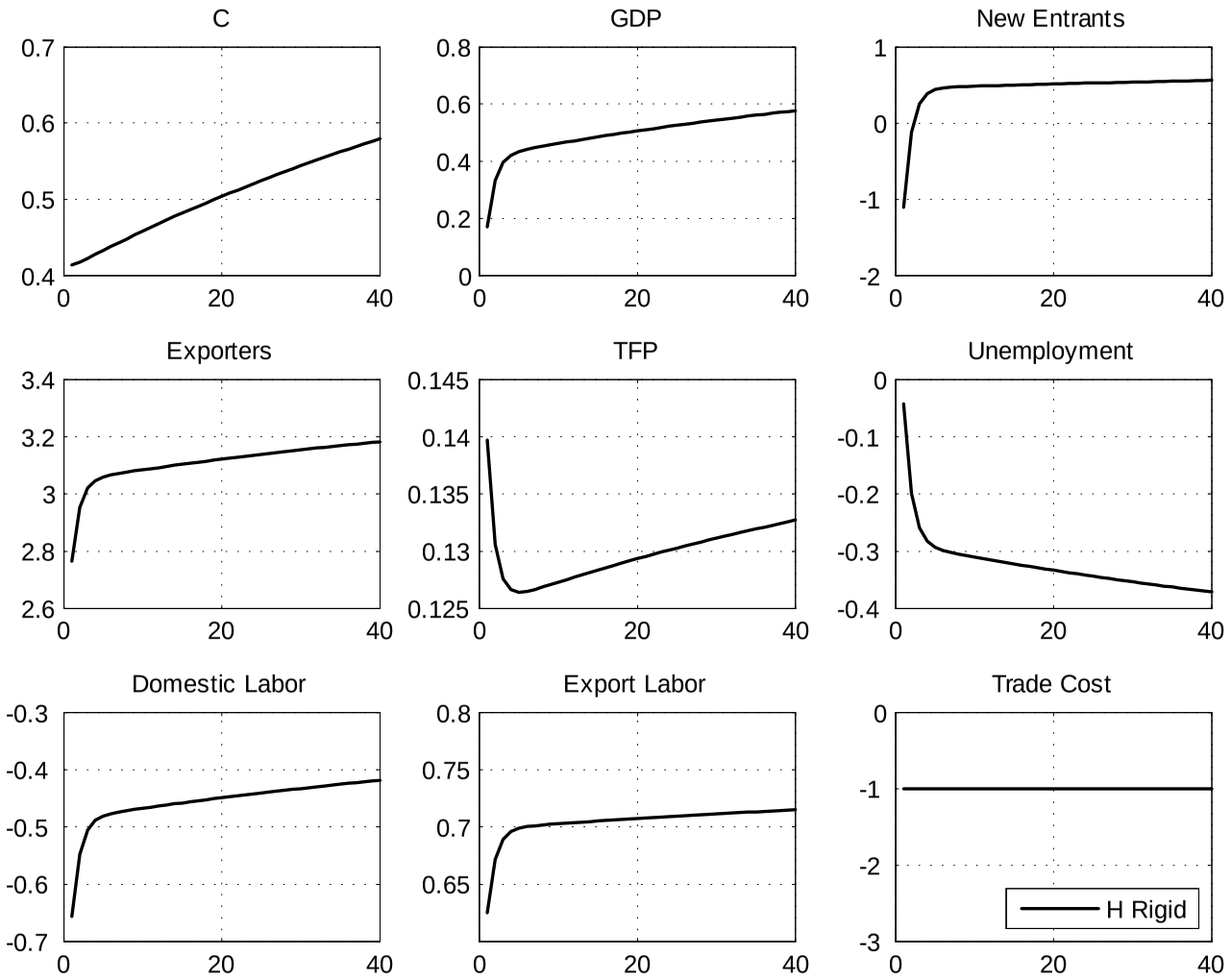

Figure 3. Permanent Global Reduction in τ and τ^* - Symmetric Labor Markets

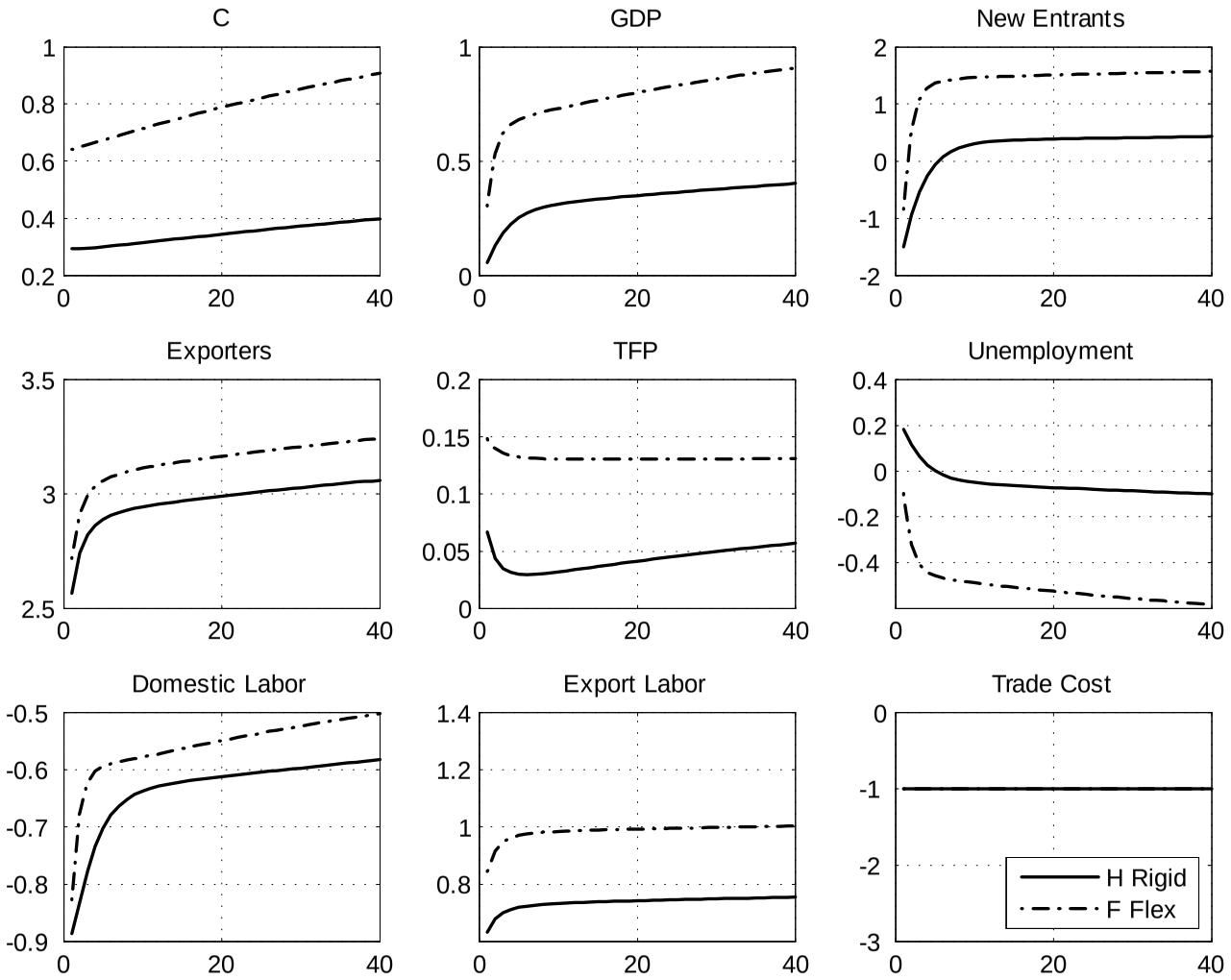

Figure 4. Permanent Global Reduction in τ and τ^* - Asymmetric Labor Market

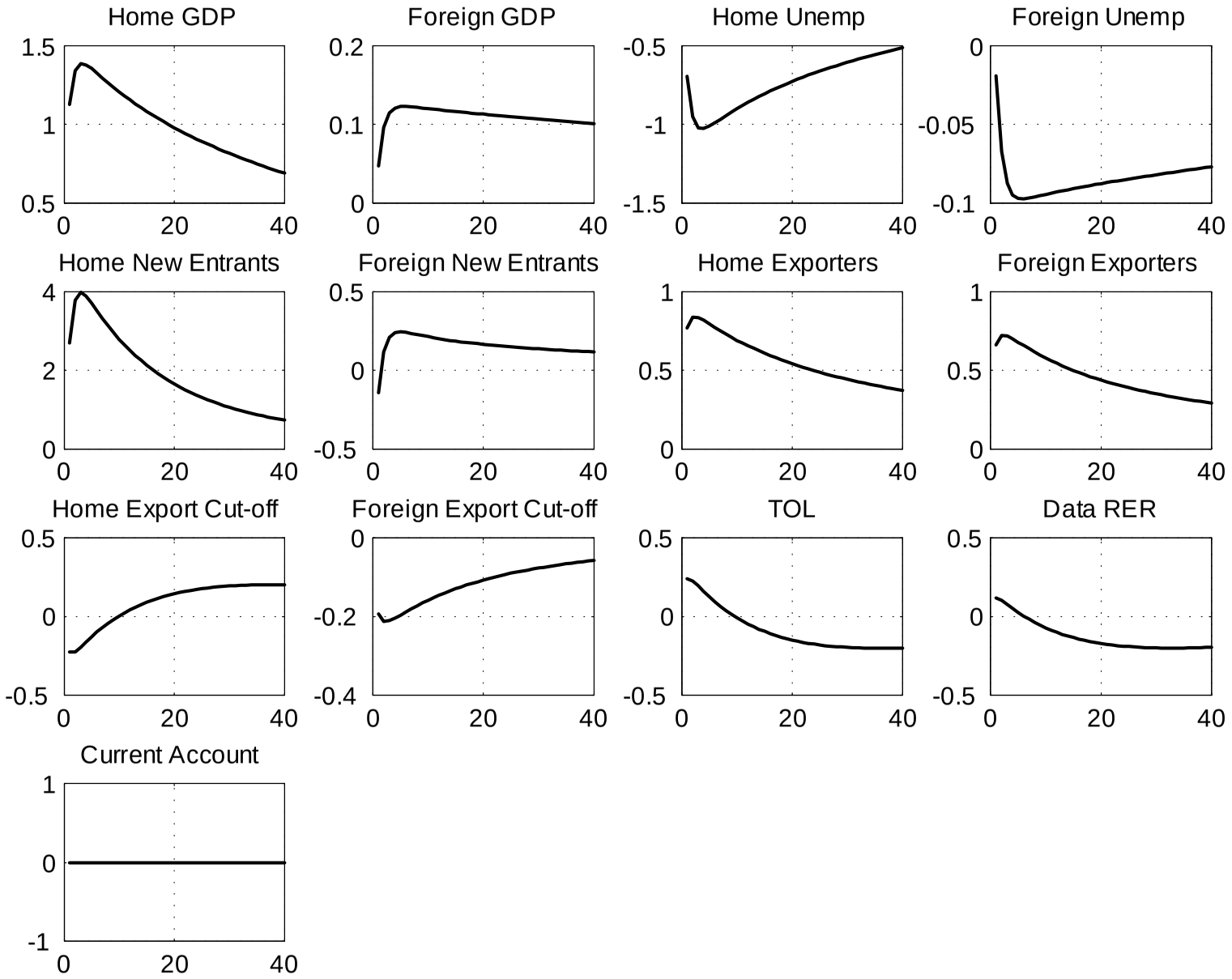

Figure 5. Transitory, Domestic Productivity Shock with Symmetric Labor Markets (Financial Autarky).

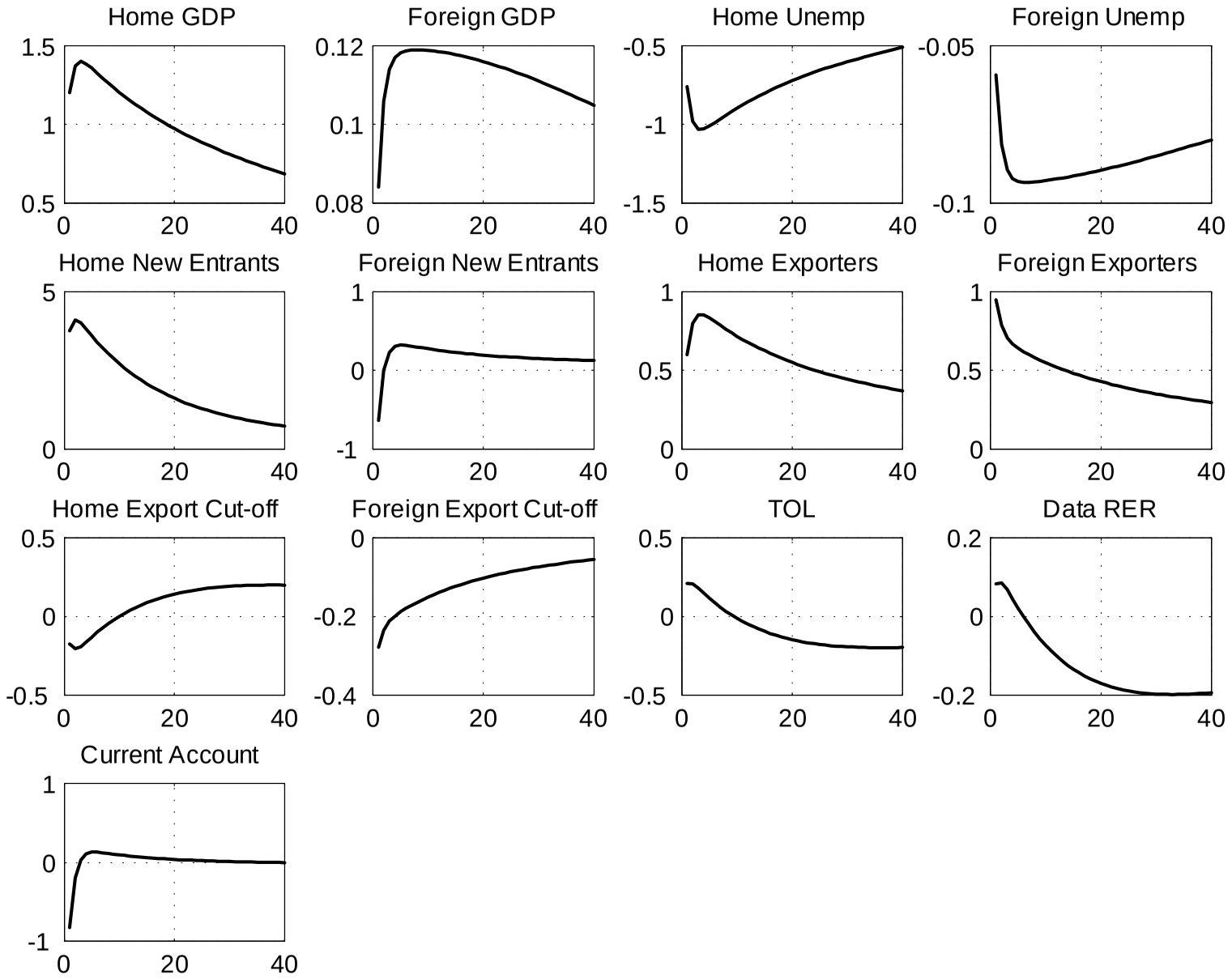

Figure 6. Transitory Domestic Productivity Shock with Symmetric Labor Markets (Bond Trading).

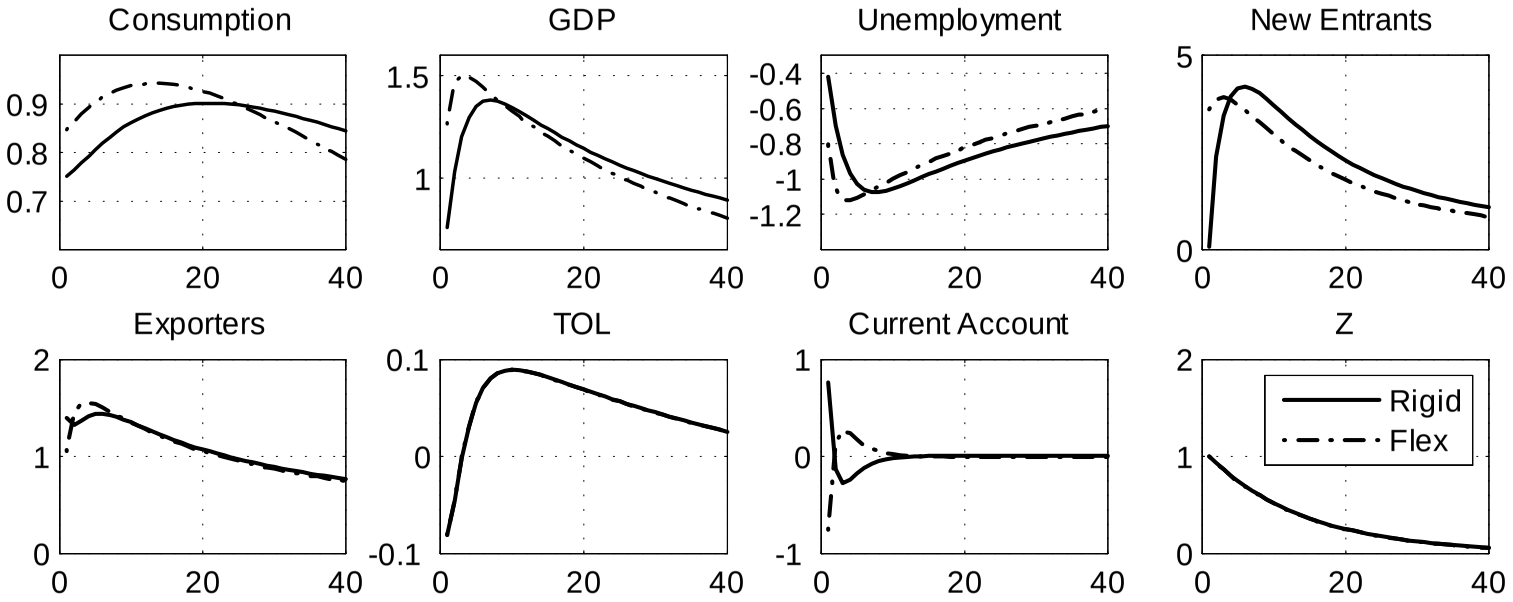

Figure 7. Transitory Global Z Shock with Asymmetric Labor Markets (Bond Trading)

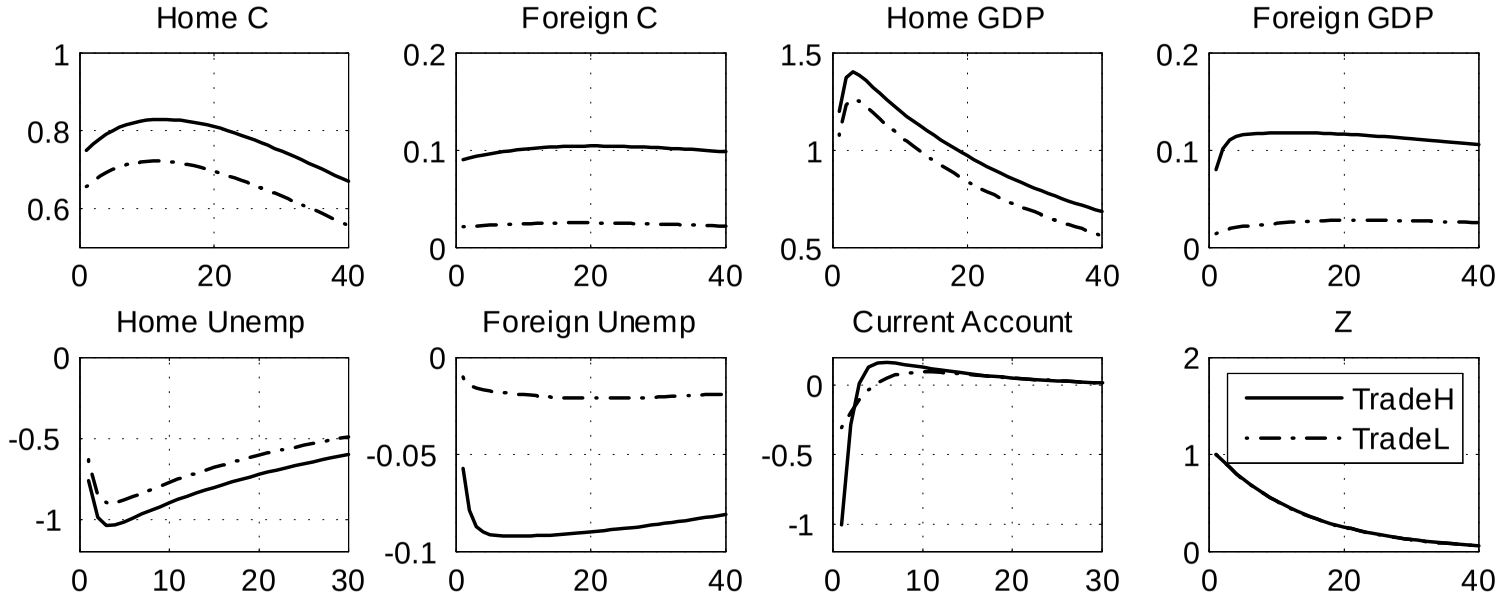

Figure 8. Transitory Global Productivity Shock - High Trade vs Low Trade.

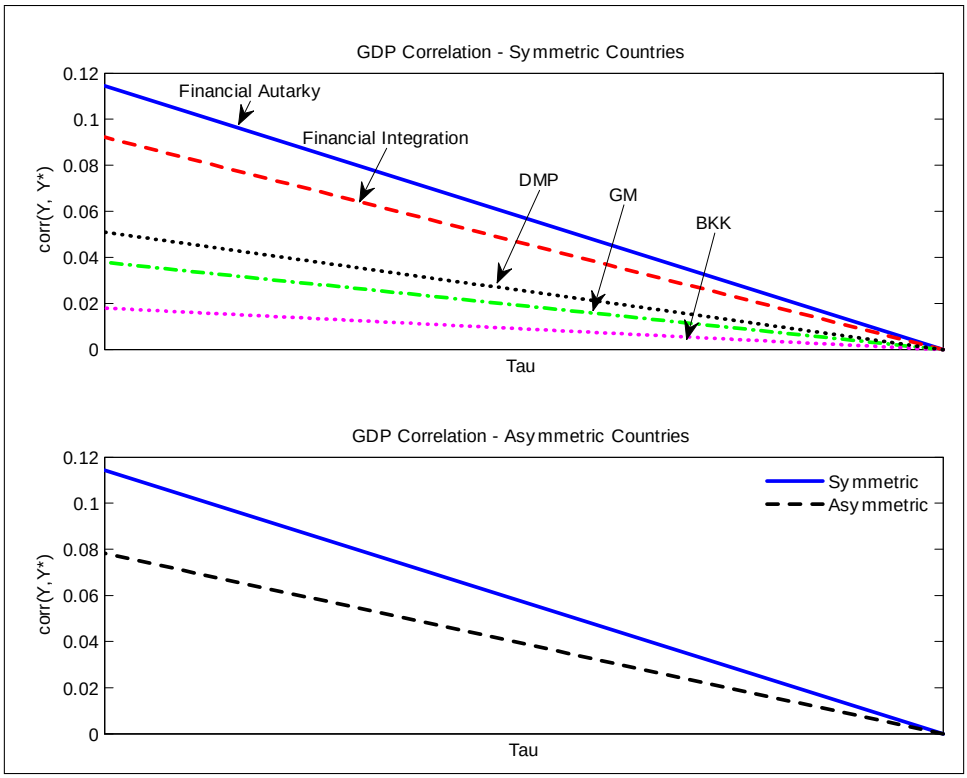

Figure 9. Trade Integration and Cross-Country GDP correlations.

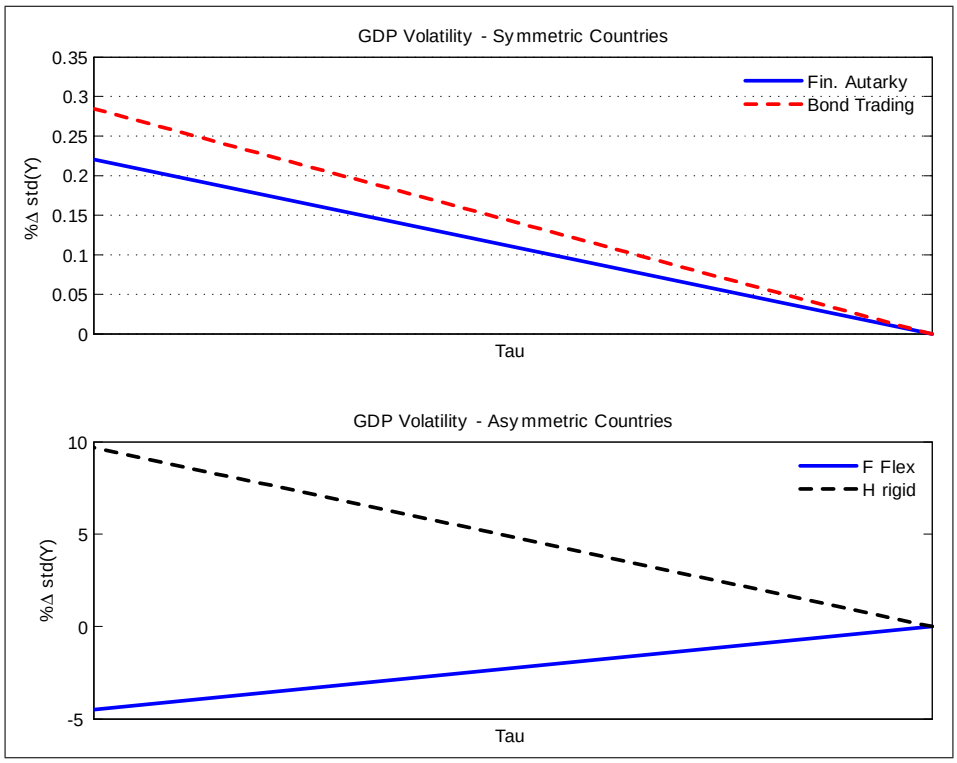

Figure 10. Trade Integration and Domestic GDP volatility.