Doctoral Thesis

# Essays in International Macroeconomics and Trade

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# Contents

# Chapter 1

# Product Quality and International Price Dynamics

**Abstract**

Two puzzling features of international real business cycles are 1) weak or negative correlations between the terms of trade and output, and 2) a rise in relative consumption for countries where goods become relatively more expensive. I show both puzzles either vanish or become much weaker in recent data. I propose a mechanism capable of endogenously generating international price movements that are consistent with both the "old" facts as well as the "new" facts. In this mechanism, firms operating in a monopolistically competitive environment adjust price and quality of their products in response to technological shocks. This model is consistent with the old facts if price levels are not adjusted for quality. For many years, and especially following the 1996 Boskin commision report, statistical agencies have devoted many efforts towards improving their quality-adjusting methodologies. If quality adjustments to price level calculations are introduced, the model's properties are in line with the new facts.

## 1.1 Introduction

### 1.1.1 Motivation

Two common observations of the international real business cycle literature with regard to international price dynamics are 1) a strong negative correlation between the terms of trade[1] and output (Backus et al., 1994) and 2) a rise in relative consumption in a country where goods become relatively more expensive (Backus and Smith, 1993). Table 1.1 reports these correlations for the twelve largest economies in the OECD between 1971 and 1998. In most cases the correlation between output and the terms of trade[2] is negative or close to zero, while US consumption relative to other countries typically rises following a drop in the real exchange rate (which captures relative price levels). Both of these observations have been of great interest to researchers in this area because standard models of international RBCs predict the exact opposite of these observations. In particular, the failure to replicate the correlation between relative consumption and the real exchange rate is typically referred to as the Backus-Smith puzzle. The first goal of this paper is to provide an explanation for the failure of standard models to account for these facts.

Interestingly, a look at more recent data would suggest that a fundamental change has occurred to the dynamics of international prices. Table 1.2 shows the same correlations for the period 1999-2009. Surprisingly, the correlation between output and the terms of trade is now strongly positive for most countries, except for Canada, where it remains at about the same level, and Mexico, where it is much weaker than before. The Backus-Smith

[1] I adhere to standards of the international RBC literature and define terms of trade as the price of imports divided by the price of exports.

[2] Terms of trade are computed as the ratio of the price deflator for imports and the price deflator for exports, while price deflators are calculated as the ratio of imports (exports) in current prices and their corresponding value in real terms. For details on the data refer to the appendix.

Table 1.1: International correlations 1971-1998.

| | $(GDP, tot)$ | $({}^{c_{US}}/_{c}, RER)$ |
|---|---|---|
| United States | -0.24 | N/A |
| Japan | -0.11 | 0.26 |
| Germany | -0.07 | -0.15 |
| France | -0.06 | -0.94 |
| United Kingdom | 0.06 | -0.46 |
| Italy | 0.22 | -0.10 |
| Canada | -0.00 | -0.09 |
| Spain | -0.05 | -0.63 |
| Australia | 0.07 | -0.22 |
| Mexico | -0.38 | -0.61 |
| South Korea | -0.36 | -0.64 |
| Netherlands | -0.05 | -0.14 |

Source: OECD, FRED.

puzzle is weaker for all but one of the twelve OECD economies in my sample (Australia). This poses a great challenge for any theory of international price dynamics. Not only should this theory explain the old puzzles, but it should also be capable of providing a reasonable justification for the dramatic change of these correlations in recent years. A second objective of this paper is to provide one possible explanation for the reversal or weakening of the aforementioned puzzles.

I present here a simple yet powerful mechanism capable of generating international price correlations that are consistent with these facts. My mechanism consists of giving firms a second dimension of production, namely quality. In standard models, price-taking firms choose to expand production in response to lower production costs as a result of a positive technology shock (firms like to "make hay when the sun shines"). This is the only possible response for firms, so naturally an increase in the domestic

Table 1.2: International correlations 1999-2009.

| | $(GDP, tot)$ | | $(^{c_{US}}/_{c}, RER)$ | |
|---|---|---|---|---|
| United States | 0.54 | [+0.78] | N/A | N/A |
| Japan | 0.77 | [+0.88] | 0.33 | [+0.07] |
| Germany | 0.66 | [+0.73] | 0.09 | [+0.24] |
| France | 0.54 | [+0.60] | -0.45 | [+0.49] |
| United Kingdom | 0.08 | [+0.02] | -0.32 | [+0.14] |
| Italy | 0.77 | [+0.55] | 0.05 | [+0.15] |
| Canada | -0.37 | [−0.37] | 0.24 | [+0.33] |
| Spain | 0.63 | [+0.68] | 0.27 | [+0.90] |
| Australia | 0.30 | [+0.23] | -0.41 | [−0.19] |
| Mexico | -0.40 | [−0.02] | -0.61 | [+0.00] |
| South Korea | 0.19 | [+0.55] | -0.60 | [+0.04] |
| Netherlands | 0.23 | [+0.28] | 0.10 | [+0.24] |

In brackets: Change with respect to 1971-1998 period.

supply of goods puts downward pressure on prices. In the model proposed, producers have the option to spend their productivity gains differently by improving the quality of their products. This affects goods' prices through two channels: 1) A demand-side channel, whereby higher-quality goods are more valued by consumers, and 2) a supply-side channel, since producing higher quality goods is generally costlier. Both effects push prices of domestic goods up instead of down.

So now there are two effects – quantity and quality changes – pushing prices in opposite directions, whereas before we only had downward pressure on prices. It then remains a quantitative question whether the effect of quality improvements is strong enough to offset or even dominate the response in quantities. To test this, I calibrate my model to match a number of features of the US economy over the 1971-1998 period. I then argue that the signs and magnitudes of international price correlations generated by this model crucially depend on how price levels are measured. I find that international price fluctuations are much more like the ones we observe in the data for 1971-1998 if we assume that statistical agencies ignore changes in quality in their price level calculations. On the other hand, adjusting price levels for shifts in good quality affects the time series properties of the model in a way that is consistent with more recent data.

This change in the way price levels are determined by statistical agencies is in line with their methodological history. Quality adjustments to price indices in the US and elsewhere have improved over the years. One big push in this direction came partly in response to the 1996 Boskin commission report[3], which stated that

> Many of the products sold today are dramatic improvements over their counterparts from years ago. They may be more durable and subject to less need for repair; more energy efficient; lighter; safer; etc. Sometimes, at least initially, a better quality product replacing its counterpart may cost more. Separating out how much of the price increase is due to quality change rather than actual inflation in the price of a standardized product is far from simple, but is necessary to obtain an accurate measure of the true increase in the cost of living.

This report lead to expanded use of hedonic methods and more frequent updating of the goods in the consumer's basket used to calculate the CPI (Johnson et al., 2006). Quality adjustments have also been increasingly important in price adjustments performed by the BEA in the US national accounts (Wasshausen and Moulton, 2006). Quality adjustments are quite significant in categories of goods that are of great importance to trade, such as vehicles, consumer electronics, or apparel. The findings in table 1.2 suggest the possibility that recently introduced quality adjustments to price indices have reduced the discrepancies between theory and data. I

[3] http://www.ssa.gov/history/reports/boskinrpt.html#list

interpret this as evidence of the importance of the mechanism presented in this paper.

To conclude this section, a brief overview of the rest of the paper: Section 1.1.2 presents related literature in more detail. Section 1.2 presents the basic model of a dynamic, general equilibrium economy with quality production. Section 1.3 explains how statistical agencies in my model measure business cycle statistics with and without quality adjustments, and then evaluates the quantitative predictions of the model. Section 1.4 concludes.

### 1.1.2 Literature

Following the seminal works of Backus, Kehoe, and Kydland (1992, 1994), many studies have tried to explain the puzzle of strongly pro-cyclical terms of trade as well as the Backus-Smith puzzle, though so far the results seem unconvincing. As I mentioned before, the correlation reversal observed in the data is a fact that has not yet been addressed by the literature; none of the papers I refer to in the following paragraphs seeks to explain this issue.

The solutions proposed generally fall within one of two camps: First, a number of papers address the issue by introducing new shocks that mitigate or even reverse the effects of productivity shocks on the terms of trade. This avenue was pioneered by Stockman and Tesar (1995), who add exogenous taste shocks to a standard model with non-traded goods. This innovation solves many of the problems of the theory, but at the expense of a deterioration in the correlation between the trade balance and output and the introduction of hardly identifiable structural disturbances. The effects of quality changes are similar to the effects of taste shocks. The advantage of the mechanism proposed in this paper is that it retains most of the parsimony of the original model because it refrains from introducing new exogenous disturbances into the standard theory, as quality is determined endogenously. Backus and Crucini (2000) extend the basic international RBC model to include oil as a production input and a third, oil producing country with exogenous shocks to its supply of oil. They document that for countries who are net oil importers the terms of trade are strongly negatively correlated to the price of oil, while the opposite is the case for net exporters. They also show that periods of high oil price volatility tend to coincide with periods of highly volatile terms of trade and lower output-terms of trade correlations. Their baseline model does a poor job at matching the volatility of trade and terms of trade yet it does a reasonably good job at matching the direction (but not the magnitude) of the correlations between output, the trade ratio, and the terms of trade. They also explore a variation of their model with no technological shocks, only oil supply shocks, which does a better job at matching moments of international trade variables, but does poorly in other regards. Raffo (2010) introduces investment-specific technological (IST) shocks and variable capacity utilization to a standard model with Greenwood-Hercowitz-Huffman (GHH) preferences[4]. He shows that generating large shifts in domestic absorption relative to output is crucial to understanding the dynamics of international quantities and prices and suggests that IST shocks provide a plausible source of variation to this effect. IST shocks resemble taste shocks in that they do not change aggregate production possibilities, but with the advantage that there are plausible ways of identifying these shocks in the data. This model has many good properties and does a good job of capturing the observed moments of international trade variables. However, Mandelman et al. (2011) raise some concerns about the robustness of these results. They estimate an IST process for the U.S. and a "rest of the world" aggregate and then feed the estimated IST process to the model in place of the calibrated process that Raffo uses. The model in this case does a poor job at explaining the puzzles

[4]IST shocks affect the level of investment that effectively goes into the equation for capital accumulation. GHH preferences, introduced by Greenwood et al. (1988), have the property that the marginal rate of substitution between consumption and leisure is independent of the consumption level within the period. In Raffo (2008), GHH preferences address the excessive smoothness of consumption that is common in international RBC models. See section 1.3.4 for details.

mentioned.

A second group of studies explores the effects of restricting the flow of capital to countries that receive a positive shock. The idea is that this would mitigate the expansion of production and the drop in domestic prices. Baxter and Crucini (1995) replace the complete markets structure of the standard model by a bond economy. They find that the incomplete markets model is not too different from the complete markets version unless there is high persistence of shocks and very little spillovers. In light of this and for simplicity, the model presented in this paper features a single asset that might be traded internationally. Heathcote and Perri (2002) take this idea further and compare both the complete markets model and the incomplete markets model to an economy in which countries are financially autarkic. They find that the model with financial autarky behaves very differently and does a better job at replicating the volatility of the terms of trade as well as cross country correlations. However, counter to the data, the financial autarky model predicts pro-cyclical net exports. Corsetti et al. (2008) take the model with non-traded goods of Stockman and Tesar (1995) and add an incomplete financial market structure and distribution costs. They find that when the trade elasticity is low, incomplete markets reconcile theory and data to a large degree and the Backus-Smith puzzle largely goes away, but the strong, positive correlation between output and the terms of trade remains.

Finally, one study that doesn't fall in either group was carried out by Ghironi and Melitz (2005), who endogenize the 'non-tradedness' of goods by introducing Melitz's heterogeneous firms structure to the production of intermediate goods. Their model provides an endogenous, micro-founded explanation for a Harrod-Balassa-Samuelson effect: More productive economies exhibit higher average prices relative to their trading partners. Terms of trade in this setting can be uncorrelated or even negatively correlated with output, but the Backus-Smith puzzle remains. The structure of production introduced in section 1.2 is closest to this work: there is monopolistic competition in the market for intermediate goods and firm technology is linear in labor. However, intermediate good firms in my model are homogeneous and they have to make two decisions each period, one for price and one for quality. The following section outlines these differences in detail.

## 1.2 An Economy with Quality Production

As is standard in the literature, I will limit myself to the case of two countries, Home and Foreign, receiving different streams of technological shocks. Whenever necessary, I use an asterisk to differentiate Foreign country variables from Home country variables.

### 1.2.1 Households

Preferences of the representative agent in each country are characterized by a utility function of the form $U(c, 1-n)$, where $c$ and $n$ are consumption and hours worked, respectively. The function is concave in both arguments. Individuals can save in form of capital $k$, or bonds $b$; capital is immobile across countries, while bonds allow international borrowing and lending so that trade need not be balanced every period. Let $x$ denote irreversible investment in capital goods. Let $w_t$, $R_t$, and $r_t$ respectively denote salaries, the rental price of capital, and the price of bonds that pay one unit of the final good the next period. Following Heathcote and Perri (2002), I assume there is a small quadratic cost to holding bonds to make the model stationary. Households seek to solve

$$\max E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, 1-n_t) \tag{1.2.1}$$

subject every period to

$$c_t + x_t + r_t b_t + \frac{\phi_b}{2} b_{t-1}^2 \leq w_t n_t + R_t k_{t-1} + b_{t-1}$$
$$k_t = (1-\delta)k_{t-1} + \psi(x_t/k_{t\text{-}1})k_{t-1}.$$

Following Backus and Crucini (2000), physical capital formation is subject to adjustment costs captured by $\psi$, a function such that $\psi > 0$, $\psi' > 0$, and $\psi'' < 0$. I use $\psi(x/k) = (x/k)^\eta$, $\eta \in (0, 1)$.

### 1.2.2 Final good firm

Production of the final good takes place in a competitive market. Final good technology uses both domestic and imported inputs, both of which are available in a large number of varieties. Final output depends on the quantity as well as the quality of each of the intermediate goods used in production. The final good firm takes prices and qualities of intermediates as given and chooses the amount of each input that it needs for production, and then aggregates them according to

$$Y_t = \left( \alpha \sum_{i=1}^{I_t} (q_{i,t} d_{i,t})^\nu + (1-\alpha) \sum_{i=1}^{I_t^*} (q_{i^*,t} m_{i,t})^\nu \right)^{\frac{1}{\nu}}$$

where $I_t$ stands for the number of domestic and $I_t^*$ for the number of foreign firms/varieties, $d_{i,t}$ is the total quantity produced domestically and consumed domestically, $m_{i^*,t}$ is the total quantity produced abroad and consumed domestically, while $q_i$ and $q_{i^*}$ capture quality at home and abroad, respectively. More broadly, $q$ may be interpreted as a characteristic of the good that makes it more or less desirable. Producers can invest in increasing "desirability" of their goods by raising the quality of their products as well as by spending on advertising that affects how consumers perceive the benefits they derive from consumption of this good. $\nu \in (0, 1)$ determines the elasticity of substitution between varieties, and $\alpha \in (0.5, 1)$ captures home bias in consumption. The problem of the final good firm is thus:

$$\max_{x_{i,t}, m_{i,t}} Y_t - \left( \sum_{i=1}^{I_t} p_{i,t} d_{i,t} + \sum_{i=1}^{I_t^*} \tilde{p}_{i^*,t} m_{i,t} \right),$$

where $\tilde{p}_{i^*,t}$ are foreign export prices. This determines the demand for each variety as

$$d_{i,t} = Y_t \left( \alpha \frac{q_{i,t}^{\nu}}{p_{i,t}} \right)^{\frac{1}{1-\nu}} \tag{1.2.2}$$

$$m_{i,t} = Y_t \left( (1-\alpha) \frac{q_{i^*,t}^{\nu}}{\tilde{p}_{i^*,t}} \right)^{\frac{1}{1-\nu}}. \tag{1.2.3}$$

Demand of each production input increases therefore with domestic absorption, $Y_t$, decreases with the price and increases with the quality of the input. For any reasonable parametrization, in a model without quality if a final good producer takes aggregate final good production as given, demand of intermediates depends exclusively on prices: if prices go up, demand must automatically go down. In this model however, demand of a good also depends on its quality. If quality goes up enough, demand for an intermediate good may increase even after an increase in prices.

### 1.2.3 Intermediate good firms

Intermediate good firms operate in a monopolistically competitive environment, so in terms of market structure this model is closest to Ghironi and Melitz (2005) with three important differences: First, to keep things simple firms in this setting are homogeneous (they all have the same level of productivity and receive the same productivity shock). Second, firms choose not only a price for their products but also an associated quality. More broadly, $q$ may be interpreted as a characteristic of the good other than price that makes it more or less desirable. Producers may invest in increasing "desirability" of their goods by raising the perceived quality of their products. The third difference is that I explicitly introduce capital by requiring that firms rent $F$ units of capital every period to operate.

The only (variable) input of production in this sector is labor. Workers in each firm can be assigned to either production tasks or quality generating tasks. Demand for labor devoted to manufacturing of the good $i$ is labeled $l_{i,y}$, while demand for labor devoted to generating a certain level of good quality is labeled $l_{i,q}$. Quality is purely determined by the amount of labor put into labor activities, so $q_i = l_{i,q}$. The production technology is given by

$$y_i = \frac{z\, l_{i,y}}{q_i^{\rho}} = z\, l_{i,y}\, l_{i,q}^{-\rho}, \quad \rho \in (0,1),$$

where $z$ is a productivity draw the firm receives. The constant $\rho$ captures how $q$ affects production costs: holding $z$ constant, if $\rho > 0$ then higher quality goods require more more production workers per unit of output. Taking factor prices as given, intermediate firms solve the problem given by:

$$\pi_i = \max_{l_{i,y}, l_{i,q}, p_i, \tilde{p}_i} d_i p_i + m_i^* \tilde{p}_i - l_{i,y} w - l_{i,q} w - F\, R,$$

subject to equations (1.2.2), (1.2.3), and the condition that production must be able to meet demand

$$d_i + m_i^* \leq z\, l_{i,y} l_{i,q}^{-\rho}.$$

One can easily show that for any $\nu < 1/(2-\rho)$, this is a concave problem so that the result of this optimization is guaranteed to be a maximum. There are no barriers of entry for new firms in this sector so that the equilibrium number of firms is given by the zero profit condition.

Optimal quality and prices are given by

$$\bar{q}_t = \left[ (1-\rho)\, z_{y,t}^{\frac{\nu}{1-\nu}} W_t \left(\frac{\nu}{w_t}\right)^{\frac{1}{1-\nu}} \right]^{\frac{1-\nu}{1-(2-\rho)\nu}} \tag{1.2.4}$$

$$\bar{p}_t = \bar{\tilde{p}}_t = \frac{1}{\nu}\frac{\bar{q}_t^{\rho}}{z_{y,t}} w_t \tag{1.2.5}$$

where

$$W_t = \left( \alpha^{\frac{1}{1-\nu}} Y_t + (1-\alpha^*)^{\frac{1}{1-\nu}}\, Y_t^* \right).$$

Note that prices are linearly dependent on quality. There is a fixed mark-up over unit cost of $1/\nu$. Note also that the condition $\nu < 1/(2-\rho)$ ensures that the outer exponential in the expression for quality is positive, so we can expect to observe that quality increases with positive technology shocks. Finally, the solution to this problem implies there is a constant relationship between $l_y$ and $l_q$, an observation that will be very useful in calibrating the model:

$$l_q = (1-\rho) l_y. \tag{1.2.6}$$

### 1.2.4 Equilibrium

Let $s_t = (z_{y,t}, z_{y,t}^*)$ denote the state of the economy at time $t$. Equilibrium in this economy consists of a sequence of international interest rates $r_t$ and, for each country, sequences of

- ◇ salaries $w_t$,
- ◇ rental prices $R_t$,
- ◇ number of firms $I_t$,
- ◇ capital stocks $k_t$,
- ◇ household decisions $\{c_t, n_t, x_t, b_t\}$,

◇ final good firm decisions $\{d_t, m_t\}$,

◇ intermediate good firm decisions $\{p_t, \tilde{p}_t, q_t, l_{y,t}, l_{q,t}\}$

such that

◇ given salaries, prices, the interest rate, the number of firms, the current stock of capital and savings, and a transition rule $s_{t+1} = g(s_t)$, the household's decision variables solve the household's problem 1.2.1,

◇ given qualities, intermediate good prices, and the number of intermediate good firms, the final firm's decisions are 1.2.2 and 1.2.3,

◇ given the state of the economy and salaries, qualities and prices are given by 1.2.4, 1.2.5,

◇ good markets clear, i.e. $c_t + x_t = Y_t$ and $d_t + m_t^* = (z_{y,t}/q_t^{\rho})l_{y,t}$,

◇ labor markets clear, i.e. $n_t = I_t(l_{y,t} + l_{q,t})$,

◇ capital markets clear, i.e. $k_{t-1} = I_t F$,

◇ financial markets clear, i.e. $b_t = -b_t^*$,

◇ firms make zero profits, i.e. $\Pi_t = \pi_{i,t} = 0 \quad \forall i$,

◇ no-Ponzi-scheme conditions hold.

## 1.3 Numerical Analysis

### 1.3.1 Measurement and adjustment for quality

Before proceeding to calibrate the model to the data, it is necessary to take a moment to think about the variables in the model and their observability to agencies that compute the statistics to be used in the calibration. Assume that statistical agencies do not adjust for quality so that steady state prices are taken to be the base year prices. In this scenario, real GDP is measured as

$$GDP_t = I_t\, p_{ss}\,(d_t + m_t^*),$$

while observed domestic absorption is given by

$$\hat{Y}_t = GDP_t - (I_t\, p_{ss} m_t^* - I_t^*\, p_{ss}^* m_t).$$

$Y_t$ is allocated to consumption and investment. I assume the share of $\hat{Y}_t$ that is consumed is the same as the share of $Y_t$ that is consumed, hence observed consumption is:

$$\hat{c}_t \equiv \frac{c_t}{c_t + x_t}\hat{Y}_t = \frac{\hat{Y}_t}{Y_t} c_t.$$

Similarly, observed investment is $\hat{x}_t \equiv \frac{\hat{Y}_t}{Y_t} x_t$. Terms of trade are defined as the ratio of import price deflators to export price deflators. Since in equilibrium all goods from the same country have the same price, the terms of trade can be defined simply as

$$tot_t \equiv \frac{I_t^* p_t^* m_t / I_t^* p_{ss}^* m_t}{I_t\, p_t m_t^* / I_t\, p_{ss} m_t^*} = \frac{p_t^*}{p_t}\frac{p_{ss}}{p_{ss}^*}.$$

Calculating the consumption real exchange rate requires construction of a consumption price index for each country. Let $M_t$ be the period $t$ share of imported goods in consumption, then

$$P_t \equiv (1 - M_t)\,\frac{p_t}{p_{ss}} + M_t\,\frac{p_t^*}{p_{ss}^*}.$$

Finally, I define the real exchange rate as the ratio of these price indexes:

$$rer_t \equiv \frac{P_t^*}{P_t}.$$

Now suppose that the statistical agency observes quality and so it can adjust prices to reflect changes in this dimension of each good. I assume that the statistical agency makes the following correction:

$$\check{p}_t = \left(\frac{q_t}{q_{ss}}\right)^{\rho} p_{ss}. \tag{1.3.1}$$

This is the ideal correction given the expression for optimal prices (1.2.5); it guarantees that in the steady-state both adjusted and non-adjusted variables are the same. The agency then replaces $p_{ss}$ by $\check{p}_t$ in all the expressions above.

### 1.3.2 Calibration

For the benchmark calibration of the model I will use the standard utility function $U(c, 1-n) = [c^{\mu}(1-n)^{1-\mu}]^{\theta}/\theta$. The model is calibrated to match features of the US economy over the 1971-1998 period as follows: I set the value of the discount factor $\beta$ to 0.99 to match an annualized interest rate of about 4%, the capital depreciation rate $\delta$ is set to 0.025 to match an annualized depreciation rate of 10%. Following the literature the coefficient of risk aversion $\theta$ is set to -1. Following Mandelman et al. (2011) I assume a cost of holding bonds ($\phi_b$) equal to one basis point. I set $\alpha$ to obtain an import share of 15% and $\mu$ to obtain a share of hours worked equal to 0.34. The capital adjustment cost parameter $\eta$ is set so that the standard deviation of investment is about three times that of output. The value of the trade elasticity $\nu$ is set to 0.73 so that investment is close to 23% of GDP. The reason this parameter strongly affects the level of investment is that under monopolistic competition with free entry, a low degree of substitutability between intermediate goods implies a high mark-up over marginal costs, which creates incentives for many firms to enter the market. Since capital is a fixed cost that is independent of the firm, the level of investment will crucially depend on the number of firms that enter the market each period. The value used is the same value used by Ghironi and Melitz, who justify their choice based on firm level evidence documented by Bernard et al.. The parameter $F$ is set so that the correlation between output and investment is close to 0.94.

The parameters calibrated so far are pretty common to most of the papers in the literature, and their values do not significantly differ from those in other studies either. This is not the case of $\rho$, which captures how changes in quality affect the costs of production. Equation (1.2.6) showed that this parameter determines the fixed relationship between the number of workers in production tasks and the number of workers in quality tasks. To calibrate this parameter I first determine a plausible range. BLS data[5] for 2008 reveals that about 51% of the workforce in manufacturing industries are production workers, while about 40% are in tasks related to management, finance, sales, administration, construction, repair, and transportation. It seems that a plausible range for workers in quality tasks would be between 1% and 5%. Put differently, for every worker assigned to quality tasks there would be between 10 and 50 workers assigned to production tasks. I take 25 as my baseline value ($\rho = 0.96$) and perform a sensitivity analysis for other values in this range. The main implications of the model are not affected by moving $\rho$ within these limits: lower values of $\rho$ imply that quality enhancements are cheaper, therefore the firm responds by making quality even more strongly pro-cyclical. If on the other hand one takes $\rho$ arbitrarily close to its maximum possible value of 1, this is still not enough to affect the sign of the correlations of interest.

### Productivity process

The shock process has the usual form,

$$s_t = As_{t-1} + \epsilon_t,$$

[5] http://www.bls.gov/emp/ep_table_108.htm

where $\epsilon_t$ is a vector of normally distributed shocks, independent from past values. The cross-country correlation of shocks is set to match the cross-country correlation of output, while the variance of shocks is set so that the standard deviation of output is 0.017. Finally, the values in the transition matrix of technology shocks ($A$) are set to closely match the cross-country correlations of consumption and hours worked obtained from OECD data for the United States and a rest-of-the-world aggregate. This is in contrast to studies like Backus et al. (1992) or Heathcote and Perri (2002), who estimate the productivity process from observable aggregate productivity measures such as Solow residuals. However, such productivity measures would themselves be problematic if my story of quality were quantitatively important. Since there are no time series for quality available, calibrating the shock process seems like a natural alternative to estimation. Compared to the values estimated in the papers mentioned above, the model requires a productivity process that has about 50% higher variance than the standard shock process, a cross-country correlation that is about twice as high, and somewhat less persistence. It should be noted, however, that if instead of the calibrated process one uses one of the specifications from the literature, the main results from the paper are not affected. The complete parametrization of the model is given in table 1.3.

### 1.3.3 Simulation

Simulation results are presented in table 1.4. These are averages over 50 simulations of 200 periods after discarding the first 100 periods. Let's first evaluate the fit of the model with no adjustments for quality to the data for the 1971-1998 period. The model suffers from a common ailment of international RBC models: consumption and net exports are excessively smooth. Net exports and the terms of trade in my model also suffer from excessive smoothness, partly as a result of excessive risk sharing, which may

Table 1.3: Benchmark parameter values.

| *Household parameters* | *Value* | *Target description* | *Target* |
|---|---|---|---|
| $\theta$ | $-1$ | From the literature | - |
| $\beta$ | 0.99 | $r_{ss}$ | 1% (4% ann.) |
| $\mu$ | 0.37 | $n_{ss}$ | 0.34 |
| $\delta$ | 0.025 | $x_{ss}/k_{ss}$ | 2.5% |
| $\eta$ | 0.96 | $sd(\hat{x})/sd(GDP)$ | 2.9 |
| $\phi_b$ | 0.01 | Bond holding costs | 1% |
| *Firm parameters* | | | |
| $\nu$ | 0.73 | $\hat{x}_{ss}/GDP_{ss}$ | 23% |
| $\alpha$ | 0.65 | $\hat{m}_{ss}/GDP_{ss}$ | 15% |
| $\rho$ | 0.96 | $l_q/l_y$ | 4% |
| $F$ | 0.2 | $corr(GDP, \hat{x})$ | 0.94 |
| *Shock process* | | | |
| $V_\epsilon$ | $10^{-5}\begin{bmatrix} 64 & 29 \\ 29 & 64 \end{bmatrix}$ | $sd(GDP)$<br>$corr(GDP, GDP^*)$ | 0.017<br>0.58 |
| $A$ | $\begin{bmatrix} 0.89 & 0.09 \\ 0.09 & 0.89 \end{bmatrix}$ | $corr(n, n^*)$<br>$corr(\hat{c}, \hat{c}^*)$ | 0.42<br>0.36 |

Calibrated to 1971-1998 US data.

be a cause of concern. Raffo (2008) suggests that excessive smoothness can be alleviated by introducing GHH preferences, a possibility that I explore later in the paper. The model matches domestic correlations remarkably well: output, consumption, and investment are strongly positively correlated with each other, while net exports are strongly countercyclical. The cross-country correlation of investment is a little too strong in the model compared to the data. The model is capable of generating countercyclical terms of trade that are very similar in magnitude to what we observe in the data. The Backus-Smith puzzle goes away, both the sign and magnitude of the correlation between relative consumption and the real exchange rate are in line with the data. The model does appear to successfully address both of the "old" puzzles.

The column labeled *adjusted* contains the results from an adjustment to price level calculations for changes in quality in the way described in equation (1.3.1). What changes does the model predict will result from this shift in the way we measure prices? Consider first the two correlations that are the main objective of this paper. The correlation between the terms of trade and GDP increases from $-0.28$ to $+0.42$, a remarkable change, almost as remarkable as the $+0.54$ increase observed in the data. The correlation between relative consumption and the real exchange rate increases by even more, from $-0.75$ to $+0.94$. The direction of the change is in line with the data, but the magnitude of the change is much too strong. I believe that the discrepancies in the magnitudes of these changes might be explained by a composition effect. Adjustments for quality are not performed for all categories of goods in the CPI. Some of the categories of goods that are affected by these adjustments are vehicles, computers, other consumer electronics, apparel, and appliances. These categories of goods represent a large fraction of international trade, but are not as important to the consumption basket of the average consumer. Therefore quality adjustments to these categories will affect import and export deflators much more than they affect the CPI, so we should expect to see a stronger effect to the terms of trade than to the real exchange rate, but the model currently does not take into account this composition effect.

There are large discrepancies in some other aspects of the changes in the data and in the model. The model suggests we should observe an increase in the volatility of macroeconomic aggregates, a reversal in the correlation between net exports and output, and an international de-coupling in the form of weaker cross-country correlations. In fact the opposite has been observed. If we understand these phenomena as caused by factors that are

Table 1.4: Simulation results.

| | *Data*[b] | | *Model* | |
|---|---|---|---|---|
| *Standard deviations*[a] | 71-98 | 99-09 | Non-adjusted | Adjusted |
| Output | 1.00 | 0.94 | 1.00 | 1.35 |
| Hours | 1.22 | 1.30 | 0.45 | 0.43 |
| Consumption | 0.84 | 0.67 | 0.54 | 0.78 |
| Investment | 2.81 | 2.72 | 2.92 | 3.30 |
| Net exports | 0.34 | 0.39 | 0.06 | 0.09 |
| Terms of trade | 1.78 | 1.17 | 0.25 | 0.32 |
| *Corr. with domestic output* | | | | |
| Hours | 0.86 | 0.93 | 0.91 | 0.99 |
| Consumption | 0.93 | 0.96 | 0.88 | 0.99 |
| Investment | 0.94 | 0.95 | 0.96 | 0.98 |
| Net exports | −0.41 | −0.68 | −0.40 | 0.22 |
| **Terms of trade** | −0.26 | 0.54 | −0.27 | 0.42 |
| *Cross-country correlations* | | | | |
| Output | 0.58 | 0.85 | 0.59 | 0.48 |
| Hours | 0.42 | 0.45 | 0.34 | 0.34 |
| Consumption | 0.36 | 0.87 | 0.31 | 0.26 |
| Investment | 0.30 | 0.78 | 0.68 | 0.69 |
| **Rel. consumption-RER** | −0.71 | −0.06 | −0.75 | 0.94 |

[a] Relative to the standard deviation of output for the period 1971-1998.
[b] Source: OECD and FRED.

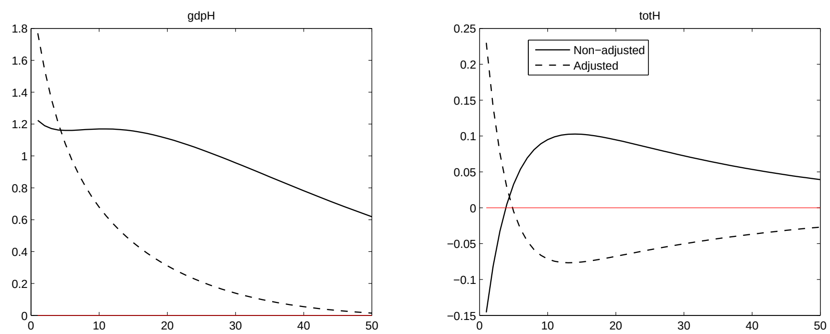


Figure 1.3.1: Impulse responses of output and terms of trade.

external to the model, we can exogenously introduce a "Great Moderation" in the form of lower volatility of the exogenous shocks as well as an increase in globalization in the form of higher interdependence of exogenous shocks as well as a reduction of the home bias parameter. If in this way we match the volatility and cross-country correlation of output as well as the share of imports in GDP for the 1999-2009 period, the sign change in the correlations of interest are robust to these changes, and their magnitudes are not greatly affected.

To appreciate the mechanism driving my results, I plot impulse response functions for a number of variables. As the country receives a positive technology shock, quality goes up. This leads to an increase in the price of goods and a decline of quality-adjusted prices, hence terms of trade (in the right panel) move in opposite directions depending on whether we apply quality adjustments or not. Output (in the left) increases in both cases, though its response is stronger when prices are adjusted for quality. Taken together this illustrates the negative correlation between output and net exports that is observed in the data before the 1990s and the reversal of this correlation once quality adjustments are introduced to price level calculations.

The top left panel in figure 1.3.2 shows the effects of a shock on the ag-

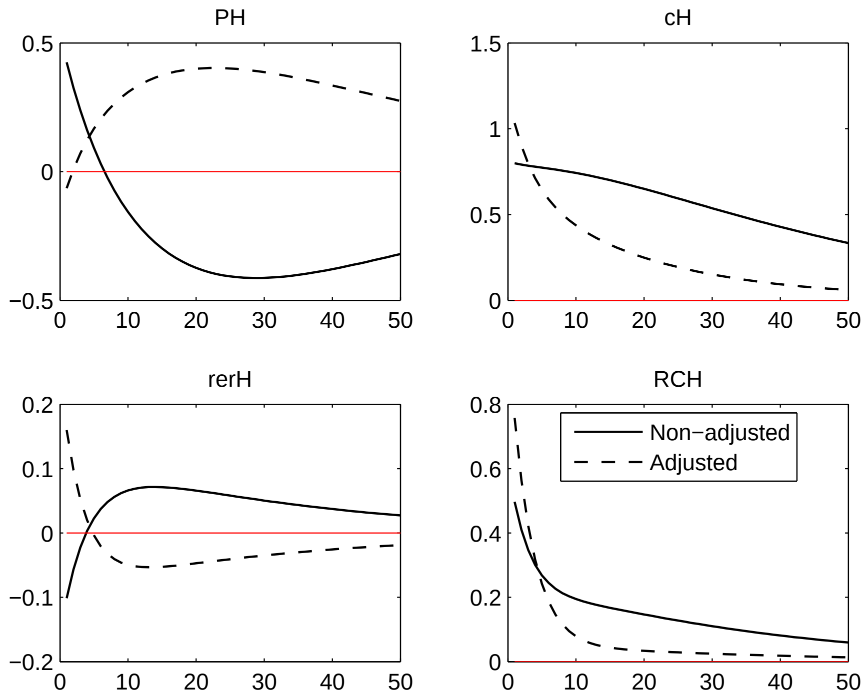


Figure 1.3.2: Impulse responses of relative consumption and the real exchange rate.

gregate price level. Since domestic good prices increase relative to foreign good prices and consumers are biased towards domestic goods, the price level increases as well. The opposite happens of course when prices are adjusted for changes in quality. Therefore, the real exchange rate (bottom-left panel) declines in the first case, but it increases in the second. Consumption (top-right panel) increases in both cases, though the response is slightly larger when quality adjustments take place. Similarly, relative consumption (bottom-right) increases in both cases. Taken together this illustrates the negative correlation between relative consumption and the real exchange rate that is observed in the data before the 1990s and the reversal of this correlation after the introduction of quality adjustments.

### 1.3.4 GHH preferences

Raffo (2008, 2010)shows that many of the inconsistencies between the theory and the data stem from the low volatility of consumption implied by the standard model. He argues that the introduction of an alternative specification of household preferences increases consumption volatility, eliminating some of the model's inconsistencies with the data. I briefly explore this possibility within the framework presented above. GHH preferences, introduced by Greenwood et al. (1988), have the property that the marginal rate of substitution between consumption and leisure is independent of the consumption level within the period. This implies that there is no income effect on labor supply and therefore hours worked respond more strongly to productivity changes, which in turn generates volatility of consumption more in line with the data. GHH preferences are characterized by the utility function

$$U(c, 1-n) = \frac{[c_t - \lambda {n_t}^{\mu}]^{\theta}}{\theta}.$$

For this exercise I set $\mu = 3$ to match a Frisch elasticity of 0.5, consistent with macroeconomic estimates (see Raffo (2008) for a discussion), and $\lambda = 4.7$ to match a share of hours worked of about a third. I leave all other parameters unchanged with respect to the benchmark model. In contrast to Raffo's results, GHH preferences in my model do not generate consumption volatility that is closer to what is observed in the data. This is also the case for net exports and terms of trade.

## 1.4 Conclusions

Over the course of a few years, many of the goods we consume have experienced dramatic changes in quality. Most of these have been innovations that occurred slowly but steadily. This is a fact that to the best of my knowledge has been largely ignored by the international real business cycle literature, and is in my view an important reason for the discrepancies that exist between theoretical model predictions and actual data estimates. Interestingly, these discrepancies have dwindled in recent years. How can we arrive at a theory that explains both the reasons for these puzzles as well as their gradual vanishment?

I have argued in this paper that in order to achieve both of these objectives one needs two elements: 1) a modification of the standard model of international RBCs that takes changes in good quality into account, and 2) a change in price measurement techniques that reflects improvements in quality adjustment practices of statistical agencies. The results presented in this study show that taking changes in quality into account has the potential to explain many of the puzzles related to the co-movement of international prices and quantities. The model introduces a mechanism capable of endogenously arriving at this result, without the need of introducing new shocks, thus preserving most of the simplicity of the original model and avoiding many of the pitfalls typically brought about by the introduction of exogenous disturbances. Furthermore, it shows that taking into account recent changes in the methodology of price level calculations has the potential to explain the diminishing importance of the puzzles.

It could be argued that prices in previous models could simply be understood as being "quality adjusted," and therefore price drops following productivity gains already reflected changes in good quality. The advantage of the framework in this paper is that by explicitly modeling both pricing and quality decisions it is possible to answer the question of whether quality improvements are quantitatively important enough to explain the aforementioned puzzles. The framework I introduce here acknowledges furthermore that price drops and quality enhancements are not necessarily two sides of the same coin. In many cases the decision to improve quality comes at the expense of higher production costs, such as hiring better designers or engineers. Profit maximizing firms often face this tradeoff, and a purely symmetrical model in which price drops and quality improvements are interchangeable completely ignores this.

While the idea that investments in quality are important to business cycle properties is highly intuitive, it would be desirable to find additional support in the data for this mechanism. Paradoxically, it is precisely the lack of good data on quality that creates the biases in price indices that give relevance to this idea in the first place. This difficulty is probably easier to overcome in certain industries than in others. Finding industry-level data to test the cyclical properties of quality suggested in this paper would be an important complement to the model and an avenue for research to be pursued in the future.

This model also has interesting implications for the econometric estimation of shocks. Given that changes in quality resemble demand shocks, an econometrician working with data generated by a model like the one presented in this paper could potentially mistake changes in quality driven by technological shocks with demand shocks that are independent of technology shocks. A closer evaluation of this possibility is another interesting potential extension of this model.

## Appendix - About the Data

Data in tables 1.1 and 1.4 are taken from the OECD's Quarterly National Accounts database. I obtain series for the countries listed in table 1.1 in current prices (CPCARSA) as well as volume estimates (VPVOBARSA) in US dollars at PPP adjusted prices, and use the OECD's reference year. The series are total private consumption, investment in gross fixed capital formation, exports of goods and services, and imports of goods and services. I define GDP to match the definition of the model, that is the sum of consumption, investment, and the trade balance. Net exports are defined as exports minus imports as a share of GDP. Price deflators are calculated as the ratio of imports (exports) in current prices and their corresponding value in real terms. Terms of trade are defined as the ratio of the price deflator for imports and the price deflator for exports. To construct the real exchange rate I obtain nominal exchange rates and consumer price indices from the Federal Reserve Bank of St. Louis. Hours worked series are constructed from the OECD-MEI civilian employment index. "Rest of the world" aggregates are constructed using data from all countries in table 1.1 other than the US. Real exchange rates between the US and this fictional country are computed using trade-weighted averages, and hours worked are population-weighted averages. Weights correspond to 1995-2005 averages. Finally, to compute standard deviations and correlations I take logarithms of each of the series (except for net exports, which can be negative) and apply a Hodrick-Prescott filter to detrend them.

# Chapter 2

# Trade Finance and Trade Dynamics

## (jointly with Marta Arespa)

**Abstract**

According to recent evidence around 90% of international trade relies on some form of credit. However, current literature is not conclusive on the effects of trade finance on trade and the economy. We propose a suitable framework to explore linkages between trade and finance based on an international RBC model, where firms require external finance to import and can be financially constrained. We find credit shocks do not affect the dynamic properties of the economy, but do have the potential to cause significant deviations in trade and economic performance. The trade-to-GDP ratio falls following a negative credit shock, as the capability of firms to purchase foreign intermediate goods is affected, causing losses in efficiency and production. However, it forces a demand substitution towards domestic intermediate goods that limits GDP deterioration. We find that financially developed countries trade more, are richer and more stable in terms of GDP and consumption, as in the data. Finally, the model sheds light on some persistent contradictions between theoretical business-cycle volatilities and their empirical counterparts.

## 2.1 Introduction

We refer to *trade finance* as either a) one of the mechanisms provided by financial institutions and governments to facilitate international trade activities, or b) an agreement whereby a customer can purchase goods on account, paying the supplier at a later date. When trade occurs across borders, sometimes sellers require either cash-in-advance payments or formal guarantees to cover themselves from the possibility of default or insolvency of their buyers. Importers are usually forced to turn to loans or letters of credit to satisfy exporter requirements before having their orders shipped. Most of these contracts are provided by financial institutions and require some form of collateral. Other times, when the goods are delivered, a trade credit is given for a specific number of days—30, 60 or 90—and it is recorded in the accounts receivable section of the firm's balance sheet.

Trade finance is an extremely important piece of the international trade mechanism; estimates find that around 90% of international trade relies on some form of credit (Auboin, 2009b). Yet relative to its importance in the actual workings of trade, very little attention had been devoted until recently to the study of the connection between trade finance and international trade performance in either the theoretical or empirical literature. The "great trade collapse", the dramatic fall in the trade-to-GDP ratio during the current financial crisis, has changed that to some extent. A large number of studies has since been devoted to clarifying the reasons why trade fell much more rapidly than GDP during this episode, a literature that we review later in this paper. In spite of the these efforts, there is still little consensus on the effects of trade finance on macroeconomic variables and, specifically, on international trade performance.

We would like to make a theoretical contribution to this debate within the framework of an international RBC model. We propose a dynamic, quantitative, micro-founded macroeconomic model that departs very little from the standard model of international RBCs proposed by Backus et al.

(1992) (BKK). Our main departure is an additional requirement for importers, who must borrow proportionally to the value of the goods they wish to import. This departure enables us to shed some light on the role of credit in international trade performance.

Our model provides some improvements over standard international RBC models. Indeed, imports are more volatile than GDP, our quantitative analysis does not suffer from the consumption/output anomaly (i.e., GDP cross-country correlation is larger than consumption cross-country correlation, as in the data), and the volatilities of consumption, imports, and terms of trade relative to GDP are close to those in recent US data. The latter is a property that, as far as we know, required the introduction of non-standard preferences into the model of international RBCs (Raffo, 2008). As we will see, these improvements are the result of introducing some modifications to accommodate the financial constraint within the framework of the standard BKK model, and they remain even if we fully relax the financial requirements to importers.

In this artificial economy we can test the macroeconomic effects of alterations in the availability of finance to importers. We find that even though trade finance does not appear to have a large effect on the behavior of macroeconomic aggregates over the business cycle, long term variations in trade finance do have the potential to cause significant deviations in trade and economic performance. A negative credit shock reduces the ability of a producer to use foreign inputs, thereby reducing efficiency, which negatively affects aggregate production. However it also stimulates demand for domestic goods, making them more expensive and harder to come by in foreign markets and reducing exports as well. The net effect on the trade balance is positive, which together with higher demand for domestic goods from constrained importers alleviates the fall in GDP. Hence trade falls faster than GDP in our model following a credit shock. However, unless the variance of credit shocks is much larger than that of productivity shocks, these effects appear to be small in comparison to the effects of productivity shocks, which remain the main drivers of business cycles in our model. Nonetheless, we also find that more financially developed countries trade more, have higher levels and lower volatility in GDP and consumption, consistent with the empirical evidence in this area.

A number of other papers (for instance Chaney (2005); Manova (2008b); Manova et al. (2009)) have focused on the internal and external finance of fixed costs but they have largely ignored the important role of export insurance via trade finance. One important exception is Ahn (2011), who provides a theory model of trade finance to explain the great trade collapse. His main conclusions are two: First, international trade takes place in a more risky environment compared to domestic trade and, as a consequence, it is subject to more demanding financial conditions, a result also sustained in Ellingsen and Vlachos (2009). Second, higher risk makes international trade finance more economically-sensitive and it becomes much more procyclical than domestic trade finance. Our paper cannot address these issues as we simplify and assume that finance is required only for international transactions.

A recent paper on international RBCs that considers the financial sector is Kalemli-Ozcan et al. (2012). They explore the implications of financial integration for international business-cycle synchronization. Their empirical analysis concludes that financial integration enhances cross-border co-movement during financial turmoils whereas it reduces synchronization during relatively stable periods, demonstrating the importance of the financial channel as a mechanism of contagion. On the theoretical part, they construct a one-good dynamic stochastic general equilibrium model with a two-sector banking system (one for global banks and one for local banks). Their firms need external resources to finance working capital and this dependence is determinant to produce GDP cross-correlations consistent with their empirical results. However, they do not account for the financial needs for trade activities and disregard international trade patterns in the analysis.

In the following section we present the model setup and define an equilibrium of the theoretical economy. Section 3 presents a number of international real-business cycle statistics that we hope to capture with our model. We then use these numbers to calibrate the model and then test its numerical properties. Section 4 presents our main results. First, we present an overview of empirical findings from the literature on the effects of trade finance on trade performance. We then ask what can we learn from our model to help us understand this relationship. We explore the effects of temporary variations in trade finance as well as to permanent changes in financial development and how they affect the dynamic properties of international trade in the short and in the long run. Section 5 concludes.

## 2.2 The model economy

Let there be two countries, we denote foreign country variables by an asterisk. Countries will be identical except for the stream of productivity shocks they receive. A country consists of four types of agents:

1. Infinitely lived **households** taking decisions every period about their optimal levels of consumption, leisure, investment, and savings. Households are the only agents in this economy taking inter-temporal decisions, and so are the ultimate holders of savings and debt in the model.

2. **Final-good firms** put together a basket of domestically produced intermediate goods; their output is a final good that can be used for consumption or the accumulation of capital by households. Final goods are sold domestically in perfectly competitive markets.

3. **Intermediate good firms**, on the other hand, operate in a monopolistically competitive setting. They use a fixed amount of labor each period to combine domestic and foreign inputs and manufacture their goods. The amount of foreign inputs they use in production is limited by how much they can borrow to finance their imports. How much they produce depends also on their productivity level, which is affected by a random productivity shock.

4. Production inputs are bought from domestic and foreign **input producers**, who combine capital and labor in their production process. They can sell their products in domestic markets or export to foreign intermediate good producers.

Financial intermediaries are not explicitly modeled in this paper[1]. We assume competitive financial intermediaries channel household savings to intermediate good producers, who require financial support to access to imported input goods. They do so in such a way that default is never an optimal choice for borrowers. Household savings are pooled across countries, so it is possible for a household to lend to a foreign intermediate good producer. This allows for unbalanced trade in the model. Negative household savings imply that firms are borrowing more than they could obtain in domestic savings markets.

Though there are important differences between formal borrowing from financial institutions and trade credit (as pointed out in the introduction), we will not treat them separately in the model. In both cases trade finance allows for a variation of risk-sharing configurations between importer

[1]For a model that explicitly models trade finance see Ahn (2011). In his model, banks have access to asymmetric information on their customers and can incur in costs to improve this information. However, information is of less quality when the customer performs international transactions. Since importers or exporters depend on foreign firms' success and reliability to pay back their loans, poorer information quality makes them riskier for banks. We bypass this by assuming credit is required only for trade with foreigners.

and exporter. However, most of the reviewed literature agrees on the substitutability between both types of financing (Fisman and Love, 2003; Iacovone and Zavacka, 2009). It seems that this substitutability is specially important when financial disruptions appear (Wilner, 2000), as importers move from formal loans to accounts payable, offered by their foreign suppliers, when banks tighten credit availability. Or the other way around: importers turn to banks when their suppliers are reluctant to risk with accounts receivable from their foreign customers. Some authors also suggest both forms of credit are complementary (Love et al., 2007) in that large and well-reputed firms have easier access to credit issued by financial institutions and play the role of trade finance creditors to their customers, allocating banking credit they obtained via accounts receivable. In view of the aforementioned surveys outcome, we focus on the substitutability between them and we do not disentangle banking sector finance from inter-firm finance.

We now proceed to outline in detail the optimizing behavior of each agent in the model as well as the resulting equilibrium.

### 2.2.1 Households

Each country has a mass 1 of identical households, who enjoy consumption and leisure every period. Their utility at each period is given by a strictly concave function $u(c_t, 1-n_t)$, where $c_t$ is consumption and $n_t$ the fraction of the time household members spend at work. Furthermore, households must choose how much they invest in new capital ($i_t$) and how much they lend to importers ($s_t$). There is a small cost of holding savings in the form of credit to importers equal to $\frac{\phi}{2}s_{t-1}^2$. Household earnings come from the salaries they perceive for the amount of time they spend at work ($w_t$), from the share of profits they receive from intermediate good firms ($\pi_t$), the interest they are paid on their savings ($r_t$), and the rents that accrue to them from input producers who rent the capital they own ($R_t$). Putting it all together we obtain the household's budget constraint for each period:

$$c_t + i_t + s_t + \frac{\phi}{2}s_{t-1}^2 \leq w_t n_t + \pi_t + s_{t-1}(1+r_t) + K_{t-1}R_t, \qquad \forall t. \quad (2.2.1)$$

Physical capital is subject to depreciation at rate $\delta$ every period. Following Backus and Crucini (2000), physical capital formation is subject to adjustment costs, which are capture by a function $\Psi(\cdot)$, which satisfies $\Psi > 0$, $\Psi' > 0$, and $\Psi'' < 0$. Capital evolves according to

$$K_t = (1-\delta)K_{t-1} + \Psi(i_t/K_{t\text{-}1})K_{t-1}, \qquad (2.2.2)$$

We use $\Psi(i/k) = (i/k)^{\psi}$, $\psi \in (0,1)$, so investment is described by the change in capital stocks as follows:

$$i_t = \left(\frac{K_t}{K_{t-1}} - (1-\delta)\right)^{\frac{1}{\psi}} K_{t\text{-}1}.$$

If households discount utility from future periods at rate $\beta$, optimizing behavior is described by the following problem:

$$\max_{\{c_t,n_t,i_t,s_t,K_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t u(c_t, 1-n_t), \qquad (2.2.3)$$

subject to conditions (2.2.1) and (2.2.2). We can re-write this problem as:

$$\max_{\{n_t,s_t,K_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t u\left(w_t n_t + \Pi_t + K_{t-1}R_t + s_{t-1}(1+r_t) - i_t - s_t - \frac{\phi}{2}s_{t-1}^2,\ 1-n_t\right)$$

and obtain the following first order conditions:

$$w_t u_{c,t} = -u_{n,t}$$
$$u_{c,t} = \beta(1 + r_{t+1} - \phi s_t)u_{c,t+1}$$
$$\frac{1}{\psi}\left(\frac{i}{K_{t-1}}\right)^{1-\psi} u_{c,t} = \beta\left(R_{t+1} - \frac{i_{t+1}}{K_t} + \frac{1}{\psi}\left(\frac{i_{t+1}}{K_t}\right)^{1-\psi}\frac{K_{t+1}}{K_t}\right)u_{c,t+1}.$$

Letting $u(c, 1-n) = [c^{\mu}(1-n)^{1-\mu}]^{\theta}/\theta$, the marginal utilities of consumption and labor are given by

$$u_{c,t} \;=\; \mu c^{\theta\mu-1}(1-n)^{\theta(1-\mu)}$$
$$u_{n,t} \;=\; -(1-\mu)c^{\theta\mu}(1-n)^{\theta(1-\mu)-1}.$$

### 2.2.2 Final-good firms

Final good firms are homogeneous and they participate in a competitive market, so they act as price takers and make zero profit. They put together a basket of intermediate goods to create a final good. Their production function is

$$Y_t = \left( \int_0^1 d_{j,t}^{\sigma} dj \right)^{1 \backslash \sigma}, \tag{2.2.4}$$

where $d_{j,t}$ denotes their demand of intermediate good $j$. Profits are given by $\Pi_t = Y_t - \int_0^1 d_{j,t} p_{j,t} dj$. Maximizing profits gives their optimal demand of each variety of intermediate goods, which is

$$d_{j,t} = Y_t p_{j,t}^{\frac{1}{\sigma - 1}}. \tag{2.2.5}$$

### 2.2.3 Intermediate-good firms (importers)

Each country has a mass 1 of firms producing differentiated, non-tradable goods. These firms operate in a monopolistic competition setting; we want importers to have some benefits they can use as collateral to obtain credit. Productivity is given by a random shock $z_t$ common to all firms, and production takes place according to the function:

$$F_{j,t} = z_t h_{j,t}^{\alpha} x_{j,t}^{1-\alpha}, \ \alpha \in (0,1),$$

where $h_{j,t}$ represents the demand of domestic inputs and $x_{j,t}$ the demand of imported inputs of firm $j$. Firms pay a fixed cost $Q$ units of labor to operate every period. Profits for the intermediate good producer are given by

$$\pi_{j,t} = p_{j,t} d_{j,t} - P_t h_{j,t} - (1 + r_t) P_t^* x_{j,t} - Q w_t, \tag{2.2.6}$$

where input prices are denoted by $P_t$ and $P_t^*$, while the intermediate good's market price is $p_{j,t}$. Note that the firm must borrow in order to buy any imported inputs and therefore also pays an interest $r_t$ over their total cost.

Since imports are bought on credit they are subject to a trade credit constraint. We think of the degree $\tilde{\eta}$ to which contracts can be enforced as summarizing the average quality of enforcement in a given economy. The financial intermediary behaves competitively. A credit constraint states that it must be individually rational for the managers to repay their loan. When they abide by the contract, managers receive their net income. When they default, they economize on the payment they owe the intermediary but lose fraction $\tilde{\eta}$ of the resulting resources. i.e.

$$\begin{aligned} \pi_{j,t} &\geq (1-\tilde{\eta})\left[\pi_{j,t} + (1+r_t)P_t^* x_{j,t}\right] \\ \frac{\tilde{\eta}}{1-\tilde{\eta}}\pi_{j,t} &\geq (1+r_t)P_t^* x_{j,t} \\ \eta\left(p_{j,t}d_{j,t} - P_t h_{j,t} - Qw_t\right) &\geq (1+\eta)(1+r_t)P_t^* x_{j,t} \qquad (2.2.7) \end{aligned}$$

where $\eta = \frac{\tilde{\eta}}{1-\tilde{\eta}}$. Suppose the firm has already chosen a price $p_{j,t}$ inducing demand $d_{j,t}$. Taking them as given, the combination of domestic and foreign inputs that minimize the cost of satisfying this demand is given by

$$\min_{h_{j,t},x_{j,t}} P_t h_{j,t} + (1+r_t)P_t^* x_{j,t} \qquad (2.2.8)$$

$$\text{s.t.}$$

$$z_t h_{j,t}^{\alpha} x_{j,t}^{1-\alpha} = d_{j,t}$$

$$\eta\left(p_{j,t}d_{j,t} - P_t h_{j,t} - Qw_t\right) \geq (1+\eta)(1+r_t)P_t^* x_{j,t}$$

Kuhn-Tucker conditions (KTCs) with Lagrangian multipliers $\zeta_t$ and $\xi_t$ are:

$$\begin{aligned} (1-\xi_{j,t}\eta)P_t h_{j,t} &= \alpha\zeta_{j,t}d_{j,t} \\ (1-\xi_{j,t}(1+\eta))(1+r_t)P_t^* x_{j,t} &= (1-\alpha)\zeta_{j,t}d_{j,t} \\ \xi_{j,t}\left[\eta\left(p_{j,t}d_{j,t} - P_t h_{j,t} - Qw_t\right) - (1+\eta)(1+r_t)P_t^* x_{j,t}\right] &= 0. \end{aligned}$$

The first two KTCs together imply $h_{j,t} = \lambda_{j,t}x_{j,t}$, where

$$\lambda_{j,t} \equiv \frac{\alpha}{1-\alpha}\left(\frac{1-\xi_{j,t}\eta-\xi_{j,t}}{1-\xi_{j,t}\eta}\right)\frac{(1+r_t)P_t^*}{P_t}.$$

By the first constraint then:

$$x_{j,t} \quad = \quad \frac{d_{j,t}}{z_t \lambda_{j,t}^{\alpha}}. \tag{2.2.9}$$

We assume intermediate good firms know demand functions (2.2.5) and (2.2.9) and set their prices accordingly by solving the following profit maximization problem:

$$\max_{p_{j,t}} \quad \left( p_{j,t} - \frac{P_t}{z_t \lambda_{j,t}^{\alpha-1}} - (1+r_t) \frac{P_t^*}{z_t \lambda_{j,t}^{\alpha}} \right) Y_t p_{j,t}^{\frac{1}{\sigma-1}} - Q w_t. \tag{2.2.10}$$

The solution to this problem is given by

$$p_{j,t} = \frac{1}{\sigma z_t \lambda_{j,t}^{\alpha}} \left( \lambda_{j,t} P_t + (1+r_t) P_t^* \right). \tag{2.2.11}$$

### 2.2.4 Input producers (exporters)

Each country has a mass 1 of identical input good firms with technologies operating in a perfectly competitive environment. Their technology uses capital ($k_t$) and labor ($l_t$) to generate output $f_t$:

$$f_t = k_t^{\gamma} l_t^{1-\gamma},\ \gamma \in (0,1),$$

An input producer seeks to solve the following optimization problem when supplying to domestic and foreign intermediate good firms:

$$\max_{k,l} \ P_t\, f_t - w_t l_t - R_t k_t \tag{2.2.12}$$

The usual FOCs are:

$$P_t\, f_{k,t} = \gamma P_t (k_t/l_t)^{\gamma-1} = R_t$$
$$P_t\, f_{l,t} = (1-\gamma) P_t (k_t/l_t)^{\gamma} = w_t,$$

which together imply an optimal capital-labor ratio equal to:

$$\frac{k_t}{l_t} = \frac{\gamma}{1-\gamma} \frac{w_t}{R_t}.$$

### 2.2.5 Equilibrium

This economy is said to be in equilibrium if every period, given a state of the economy $(z, z^*)$ and prices $P$, $R$, $r$, and $w$

- functions $c(\cdot)$, $i(\cdot)$, and $s(\cdot)$ solve the household's problem (2.2.3),
- given prices $p_j$, demand functions $d_j$ solve final good firm problem (2.2.6) and their profits are equal to zero,
- $h_j$, $x_j$ and $p_j$ are the same for all $j$ and they solve the intermediate good firm problem (2.2.7) and (2.2.10),
- demands of labor and capital $l$ and $k$ solve the maximization problem of input producers (2.2.12) and they have zero profits,
- good markets clear: $c + i = Y$, $d_j = F_j$, and $f = h + x^*$,
- labor markets clear: $l + Q = n$,
- capital markets clear: $k = K$,
- financial markets clear: $s + s^* = P^*x + Px^*$,
- and no-Ponzi-scheme conditions hold.

Given that this model does not have an analytical solution, we perform a calibration exercise in the next section in order to understand its quantitative properties by means of a numerical solution.

## 2.3 Quantitative exercise

### 2.3.1 International business-cycle statistics

Table (2.1) presents several time-series properties for some of the main aggregates from the largest economies in the OECD[2], which we hope to be able to replicate with our model.

Some facts that stand out:

- ◇ For almost every country, the volatility of consumption is less than the volatility of output.
- ◇ The average volatility of investment and imports are about three times larger than that of output.
- ◇ The average volatility of net exports is about half the volatility of output.
- ◇ Domestic correlations between output, consumption, investment, and imports are strong and positive.
- ◇ The correlation between output and net exports is negative in most cases.
- ◇ There is no clear rank between the cross-country correlations of output, consumption, and investment.

### 2.3.2 Calibration

To proceed with the calibration of the model we need precise definitions of macroeconomic aggregates in our model, so that we can match data to our simulations. We shall understand nominal GDP as the sum of private

[2]See the data appendix in chapter 2 for details on the construction of these variables and the sources of the data.

Table 2.1: International business cycle statistics 1973-2010.

| | *Standard deviation*[a] | | | | | *Domestic correlation* | | | | | *International corr.*[b] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $c$ | $i$ | $m$ | $nx$ | $tot$ | $y, c$ | $y, i$ | $y, m$ | $y, nx$ | $y, tot$ | $y$ | $c$ | $i$ |
| United States | 0.80 | 2.86 | 3.27 | 0.36 | 1.64 | 0.93 | 0.95 | 0.79 | -0.50 | -0.08 | | | |
| Japan | 0.73 | 2.00 | 3.42 | 0.52 | 3.55 | 0.81 | 0.86 | 0.59 | -0.11 | 0.11 | 0.52 | 0.34 | 0.48 |
| Germany | 0.60 | 2.17 | 2.16 | 0.53 | 1.34 | 0.65 | 0.86 | 0.66 | 0.23 | 0.22 | 0.54 | 0.41 | 0.57 |
| France | 0.81 | 2.87 | 3.62 | 0.81 | 2.42 | 0.79 | 0.86 | 0.67 | -0.20 | 0.03 | 0.50 | 0.42 | 0.36 |
| United Kingdom | 1.01 | 2.49 | 2.54 | 0.71 | 1.30 | 0.90 | 0.78 | 0.59 | -0.25 | 0.05 | 0.64 | 0.51 | 0.50 |
| Italy | 0.94 | 2.32 | 3.53 | 0.93 | 2.10 | 0.68 | 0.82 | 0.64 | -0.23 | 0.37 | 0.50 | 0.08 | 0.32 |
| Canada | 0.71 | 2.82 | 3.05 | 0.74 | 1.66 | 0.79 | 0.69 | 0.54 | 0.29 | -0.21 | 0.68 | 0.57 | 0.36 |
| Spain | 0.92 | 2.76 | 3.52 | 0.96 | 2.84 | 0.85 | 0.91 | 0.71 | -0.45 | 0.02 | 0.41 | 0.33 | 0.18 |
| Australia | 0.92 | 3.98 | 5.26 | 1.12 | 4.35 | 0.42 | 0.68 | 0.17 | -0.00 | -0.05 | 0.23 | 0.02 | 0.37 |
| Mexico | 1.03 | 3.28 | 4.90 | 0.81 | 2.50 | 0.95 | 0.88 | 0.66 | -0.52 | -0.38 | 0.22 | 0.09 | 0.15 |
| Korea | 1.05 | 2.70 | 2.65 | 1.18 | 1.28 | 0.81 | 0.89 | 0.66 | -0.25 | -0.29 | 0.26 | 0.15 | 0.26 |
| Netherlands | 0.75 | 2.64 | 1.84 | 0.77 | 0.66 | 0.70 | 0.82 | 0.59 | 0.05 | -0.05 | 0.59 | 0.47 | 0.49 |

[a] Relative to standard deviation of GDP.
[b] Correlations with corresponding United States series.
[*] See data appendix in chapter 2 for details on construction of these variables and data sources.

consumption, investment and exports minus imports: $GDP_t = c_t + i_t + P_t x_t^* - P_t * x_t$, whereas real GDP will be measured using steady state prices, so $RGDP_t = c_t + i_t + P_{ss} x_t^* - P_{ss} * x_t$. We will refer to net exports as the result of the trade balance divided by GDP, i.e. $nx_t = (P_t x_t^* - P_t * x_t)/GDP_t$. Terms of trade will refer to the ratio of import and export prices, so $tot_t = P_t^*/P_t$, while the real exchange rate will refer to the ratio in the price level of intermediate goods, $rer_t = p_t^*/p_t$.

The model is calibrated to match features of the US economy over the 1973-2010 period as follows: we set the discount factor $\beta$ to the standard value of 0.99 to match an annualized interest rate of about 4%, the capital depreciation rate $\delta$ is set to 0.025 to match an annualized depreciation rate of 10%, and the coefficient of risk aversion $\theta$ to -1. Following Mandelman et al. (2011) we assume a cost of holding savings ($\phi_b$) equal to one basis point. We set $Q$ to obtain an import share of 15% and $\mu$ to obtain a share of hours worked equal to 0.34, both also standard targets in the literature. The capital adjustment cost parameter $\psi$ is set so that the standard deviation of investment is about three times that of output. The value of the trade elasticity $\nu$ is set to 0.73 as in Ghironi and Melitz, who justify their choice of values based on firm level evidence documented by Bernard et al.. The parameter $\alpha$ is set so that the volatility of imports is between 2 and 3 times that of output (Engel and Wang, 2011). $\gamma$ is set to match an investment share of 22% of GDP. As a baseline we will set $\eta = 0.57$, which is the baseline value used by Amaral and Quintin (2005) to match the ratio of financial intermediation to GDP. We will later perform a sensitivity analysis for this parameter. The shock process has the usual form,

$$\log \begin{bmatrix} z_t \\ z_t^* \end{bmatrix} = A \log \begin{bmatrix} z_{t-1} \\ z_{t-1}^* \end{bmatrix} + \begin{bmatrix} \epsilon_t \\ \epsilon_t^* \end{bmatrix},$$

where $(\epsilon_t, \epsilon_t^*)$ is a vector of normally distributed shocks, independent from past values. The covariance matrix of these shocks as well as the parameters in the transition matrix $A$ are set after the values estimated by Heathcote and Perri (2002). The complete parametrization of the model is given in table 2.2.

Table 2.2: Benchmark parameter values.

| *Parameter* | | *Value* | *Source or Target* |
|---|---|---|---|
| Risk aversion | $\theta$ | $-1$ | Backus et al. (1994) |
| Discount rate | $\beta$ | 0.99 | 4% annualized interest rate |
| Leisure share | $\mu$ | 0.48 | Hours worked = 0.34 |
| Depreciation rate | $\delta$ | 0.025 | 10% annualized depreciation |
| Adjustment cost | $\psi$ | 0.88 | Volatility of investment = 2.9 |
| Trade elasticity | $\sigma$ | 0.73 | Ghironi and Melitz (2005) |
| Fixed cost | $Q$ | 0.01 | 15% import share of GDP |
| Capital share | $\gamma$ | 0.43 | 22% Investment share of GDP |
| Home bias | $\alpha$ | 0.75 | Volatility of imports $\in (2, 3)$ |
| Shock process | $V_\epsilon$ | $10^{-6}\begin{bmatrix} 53 & 15 \\ 15 & 53 \end{bmatrix}$ | Heathcote and Perri (2002) |
| Transition matrix | $A$ | $\begin{bmatrix} 0.97 & 0.01 \\ 0.01 & 0.97 \end{bmatrix}$ | Heathcote and Perri (2002) |

Calibrated to 1973-2010 US data.

### 2.3.3 Simulation

We ran fifty 300-period simulations of this economy and took the log of each series (except for net exports, which may be negative) and used a Hodrick-Prescott filter for quarterly data to remove their trends. We then averaged results from all fifty simulations. Table (2.3) presents these averages compared to their data counterparts, which have also been logged and HP-filtered as needed for comparison.

The baseline model does a good job at explaining some of the discrepancies between standard international real business cycle models and the data. Excessive consumption smoothness is one such common problem that goes away when trade finance is taken into consideration. Raffo (2008, 2010) suggests introducing an alternative specification of household preferences to increase consumption volatility[3]. Our model, however, is capable of generating consumption that is as volatile as in the data with standard preferences.

The volatility of imports is about two times as large as the volatility of output. While it isn't as large as in the data, it is quite an improvement over standard models, which typically imply lower import volatility than output volatility. The volatility of net exports is a little higher than in the data, but remains lower than the volatility of output. Another significant improvement can be seen in the volatility of terms of trade, which is larger than that of output and quite close in magnitude to what we observe in the data. The volatility of hours worked is low, but this is a common problem elsewhere in the literature.

Auto-correlations of the series in the model are very similar to those in the data as are domestic correlations. Our mechanism works as follows: when a positive productivity shock hits the economy, households have more income left after consumption. They decide to allocate these savings between importers that need to finance international purchases and input producers (serving both domestic and foreign markets) that need to finance capital. In any case, the extra resources make international trade cheaper:

[3]GHH preferences, as introduced by Greenwood et al. (1988), have the property that the marginal rate of substitution between consumption and leisure is independent of the consumption level within the period, which implies that there is no income effect on labor supply and hours worked respond more strongly to changes in productivity. Although this generates volatility of consumption more in line with the data, the unresponsiveness of labor supply to changes in consumption levels appears to be empirically troublesome.

savings devoted to finance imports reduce the total cost of imported goods and savings used to finance exporter capital allow them to produce inputs at a lower cost, becoming more attractive to foreign customers.

The correlation between output and the terms of trade is another common puzzle of international RBC models. Looking at long time series this correlation is typically negative, while the standard models predict a positive correlation. In chapter 2 of this thesis it is shown that this correlation is strongly negative in earlier data and positive in recent years. He suggests that in order to explain the negative correlations of the past and their recent reversal, models of these type should introduce the possibility that firms alter the quality and not just the quantity of their production, and that improvements in the measurement of quality should be taken into account. Our model here predicts a strong negative correlation, consistent with earlier data but inconsistent with recent values, the opposite prediction of standard models.

Another interesting result is that the cross-country correlation of output is stronger than that of consumption, as in the data. This is typically not the case in the literature: (Backus et al., 1994) dub this the "consumption/output anomaly". Our cross-country correlations are somewhat low, but not far from the actual numbers. But most importantly, the anomaly is gone. We believe this is an important feature of our model. The cross-country correlations of investment and hours worked are wrong, another common problem in this type of models. Also, the Backus-Smith puzzle does not go away either, since the correlation between relative consumption and the real interest rate is near one. This is another anomaly that according to the findings in chapter 2 of this thesis would go away if changes in quality were taken into account.

To what extent do these changes depend on the presence of a credit constraint? To test this we run a modified version of the model that removes condition (2.2.7). Importers can buy from foreign firms as much as they can

Table 2.3: Simulation results.

| | *Data*[b] | *Model* | |
|---|---|---|---|
| *Standard deviations*[a] | 73-10 | Baseline | No constraint |
| Output | 1.00 | 1.00 | 1.00 |
| Hours | 1.27 | 0.28 | 0.25 |
| Consumption | 0.80 | 0.99 | 0.99 |
| Investment | 2.86 | 3.13 | 3.06 |
| Imports | 3.27 | 2.56 | 2.54 |
| Net exports | 0.36 | 0.74 | 0.92 |
| Terms of trade | 1.64 | 1.64 | 1.51 |
| *Autocorrelations* | | | |
| Output | 0.87 | 0.82 | 0.75 |
| Hours | 0.92 | 0.74 | 0.72 |
| Consumption | 0.87 | 0.78 | 0.74 |
| Investment | 0.90 | 0.77 | 0.73 |
| Net exports | 0.78 | 0.73 | 0.72 |
| Terms of trade | 0.81 | 0.72 | 0.71 |
| *Corr. with domestic output* | | | |
| Hours | 0.89 | 0.70 | 0.63 |
| Consumption | 0.93 | 0.93 | 0.84 |
| Investment | 0.95 | 0.75 | 0.63 |
| Net exports | −0.50 | −0.29 | −0.07 |
| Terms of trade | −0.08 | −0.28 | −0.07 |
| *Cross-country correlations* | | | |
| Output | 0.58 | 0.80 | 0.99 |
| Hours | 0.42 | −0.52 | −0.30 |
| Consumption | 0.36 | 0.21 | 0.28 |
| Investment | 0.30 | −0.44 | −0.31 |
| Rel. consumption-RER | −0.71 | 0.99 | 0.99 |

[a] Relative to the standard deviation of output.
[b] Source: OECD and FRED.

afford and households trade one period non-contingent assets that allow for unbalanced trade each period, so that $s = -s*$, a bond economy. The model uses the same calibration as the baseline model. Results for this model are in the column "no constraint" of table (2.3). Clearly, the credit constraint affects the levels of many of the model's moments, but it does not appear to qualitatively affect the behavior of the model. Differences to the standard international RBC model stem from other characteristics of our model, such as a separation between exporters and importers as well as the presence of monopolistic competition on the side of the importers. However, having a credit constraint allows us to evaluate the effects of changing conditions in financial markets to both the amount as well as the dynamic properties of trade. This is what we do in the next section, though we first delve into the empirical evidence of how trade finance affects trade performance.

## 2.4 How trade finance affects trade

### 2.4.1 Empirical evidence

International trade dynamics have been largely analyzed in both the theoretical and the empirical literature. Research has focused on the role of globalization in imports and exports as well as on the link between cross-border trade and growth. Unfortunately, this literature has largely disregarded the connection between trade finance and international trade performance; the few exceptions have mostly neglected the important role of export insurance provided by financial institutions and credit offered by suppliers to their customers via open accounts.

There is very little data available on trade finance and trade credit, and that what is available is not very reliable either. Auboin (2009b) finds that around 90% of international trade relies in some form of credit. Asmundson et al. (2011) estimate from four surveys carried out among banks of all sizes and nationalities between 2008 and 2010 that between

35%-40% of international credit was financed by banks, around 20% was paid in advance (and may have been financed by letters of credit) and between 38% and 45% relied on open accounts, although 25% of these open accounts were covered by Berne Union members insurance. Mora and Powers (2009) attribute a larger share to open accounts (40-80%) and a possibly smaller share to banks (10-50%), though they concede the role of bank financing is increased if one includes working-capital loans. These large intervals illustrate the limitations in the availability of data about trade finance. Whatever the precise numbers are, the one thing that is clear is that trade finance is a hugely relevant factor for anyone in the business of importing or exporting goods.

The scarcity of good data is the main cause for the lack of empirical research on this topic until very recently. Following the 2008 financial crisis, however, global trade collapsed even faster than global output. The downturn suffered by international trade over GDP during the last world financial crisis has produced an upsurge of interest on the possible relevance of the financial channel as a partial explanation for international trade dynamics. This literature contributes significantly to underline the importance of trade finance for the dynamics of trade and hints at some of its main properties, and so we detail some empirical findings of this literature in the present section.

Asmundson et al. (2011) use survey data to confirm that banks were increasingly cautious with real-sector customers and counter-party banks during the recent crisis and admit to have increased their loans-deposits pricing margins. Most banks (with the exception of the group of *large banks*, which indeed, accounts for a substantial majority of the trade finance share) denied having decreased credit availability in their own institutions, but all confirm they increased their demands for collateral and, in general, they adopted stricter risk management practices in response to higher risk. Moreover, ASMUNDSON ET AL. argue that exporters have become more risk averse, seeking higher protection from risk and avoiding open accounts. The latter behavior has forced importers to turn to trade credit more often. Hence, the share of world trade supported by bank intermediation has increased considerably.

Schott (2009) and Fontagné and Gaulier (2009) show how financial crises affect the volume of exports and imports much more than the range of varieties exchanged. This suggests that, during financial disruptions, firms reduce their scale of international activities although they are able to maintain their international channels open. Another interesting empirical analysis in favor of the financial channel is Van der Veer (2011). He focuses on the role of private trade insurers, who faced mounting risks after Lehman Brothers bankruptcy. He finds that, on average, every €1 of insured exports generates €2.3 of total exports. Thus, the impact on trade of a change in the supply of private trade credit insurance is bigger than the change in the value of insured trade. One important reason that could explain this trade multiplier is that trade credit insurance improves a buyer's access to supplier credit. Using data from Berne Union, the organization which counts the major private credit insurers and most export credit agencies worldwide among its members, Morel (2010) concludes that, during the crisis, whereas exporters increased their applications for covers, insurers moved to more conservative positions of risk. Both facts caused credit tightening for international trade.

There is, however, some skepticism about the role trade finance played during the great trade collapse, especially in the US. (Levchenko et al., 2009) and Eaton et al. (2009) attribute most of the decline in trade to demand shocks and compositional effects. Nevertheless, this lack of consensus may be explained by the focus of the literature on US firms due to data availability; key results may be driven by special features of this country. In fact, Eaton et al. do find that for countries like Japan or China financial shocks are the largest contributors to changes in trade over GDP ratio.

Also, a number of studies find that small and medium enterprises in developing countries were especially affected by the shortage in trade finance (Malouche, 2009; Humphrey, 2009; Berman and Martin, 2010).

Most data sets do not disentangle banking finance from inter-firm finance and none of them capture the relative share of intrafirm credit in different sectors and countries. As a consequence they make it difficult to separate cause and effect. An exception to this limitations in the data is (Amiti and Weinstein, 2009), who use a unique data-set for Japan which matches firms with their credit banking providers to examine the link between finance and exports during the Japanese financial crises of the nineties. They are the first to establish a causal link from shocks in the financial sector to exporters that result in exports declining much faster than output during banking crises. Their evidence shows that firms that rely more on trade finance (smaller firms, firms that ship by sea instead of air, firms that have no foreign affiliates, etc.) are hit much harder when the financial institutions they rely upon run into trouble. These results are robust to a large number of variations in the specification of their model. Paravisini et al. (2011) offer further empirical evidence for the supply-side effects of finance on international trade. They carry out an analysis similar to Amiti and Weinstein with Peruvian data.

Ahn et al. (2011) argue against the view that the trade finance channel has been of little relevance to the decline in trade during the crisis. They claim that the conventional measures of external finance dependence that are commonly used in the literature are completely unrelated with levels of trade finance. Indeed, Feenstra et al. (2011) also show that the trade finance channel is quite a different channel than that of the conventional external finance channel. Ahn et al. show two categorical pieces of evidence of the importance of financial shocks for international trade: First, during the crisis, export prices rose relative to domestic manufacturing prices across a large number of countries. Second, import and export prices of goods shipped by sea, which are likely to be affected most by trade finance contractions, rose disproportionately more than those shipped by air or land.

Berman et al. (2011) also support the latter thesis with a theoretical model and an empirical analysis. They run a historical analysis from 1950 to 2009 for a large number of countries and find a robust time-to-ship effect, i.e., exporters react to an increase in the probability of default of importers by increasing their export price and decreasing their export volumes to the destination in crisis. They conclude that this stylized fact of financial crises strongly suggests that they affect trade not only because they impact demand but also through financial frictions which are specific to international trade.

In conclusion, even though it might be possible that trade finance in the US was resilient during the 2008 financial crisis and the reasons for the great trade collapse lie elsewhere, it seems improbable that variations in the availability of trade finance do not have an important effect on trade performance.

### 2.4.2 Effects of a temporary credit shock

In light of all this evidence, how does our theoretical economy behave in response to an exogenous tightening of credit conditions? In our model, household savings are the crucial source of credit availability determining the volume of trade attainable in this economy. The level of development of the financial system in a country and the strength of its institutions are captured by the parameter $\eta$. However, $\eta$ can also capture changes in risk positions taken by the financial intermediaries. Hence, a larger $\eta$ may represent both a better developed financial market and a higher level of confidence of banks on loan-repayment possibilities.

In order to evaluate the effects of temporary credit shocks we need to add a second source of uncertainty in our model. We shall assume that the credit tightness parameter $\eta$ is now time dependent with mean $\bar{\eta}$ and a random component $b_t$ so that $\eta_t = \bar{\eta} b_t$; the shock process is now

$$\log \begin{bmatrix} z_t \\ z_t^* \\ b_t \\ b_t^* \end{bmatrix} = A \log \begin{bmatrix} z_{t-1} \\ z_{t-1}^* \\ b_{t-1} \\ b_{t-1}^* \end{bmatrix} + \begin{bmatrix} \epsilon_{z,t} \\ \epsilon_{z,t}^* \\ \epsilon_{b,t} \\ \epsilon_{b,t}^* \end{bmatrix}.$$

What values to set for $A$ and the covariance matrix of the shocks? There are no reliable time-series on trade finance from which to estimate these parameters. There are other forms of finance that we could use as proxies, but as we mentioned before this would be misguided considering that the evidence shows trade finance behaves much differently than other forms of credit. So instead we are going to consider and compare different scenarios and lay out their properties.

As a benchmark case, we set all correlations and spillovers between financial and technology shocks to zero. Considering that financial shock transmission across borders has been shown to be a very relevant phenomenon among modern capitalist economies in recent history, we allow for a positive international correlation between trade credit shocks, $corr(\varepsilon_b, \varepsilon_b^*) = 0.70$. The standard deviation for the financial shock as well as its persistence are initially set equal to those for the productivity shock. We will later consider the effects of altering these assumptions.

We now proceed to explore a tightening of 1% in trade credit. Continuous lines in figure 2.4.1 show the impulse responses in macroeconomic aggregates for the benchmark case. When a negative financial shock hits our economy, GDP initially increases and then falls bellow its steady state value for the rest of the transition. The reason for this result is related to the change in the composition of demand by intermediate good producers. When the financial constraint becomes tighter, firms must reduce their demand for imports. They substitute foreign intermediates by relatively more expensive national products, pushing domestic production up and, hence, improving GDP as well as consumption. In anticipation of increased demand for domestic products, there is an upsurge in investment and labor causing this effect. The positive demand effect on national inputs causes $P_t$ to increase and, as a consequence, reduces (i.e., improves) terms of trade. This leads to a fall in exports and, as a consequence, in national GDP. Both imports and exports over GDP are below the steady state during the transition. However, the negative effect of the financial tightening on imports is much larger than on exports, so net exports over GDP improve.

On the other hand, the tightening in the financial constraint affects productivity: firms are forced to chose a less efficient mix of domestic and foreign inputs due to the restriction. Under the current parametrization, the positive effect described above dominates the negative initially. However after a few periods, investment and labor collapse and the initial surge in GDP and consumption disappears.

The dashed lines in the impulse-response figures above show that the balance between positive and negative effects on macroeconomic aggregates crucially depends on the level of financial shock persistence. When persistence is low (0.80) the surge in demand for domestic goods is much more short-lived, and therefore increases in investment and labor in anticipation of this surge are too weak to counteract the negative effects of credit-tightening on productivity and exports. In this case the increase in GDP and consumption are both milder and of shorter duration, and of course the economy returns to the steady state much more quickly than in the case of high persistence.

How are results affected by a change in the level of transmission of financial shocks? Figure 2.4.2 illustrates what happens if international correlations drop from the benchmark case of 0.70 to 0.50. This change basically affects the magnitude but not the shape of the response to the shock. In the benchmark case, since the shock is transmitted abroad more forcefully, foreign firms find it more difficult to finance imports and hence exports fall significantly more than in the case of milder spillovers. With lower

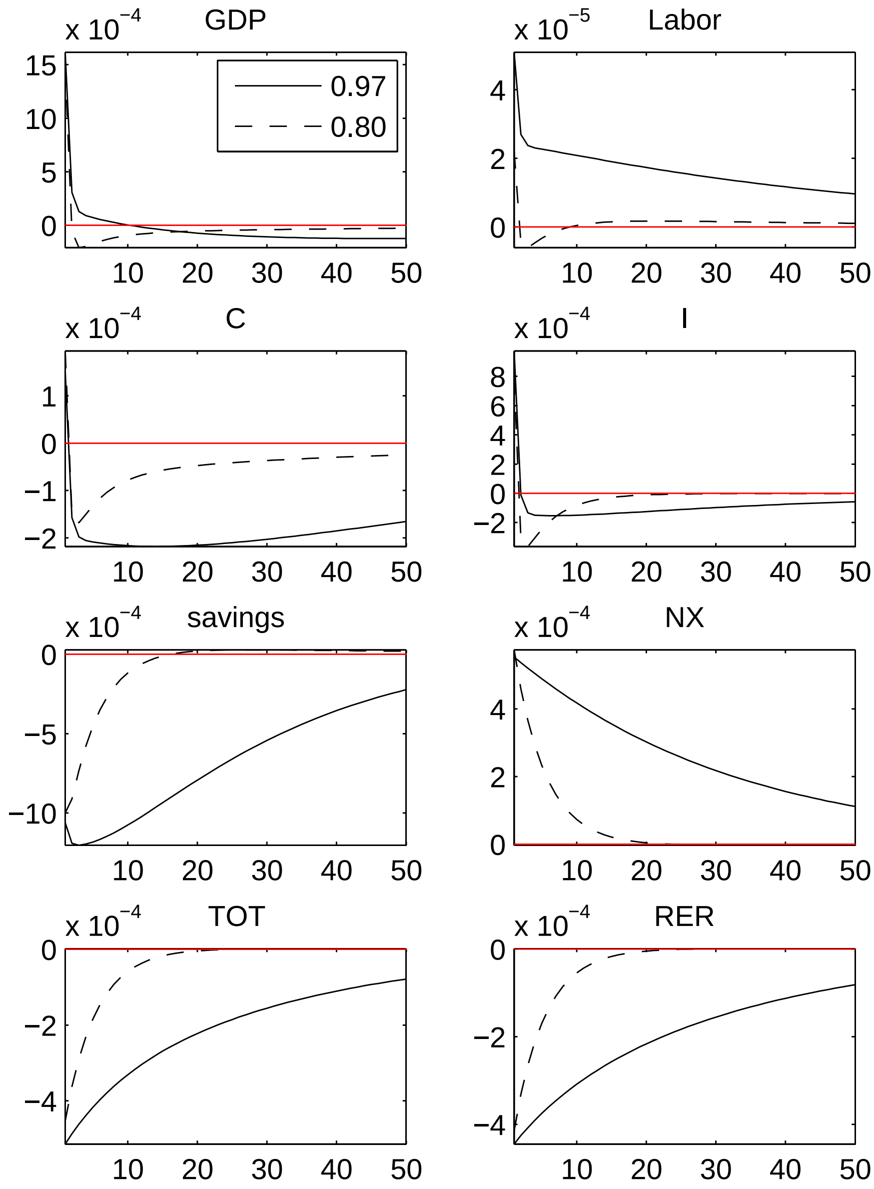


Figure 2.4.1: Change in macroeconomic aggregates following a financial shock for varying levels of financial shock persistence.

transmission of financial shocks effects over GDP and other macroeconomic aggregates are much milder. We reach virtually the same conclusions if instead of comparing economies with different levels of international correlations we compare economies with different levels of financial spillovers.

Similarly, our results are robust to changes in the correlation between financial and technology shocks. If these are different from zero, only the magnitude of the shocks is affected, but not their qualitative properties. A positive correlation will accentuate the negative effects of a financial shock on productivity, as there will be a loss in efficiency due to both a less desirable mix of foreign and domestic inputs as well as a downgrade in the technology used to combine them.

Finally, how do the effects of credit shocks compare to the effects of technology shocks? This is illustrated in figure 2.4.3 for the baseline parametrization of the credit shock; under these specifications, both shocks have the same variance, and except for the case of net exports and the real exchange rate, credit shocks have opposite effects to productivity shocks, for example by temporarily increasing GDP as discussed above. The most striking difference though is in the magnitude of the effects, as credit shock effects appear to be much weaker for all aggregates considered. Put differently, for the effects of both shocks to be of roughly comparable magnitude, the variance of credit shocks would need to be much larger than that of productivity shocks. This explains why the introduction of credit shocks appears to make little difference to the business cycle properties of this economy, as pointed out in section 2.3.3; these properties are largely driven by fluctuations in technology.

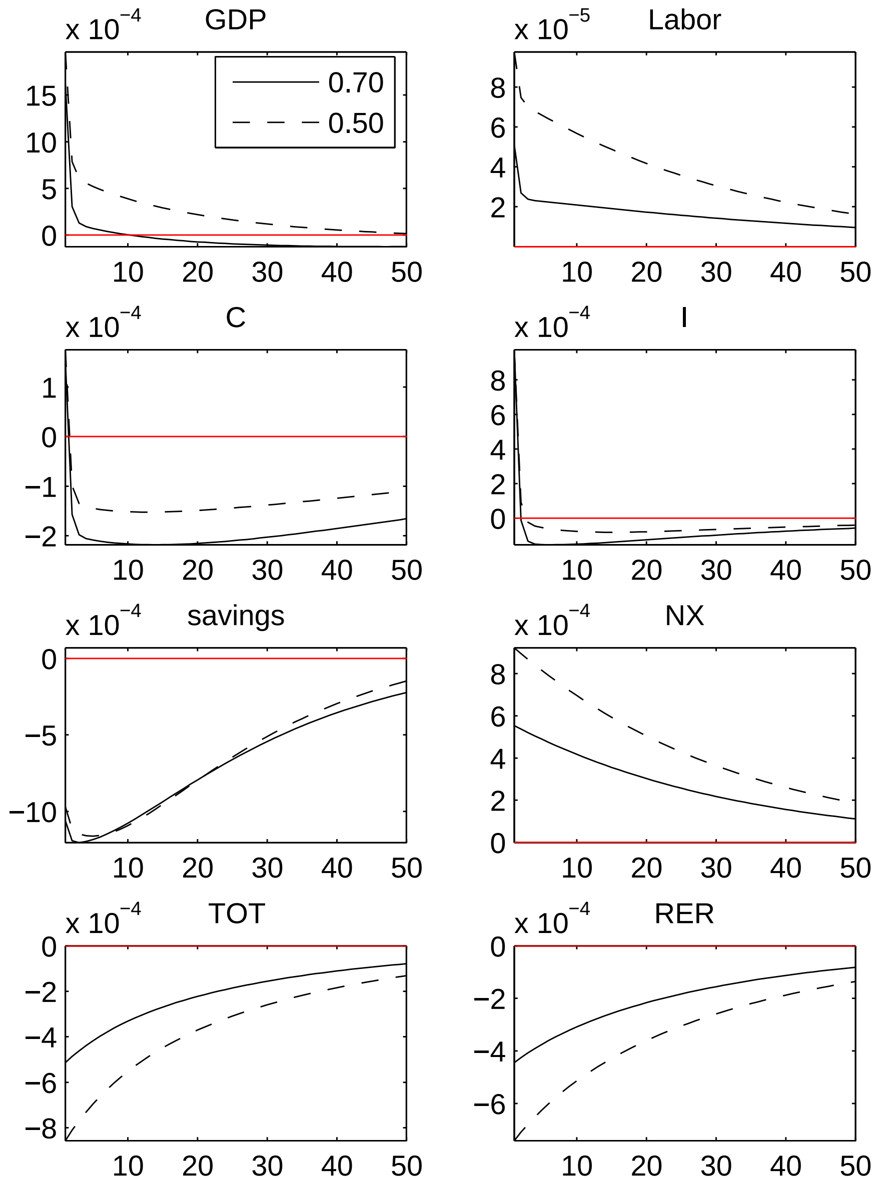


Figure 2.4.2: Change in macroeconomic aggregates following a financial shock for varying levels of international correlations.

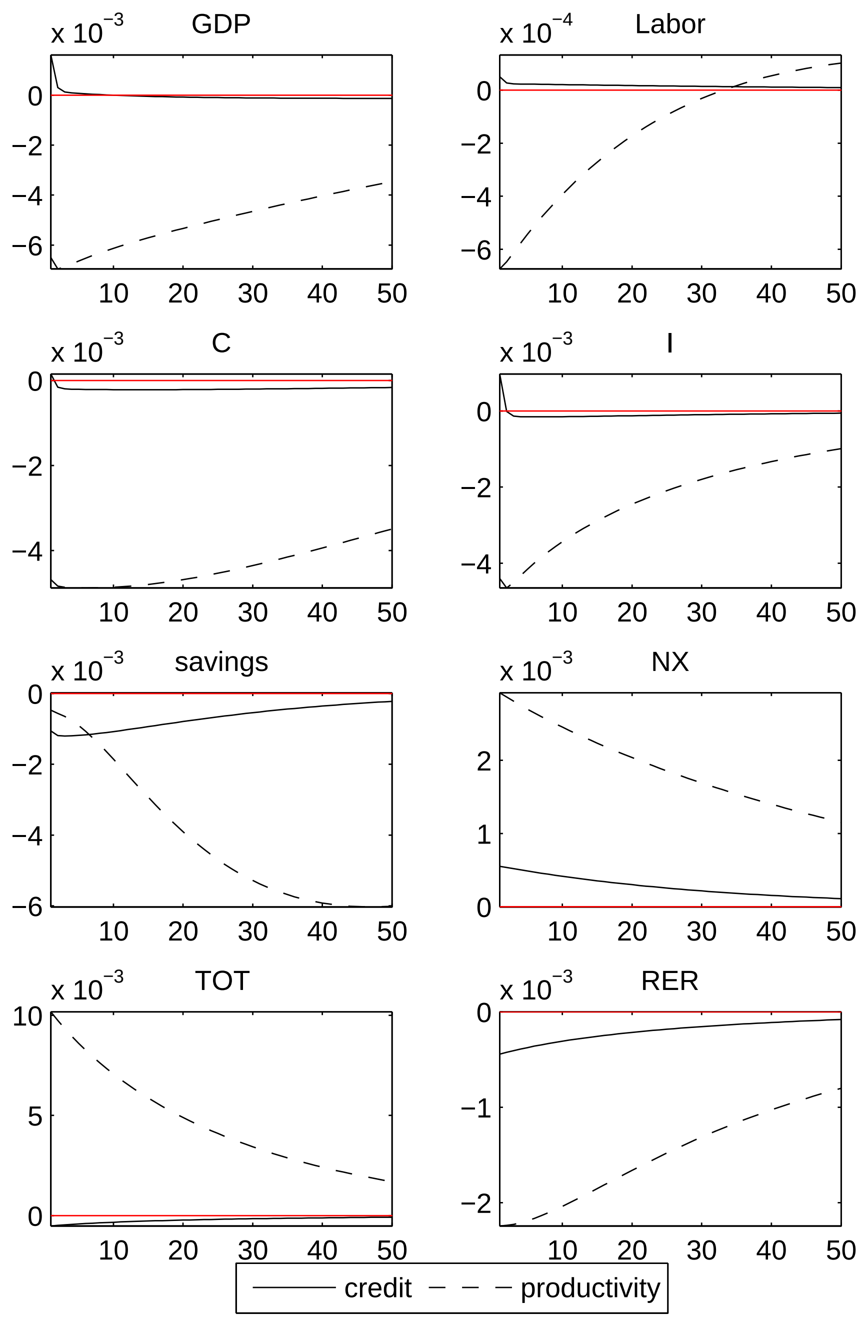


Figure 2.4.3: Comparing credit and technology shocks.

Table 2.4: Simulation results for different levels of financial development.

| | $\eta$ | | |
|---|---|---|---|
| *Steady state* | 0.57 | 0.47 | 0.37 |
| Output | 0.88 | 0.86 | 0.82 |
| Consumption | 0.69 | 0.67 | 0.64 |
| Investment | 0.19 | 0.18 | 0.17 |
| Imports/GDP | 0.14 | 0.12 | 0.09 |
| *Standard deviations*[a] | | | |
| Output | 0.81 | 0.87 | 0.90 |
| Consumption | 0.58 | 0.58 | 0.56 |
| Investment | 0.51 | 0.52 | 0.53 |
| Imports | 0.22 | 0.17 | 0.13 |
| Net exports | 0.44 | 0.36 | 0.28 |
| Terms of trade | 1.45 | 1.58 | 1.71 |
| *Corr. with domestic output* | | | |
| Imports/GDP | 0.86 | 0.92 | 0.95 |
| Net exports | −0.51 | −0.61 | −0.68 |
| Terms of trade | −0.51 | −0.61 | −0.68 |
| *Cross-country correlations* | | | |
| Output | 0.47 | 0.24 | 0.06 |
| Consumption | 0.18 | 0.13 | −0.09 |

[a] In percentage.

### 2.4.3 Effects of a permanent credit shock

We limit the analysis in this section to comparative statics of a change in the financial situation of an economy and by analyzing the qualitative consequences of a permanent tightening in $\eta$. Results are summarized in table 2.4.

First of all, a more constrained financial market reduces GDP in the steady state. Optimal intermediate firm demand allocation is bounded by the financial constraint, i.e., they would like to import more. Due to this suboptimal demand allocation, the cost of production increases and so do prices, which, in turn, reduces consumption and investment almost proportionally to GDP. This result is supported by several papers showing a positive link between financial development and economic growth (See Levine (2005) and Papaioannou (2007) for a complete survey on the issue.). Imports, on the other hand, decline more than GDP, moving from a 14.5% to 9.4% when $\eta$ changes from .57 to .37, which is approximately the 5% decrease experienced by US real imports over real GDP ratio from its peak to its valley in the recent crisis. When we isolate the financial channel by worsening importers access to financial resources, independently of any other shocks, imports are much more damaged than GDP. This may be the case because imports are restricted and firms need to turn to national production, partially offsetting the downturn in GDP.

Since the economy is less open in trade to foreign markets, cross-border spillovers are milder. This makes all real variables more correlated with national GDP. Net exports react considerably and become much more negatively correlated with GDP. The lower interrelation causes cross-country correlations to decrease. Although savings are still pooled across borders, one of the international transmission mechanisms, trade, has been partially blocked.

Regarding country uncertainty, credit tightening increases the volatility of GDP, investment and terms of trade, whereas imports, net exports and the real exchange rate are more stable. Consumption volatility has a non-linear response to credit tightening. Empirical research draws ambiguous conclusions on the effects of financial market development on macroeconomic volatilities. Our results for GDP and consumption are close to those of Kose et al. (2003a). In their empirical analysis for 76 countries, comprising 21 industrial and 55 developing countries, they find a negative effect on GDP volatility, i.e., more developed markets suffer from larger output instability. On the consumption side they show that financial development increases consumption volatility up to certain threshold, following a non-linear relationship, just as we do. For instance, for $\eta = 0.67$, the standard deviation of consumption is 0.0057, lower than that found with $\eta = 0.57$, our baseline value. Eozenou (2008), on the other hand, finds consumption volatility to increase when financial markets are underdeveloped for a panel of 90 countries.

We can explain the increasing volatilities due to the lower possibilities of risk sharing among countries. A highly developed financial market leads to more openness, because firms are able to purchase more imports. Therefore, both transmission mechanisms, trade and financial relationships, complement each other. When a country in a highly constrained world is shocked by a positive change in its technology, its firms can produce cheaper goods, which pushes consumption and investment and increases output. However, when the shock occurs in a relatively unconstrained scenario, foreign firms substitute national inputs by imports, which are now cheaper, and benefit from the shock. These spillovers cause a valuation effect on the production of the shocked country, reducing the response of consumption and investment. By the same token, GDP is also less volatile thanks to the role of trade in risk sharing.

Indeed, the combined effect of the level of trade transmission across borders (or level of spillovers) and the level of risk sharing can explain the nonlinear behavior of consumption volatility. When a country is relatively financially constrained and, hence, relatively closed, it suffers or benefits less from spillovers. This makes it less volatile. On the contrary, a relatively closed country has a worse level of risk sharing capability, which causes consumption to be more volatile in front of domestic turbulence. Both effects are present and act in opposite directions: initially, when a country develops financially, the strength of imported spillovers makes it increasingly unstable. However, for a certain level of development, the risk sharing possibilities offset the damage caused by spillovers, reducing consumption volatility.

## 2.5 Conclusions

Regardless of the scarcity of quality data, the importance of trade finance and trade credit for international trade has been clearly established in the empirical literature. This model provides theoretical support for the role of the financial channel in explaining part of the large decline in the trade levels for many countries following episodes of financial distress. Firms are bound by a financial constraint when they want to import. However, regardless of the explicit financial constraint, which affect importers, all firms in need for external finance rely on households capability for saving, the suppliers of credit resources. This capability is larger and, hence, the constraint is looser during economic expansions because households are able to save more. Indeed, when savings increase, households allocate them between credit to importers and savings in the form of capital which is rented to exporters. Whatever the decision they take, they make international trade finance cheaper. A credit tightening episode worsens the capability of importers to get access to foreign suppliers, who require guarantees to ship their products. This reduces imports dramatically and, although output is also damaged, some demand is reallocated to domestic goods, cushioning part of the decline in GDP. Therefore, while output, consumption and investment decline at the same proportion after a credit tightening, imports are hit much harder.

Despite the importance of credit shocks to individual importers, their large-scale impact on the economy appears to be limited at business cycle frequencies. Unless trade finance is much more volatile than productivity, it seems unlikely that trade finance could play a large role in short-run fluctuations of the economy. This is not to say that the availability of trade finance is unimportant to the long-run levels of trade, productivity, and output of an economy. Improvements in trade finance can produce large gains as well as more stability in production and consumption as it allows for an increase in trade performance and a better mix of foreign and domestic goods used in productive activities.

To the best of our knowledge, this paper is the first in the international real-business-cycle literature to consider the role of trade finance. We go a step forward into the understanding of international trade performance in a two-country, three-sector, micro-founded model by introducing a simple representation of the financial sector. Our model is able to shed light on many persistent contradictions between theoretical business-cycle volatilities and their empirical counterparts. First of all, we find that imports are twice as volatile as output in our simulations. Though this is still low compared to US data, it represents an important improvement, for previous models generally generate import volatility lower than GDP volatility. Terms of trade volatility in the model is larger than that of GDP and closer to the actual value compared to the existent literature. Our model is capable of generating consumption that is as volatile as in the data without the need to resort to non-standard preferences, thereby correcting the excess in consumption smoothing found in past literature. Furthermore, we overcome the "consumption/output anomaly" by producing cross-country correlations in consumption smaller than in output, as in the data. It turns out however, that these improvements are independent of the presence of a credit constraint, but are rather associated to modifications in the structure of the model economy, such as a separation between importing and exporting firms in combination with the monopolistic competition setting in which importers carry out their activities.

We believe that the model setup used in this paper is a suitable benchmark to explore the linkages between international trade and trade finance in depth. This has been only an initial step on this direction and further research is necessary to fully understand the implications of financial development and financial turbulence on international trade patterns. Two reasonable extensions from this paper may be, first, to introduce firm heterogeneity and explore the relationship between firm size and trade finance, given that the empirical evidence suggests that smaller firms are the ones that suffer more from the tightening of credit during financial crises; another important source of heterogeneity might be the possibility of intrafirm credit for firms with international subsidiaries. Finally, it would be interesting to allow for asymmetric countries to understand the evolution of trade flows among economic regions with different levels of financial development.

# Chapter 3

# Trade Liberalization and Superstar Executives

**Abstract**

I test the importance of trade liberalization for the rise in executive compensation inequality by considering two very different quantitative strategies. The first of these consists on calibrating a slightly modified version of a model of international trade with heterogeneous firms that allows for income heterogeneity. Increases in trade follow a fall in trade barriers, generating shifts in the distribution of income among managers. For the second strategy I use firm and industry-level data to test whether executive compensation has risen more rapidly in industries where trade has expanded at a faster pace. Both of these strategies suggest that contrary to recent findings, falling trade barriers are not an important source of increasing pay inequality among executives.

## 3.1 Introduction

Two facts that stand out about executive compensation over the last thirty years are 1) a rapid rise in executive compensation levels and 2) higher inequality in the distribution of income among executives (and the general population). Both facts have been the focus of several studies in recent years. A myriad of theories ranging from rent extraction in firms with weak corporate governance to the effects of global competition for scarce managerial talent have been proposed as possible explanations. One particular explanation of this phenomenon has been linked to the work of Rosen (1981) on so-called *superstars,* highly talented individuals who are able to disproportionately increase their income as the scope of their markets gets larger. While Rosen's writings suggest he had more in mind athletes and entertainers who could sell their abilities to larger audiences thanks to technological breakthroughs such as recorded music and television, some authors have speculated with the possibility that this kind of effects have a broader applicability to most economic activities. In particular, a number of recent studies[1] claim that by extending the scope of firms' markets, globalization (in the form of falling barriers to trade) generates income distribution shifts that disproportionately benefit the top earners in the economy and thereby increase inequality.

In this paper I seek to quantitatively test the importance of superstar effects of trade induced by globalization for the rise in executive compensation. For this purpose I follow two very different quantitative strategies. The first of these consists in calibrating a basic version of the model of international trade with heterogeneous firms and superstar effects that underlies the literature mentioned above, a modification of the standard Melitz (2003) model that allows for income heterogeneity. Increases in international trade are modeled as a result of the decrease in trade barriers which consequently generates shifts in the distribution of income among managers. The numerical experiments performed in this model suggest that the effects of trade expansion on the distribution of manager's income are close to zero. The magnitude of the change in trade barriers required to reproduce in the model the increases in trade observed in the data are much too small

[1]See for instance Manasse and Turrini (2001); Pica and Mora (2007); Egger and Kreickemeier (2009, 2011); Monte (2010).

to produce a significant effect in income shares of top earners. I find that even though absolute gains are indeed increasing in individual ability, gains relative to original income levels are not necessarily increasing, so that inequality can theoretically *decrease* after a fall in trade barriers and the consequent expansion of trade.

On the second part of the paper I use firm and industry-level data to test whether executive compensation has risen more rapidly in industries where trade has expanded at a faster pace. This strategy too suggests that increases in trade, even though large in absolute terms, are too small relative to the overall size of the economy to explain a significant portion of the rise in executive compensation. This is not to say that superstar effects are absent or unimportant, but their source is more likely to be found in firm-level improvements in efficiency and technology, rather than in industry-level or economy-wide changes in trade volumes induced by a trend towards trade liberalization.

The rest of this paper is organized as follows: Section 3.2 presents an overview of the literature on the rise of executive compensation, including the facts and the theories that surround them, as well as the literature on the effects of trade on the distribution of income, with special emphasis on the theory of superstar effects of trade. Section 3.3 lays out the basic model and presents results from calibrating it to the US economy. Section 3.4 presents results from analyzing executive compensation and firm level data and its relationship to changes in levels of international trade. Section 3.5 concludes.

## 3.2 Literature

Understanding how compensation of top executives and firm managers is set has been a popular subject for researchers and journalists alike for many reasons, the main of which has been the rapid rise of executive compensation in recent years, especially for the highest paid executives. Using tax-returns data, Bakija et al. (2010) report that the share of US national income earned by non-financial executives, managers, and supervisors in the top one percent of the income distribution increased from 3.65% in 1979 to 6.35% in 2005, despite the fact that individuals in these occupations represented 36% of primary taxpayers in the top one percent of the distribution of income in 1979 but only 31% in 2005. There is little agreement over what originated this phenomenon. Furthermore, they report that executive income growth was not evenly distributed even among top paid executives. Within the top 1%, average annual income growth rates for the period 1979-2005 were 0.6% for the bottom half but 4.8% for the top decile (see table 3.2 for a more detailed disaggregation). This is consistent with the work of Piketty and Saez (2004), who show that increases in income inequality are driven to a significant degree by what goes on at the top of the income distribution: The higher up they look in the distribution of income, the larger the gains over the last thirty years.

Table 3.1: Average annual income growth within the top percentile of the income distribution.

| | ‘79-93 | ‘93-99 | ‘99-02 | ‘02-05 | ‘79-05 |
|---|---|---|---|---|---|
| p99.0-p99.5 | 0.1 | 3.8 | -3.4 | 0.6 | 0.6 |
| p99.5-p99.9 | 1.2 | 4.6 | -5.2 | 3.4 | 1.5 |
| p99.9-p100 | 3.9 | 7.4 | -6.9 | 11.6 | 4.2 |

Bakija et al. provide an excellent overview of literature seeking to explain the rising shares of income at the top of the income distribution. Typically, such theories fall in one of two camps. The first of these camps attributes the rise in executive pay to the increased ability of managers to extract rents from firms with weak corporate governance. The second camp argues that the rise in executive pay can be best explained by developments in competitive labor and product markets (globalization, superstar effects, skill biased technological change, shifts in executive compensation practices, etc.). Theories of international trade as a source of the rise in inequality generally fall in the second camp. Globalization as a driver of wage inequality has been a popular subject of research since at least the nineties (for example, Feenstra and Hanson, 1996 or, for a more recent treatment of this issue, Helpman et al. (2010)). At first, probably because of the advent of NAFTA, researchers were concerned about the effects of trade between countries with very different labor force compositions. Many people in developed economies still worry that trading with unskilled labor abundant countries will hurt local unskilled workers and benefit skilled workers, thereby increasing inequality. Theories of this sort are mostly based on Heckscher-Ohlin arguments, which imply that the reverse would have to be true in the unskilled labor abundant countries, much to the contrary of what has actually been observed. This together with the fact that trade takes place to a large extent among similarly developed countries, has moved interest towards the question of whether trade by itself could cause inequality to rise, even when it occurs between trade partners that are very similar in their endowments of skilled and unskilled labor

The rise in inequality raised the question of whether trade generates advantages to the most highly skilled individuals within each participating economy. Some of the theories going in this direction argue that the income of highly skilled individuals is subject to so-called superstar effects. A concept first conceived by Rosen (1981), superstar effects occur whenever there is a convex mapping from the abilities of individuals to the rewards they perceive, and this convexity is particularly strong near the right tail of the talent distribution. In such a scenario small differences in abilities among the most talented translate into large differences in income. When the market grows larger, differences in income increase because the most talented individuals, who already earn more than their peers, capture a disproportionate amount of this expansion. Stories of superstar effects fit well with what is regarded by Murphy (1999) as "the best-documented stylized fact regarding CEO pay", namely that CEO pay is higher in larger firms. According to the theory, larger firms should be better able to leverage marginal differences in talent between CEOs and hence have an incentive to offer the best of them a higher pay.

Gabaix and Landier (2008) present a model of superstars in which the most talented managers are matched to the largest firms and small differences in CEO skills translate into large differences in pay. The effects of firm size in their paper are able to fully explain the rise in CEO pay over their period of consideration. While firm-size shifts in their paper occur exogenously, the superstar-effects-of-trade literature takes one step back and asks how a fall in barriers to trade, through its effect over firm size, affects the distribution of income. Manasse and Turrini (2001) were the first to suggest that globalization and trade could lead to larger wage differentials between skilled and unskilled workers through a superstar mechanism. More recently in an analogous framework, Pica and Mora (2007), suggest that similar effects are caused by foreign direct investment. In other related work, Monte (2010) adds skill-biased technical change to the mix to find the effects of simultaneous trade integration and technological progress and their interaction. In the standard model workers' abilities are not connected to their wages, so in contrast to entrepreneurs they all earn the same income. Egger and Kreickemeier (2009, 2011) extend the model to incorporate fair-wage preferences, which generate inequality between workers by connecting wages to the profitability of firms.

The idea underlying all theories of firm managers as superstars is that the abilities of managers are an important determinant of firm performance and that their pay reflects competition by firms for scarce talent that will make a significant difference to their outcomes. Even though many among both economists and the general public are skeptical about this hypothesis and find that the level of pay of top executives has become unreasonably high, a number of studies document the importance of CEO talent. Bennedsen et al. (2009) test the hypothesis that CEOs are important to the outcomes of the firms they work for by looking at how firm performance is affected by an unexpected death of a firm executive or one of their relatives[2]. This methodology has the advantage that in general such an event is unrelated to firm performance up to that point. This is not necessarily the case when the manager is fired or leaves the company voluntarily. The authors find that the death of a CEO or an immediate family member is likely to cause a statistically significant and economically large decline in firm profitability. In a similar study, Nguyen and Nielsen (2010) exploit the exogenous variation on stock prices resulting from reactions to sudden deaths of executives. They find that managers with high contributions to value obtain higher pay, retaining on average about 80% of the value they create. Both studies suggest that executives have a consequential impact on firm performance and give support to theories of competitive pay. And even if the impact were small, once the differential impact is magnified by the size of the firms they run, huge salaries might be justified by the market, a point that is forcefully made in the study by Gabaix and Landier mentioned above.

An alternative theory of how trade affects executive compensation is the one put forward by Cuñat and Guadalupe (2009), who argue that stronger competition originating in higher import penetration has forced firms to change their compensation schemes to provide executives with more performance incentives such as stock option packages. Firms must compensate managers for the additional risk they have to bear by offering the possibility of higher earnings in case of good performance. Together with the good stock market performance of recent decades, this would help explain

[2] The idea in this latter case is that the death of a relative leads the executive to dedicate more time to the family and less time to fulfilling his or her responsibilities at the firm.

in part why executive compensation has risen so dramatically. The findings in this paper provide some support to this theory, but my main focus will be on putting the theories of superstar effects of trade to the test using firm level data on CEO compensation and firm performance paired with industry level data on output, trade, and foreign direct investment.

## 3.3 The Model

In the standard model of trade with heterogeneous firms (Melitz, 2003), firms either self-select into becoming exporters, produce for domestic markets exclusively, or stay out of operation according to their levels of productivity. Profits made by these firms are then equally distributed among identical consumers, so the same amount of profits is transferred to each of them. In this paper I shift heterogeneity in productivity from firms to agents, who are endowed with an idiosyncratic ability for managing a firm, in the spirit of Lucas (1978). Managers must then pay workers a fixed salary, but are allowed to retain the firm's profits. This produces a non-degenerate income distribution, which is one of the main objects of study in this paper.

### 3.3.1 An economy with multiple sectors and countries

Consider a world economy consisting of $n+1$ countries, each with a population of mass 1, and $S$ sectors. A consumer in country $i$ demands $d_{ji}^s(v)$ units of good variety $v$ from country $j$ in sector $s$. If the set of sector $s$ goods from country $j$ available in country $i$ is given by $\Omega_{ji}^s$, then agent $\omega$ in country $i$ has utility given by:

$$U_i = \frac{\sigma}{\sigma-1}\sum_{s=1}^{S}\mu_i^s \log\left[\sum_{j=1}^{n+1}\int_{\Omega_{ji}^s} d_{ji}^s(v)^{\frac{\sigma-1}{\sigma}}dv\right], \qquad \sum_s \mu_i^s = 1\,\forall i,$$

where $\sigma > 1$. If an agent's income is given by $m$, then she maximizes her utility subject to

$$\sum_{j=1}^{n+1}\sum_{s=1}^{S}\int_{\Omega_{ji}^s} p_{ji}^s(v)\, d_{ji}^s(v)\, dv = m.$$

The solution to this optimization problem is an agent's individual demand functions

$$d_{ji}^s(v) = \frac{p_{ji}^s(v)^{-\sigma}}{\mathbb{P}_i^{s\,1-\sigma}}\mu_i^s m \tag{3.3.1}$$

where $\mathbb{P}_i^s$ is an aggregate price index given by

$$\mathbb{P}_i^s = \left[\sum_k \int_{\Omega_{ki}^s} p_{ki}^s(v)^{1-\sigma} dv\right]^{\frac{1}{1-\sigma}}.$$

Aggregate demand for variety $v$ in country $j$ is given by:

$$D_{ji}^s(v) = \frac{p_{ji}^s(v)^{-\sigma}}{\mathbb{P}_i^{s\,1-\sigma}}\mu_i^s E_i,$$

where $E$ is aggregate income in country $i$.

Individuals in this economy are endowed with ability level $\varphi_i^s$ distributed over the interval $[\underline{\varphi}_i^s, \infty]$ according to $G_i^s(\varphi_i^s)$, and can choose whether to become workers or entrepreneurs. For simplicity I will assume that individuals are assigned a level of ability in only one sector of the economy, and that the fraction of individuals in country $i$ with positive ability in sector $s$ is given by $\rho_i^s$. Workers perceive a salary $w_i$ that is independent of their ability. They may move freely from one sector of the economy to the other, so salaries are equalized across sectors. If individuals choose to become entrepreneurs they have to pay a fixed cost $F_{ij}^s w_i$ for entering sector $s$ in country $j$. Once entered they must ship $\tau_{ij}^s \geq 1$ units of their good for every unit of the good that arrives at destination $j$. Technology is linear in labor so that the unit cost of producing and shipping one unit of good $v$ in sector $s$ to country $j$ is equal to

$$\frac{\tau_{ij}^s w_i}{\varphi_i^s(v)}.$$

An entrepreneur's profits are thus given by:

$$\begin{aligned}\pi_{ij}^s(v) =& D_{ij}^s(v)p_{ij}^s(v) - D_{ij}^s(v)\frac{\tau_{ij}^s w_i}{\varphi_i^s(v)} - F_{ij}^s w_i \\ =& \left[p_{ij}^s - \frac{\tau_{ij}^s w_i}{\varphi_i^s(v)}\right]\frac{p_{ij}^s(v)^{-\sigma}}{\mathbb{P}_j^{s\,1-\sigma}}\mu_j^s E_j - F_{ij}^s w_i.\end{aligned}$$

Profit maximization gives the following pricing rule:

$$p_{ij}^s(v) = \frac{\sigma}{\sigma-1}\frac{\tau_{ij}^s w_i}{\varphi_i^s(v)}, \tag{3.3.2}$$

so that the aggregate price index is

$$\mathbb{P}_j^s = \frac{\sigma}{\sigma-1}\frac{1}{\tilde{\varphi}_j^s},$$

where $\tilde{\varphi}_j^s$ is a weighted average productivity index given by

$$\tilde{\varphi}_j^s = \left[\sum_{k=1}^{n+1}\left(\tau_{kj}^s w_k\right)^{1-\sigma}\int_{\Omega_{kj}^s}\varphi_k^s(v)^{\sigma-1}dv\right]^{\frac{1}{\sigma-1}},$$

I can now rewrite profits as a function of an individual's ability relative to the average ability at the country of destination:

$$\pi_{ij}^s(\varphi_i^s(v)) = \frac{1}{\sigma}\left(\frac{1}{\tau_{ij}^s w_i}\frac{\varphi_i^s(v)}{\tilde{\varphi}_j^s}\right)^{\sigma-1}\mu_j^s E_j - F_{ij}^s w_i$$

A firm in country $i$ will choose to export to country $j$ whenever $\pi_{ij}^s(\varphi_i^s(v)) \geq 0$. Since $\pi_{ij}^s$ is increasing in $\varphi_i^s$ and $\pi_{ij}^s(0) < 0$ because of fixed costs, there must be a level of ability $\bar{\varphi}_{ij} > 0$ at which the firm breaks even. An individual in this economy will choose to become an entrepreneur only if this is more profitable than becoming a worker, that is if for some $s$, $\sum_j \max[0, \pi_{ij}^s(\varphi(v))] \geq w_i$. Let $\bar{\varphi}_i^s$ be the level of ability that satisfies this condition with equality.

An equilibrium of this economy consists of

1. the demand functions in 3.3.1, which solve the consumer's problem;

2. the price functions in 3.3.2, which maximize managerial income,

3. threshold ability levels satisfying $\pi^s_{ii}(\bar{\varphi}^s_i) = w_i$ and 3.3.3,

4. salaries $w$ that provide labor market clearing.

### 3.3.2 A simple case: one sector, symmetric countries, Pareto-distributed abilities

Let salaries be the numeraire such that $w = 1$ and consider the case in which countries are symmetric and abilities are distributed over the $[1, \infty]$ interval following a Pareto distribution[3] with parameter $\gamma > 2$, so that $G(\varphi) = 1 - \varphi^{-\gamma}$. Denote domestic variables by the subscript $h$ and export variables by the subscript $x$. Let $F_x > F_h = 0$, so that the only fixed cost of becoming a domestic entrepreneur is the foregone salary. Furthermore let $\tau_x > \tau_h = 1$. This implies that if a firm is not profitable in the domestic market, it can't be profitable in export markets either. The least talented of entrepreneurs will therefore sell in domestic markets only and earn just as much as a worker, hence $\pi_h(\bar{\varphi}_h) = w_i$. This allows me to rewrite the average level of ability in terms of the distribution of abilities:

$$\tilde{\varphi} = \left[ w^{1-\sigma} \int_{\bar{\varphi}_h}^{\infty} \varphi(v)^{\sigma-1} dv + n\left(\tau_x w\right)^{1-\sigma} \int_{\bar{\varphi}_x}^{\infty} \varphi(v)^{\sigma-1} dv \right]^{\frac{1}{\sigma-1}},$$

[3]It may seem odd to assume that a natural attribute of the individual would follow such a skewed distribution as the Pareto distribution. However, the Pareto distribution provides a good approximation to the right tail of distributions that would appear more appropriate, such as a normal or Student's t distribution, and since it is the income of individuals with the highest abilities we are chiefly concerned about in this project, a Pareto distribution seems like a good choice for this model. Gabaix and Landier (2008) provide further discussion of this rationale.

It is also possible to show that there is linear mapping between domestic and export thresholds:

$$\bar{\varphi}_x = \psi \tau_x \bar{\varphi}_h, \quad \text{where} \quad \psi = F_x^{\frac{1}{\sigma-1}} \tag{3.3.3}$$

Managerial income is given by:

$$\pi_h(\varphi) = \frac{1}{\sigma}\left(\frac{\varphi}{\tilde{\varphi}}\right)^{\sigma-1} E \tag{3.3.4}$$

$$\pi_x(\varphi) = \frac{1}{\sigma}\left(\frac{\varphi}{\tilde{\varphi}}\right)^{\sigma-1} E\tau_x^{1-\sigma} - F_x \tag{3.3.5}$$

We can solve this model analytically from the following equation:

$$\pi_h(\bar{\varphi}_h) = \frac{1}{\sigma}\left(\frac{\bar{\varphi}_h}{\tilde{\varphi}}\right)^{\sigma-1} E = 1,$$

where

$$E \equiv \int_1^{\bar{\varphi}_h} \gamma\varphi^{-\gamma-1} d\varphi + \int_{\bar{\varphi}_h}^{\infty} \pi_h(\varphi)\gamma\varphi^{-\gamma-1} d\varphi + \int_{\bar{\varphi}_x}^{\infty} \pi_x(\varphi)\gamma\varphi^{-\gamma-1} d\varphi$$

$$\tilde{\varphi} = \left[\int_{\bar{\varphi}_h}^{\infty} \gamma\varphi^{\sigma-\gamma-2} d\varphi + \tau_x^{1-\sigma} \int_{\bar{\varphi}_x}^{\infty} \gamma\varphi^{\sigma-\gamma-2} d\varphi\right]^{\frac{1}{\sigma-1}}$$

The solution is the equilibrium value

$$\bar{\varphi}_h = \left[\frac{(1+\gamma\sigma-\sigma)\left(1+\psi^{\sigma-\gamma-1}\tau_x^{-\gamma}\right)}{1+\gamma-\sigma}\right]^{\frac{1}{\gamma}} \tag{3.3.6}$$

For this solution to make sense we must assume $1+\gamma-\sigma > 0$. Then aggregate income and productivity are given by

$$E = \frac{\gamma\sigma}{1+\gamma\sigma-\sigma}$$

$$\tilde{\varphi} = \left(\frac{\gamma}{1+\gamma\sigma-\sigma}\right)^{\frac{1}{\sigma-1}} \bar{\varphi}_h \tag{3.3.7}$$

Note that average productivity is proportional to $\bar{\varphi}_h$.

### 3.3.3 Effects of Trade Liberalization on Income and its Distribution

I interpret the rise of globalization in this model as a fall in the variable costs of trading, $\tau_x$. I shall first analyze the effects of this fall on the occupational choice of agents. It should make it easier for the most talented entrepreneurs to expand and sell their products abroad, thereby increasing exports and the demand for labor by exporters, which raises real wages. It should also affect managers' pay negatively through the rise in competition from imported varieties. Both effects make operations less profitable for the least efficient entrepreneurs, pushing some of them from entrepreneurship into the workforce, decreasing the number of entrepreneurs (and domestically produced varieties) in the economy. This result is illustrated in figure 3.3.1 and stated formally in the following lemma (see appendix 3.5 for proofs of the results in this section), a common result of any Melitz-type model:

**Lemma 1.** [Occupational shifts]

*(i)* $d\bar{\varphi}_h/d\tau_x < 0$.

*(ii)* $d\bar{\varphi}_x/d\tau_x > 0$.

Summing up, suppose there is a decrease in $\tau_x$ to $\tau_x'$, and let $x'$ denote the value of variable $x$ after this change. Then:

$$\bar{\varphi}_h < \bar{\varphi}_h' < \bar{\varphi}_x' < \bar{\varphi}_x.$$

so:

- ◇ Individuals in $[1, \bar{\varphi}_h]$ remain as workers,
- ◇ Entrepreneurs in $(\bar{\varphi}_h, \bar{\varphi}_h']$ move out of entrepreneurship and become workers,
- ◇ Entrepreneurs in $(\bar{\varphi}_h', \bar{\varphi}_x']$ keep producing for domestic markets exclusively,

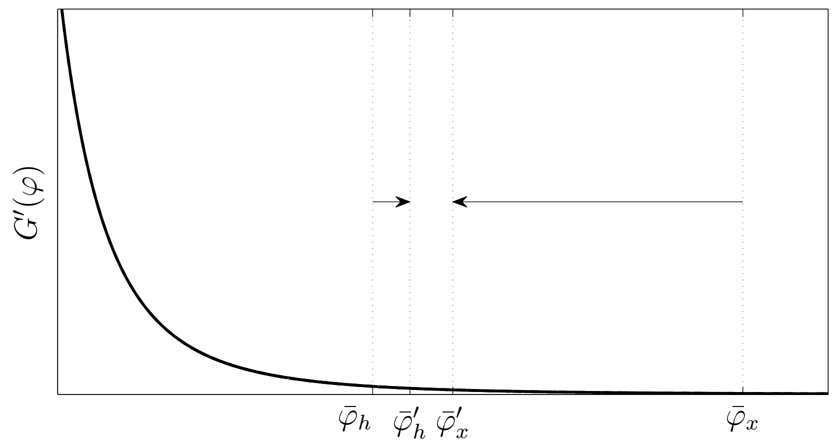


Figure 3.3.1: Occupational shifts after a decrease in $\tau$.

- ◇ Entrepreneurs in $(\bar{\varphi}'_x, \bar{\varphi}_x]$ become exporters,
- ◇ Entrepreneurs in $(\bar{\varphi}_x, \infty]$ continue exporting.

**Corollary.** *A decrease in $\tau_x$ leads to an increase in average productivity $\tilde{\varphi}$.*

This follows from $\tilde{\varphi}$ being proportional to $\bar{\varphi}_h$. Now that the effects on occupations of changes in trade barriers are clear, changes in income may be identified from the following lemmas:

**Lemma 2.** [Absolute gains from trade] *If there is a reduction in $\tau_x$, then*

*(i) domestic income falls for all managers; the size of this loss is increasing in the level of $\varphi$*

*(ii) export income increases for all managers of exporting firms; the size of this gain is increasing in the level of $\varphi$.*

*(iii) if $\psi\tau_x > 1$, there exists an ability level $\hat{\varphi}$* such *that for all $\varphi > \hat{\varphi}$ profit gains in export markets dominate losses in domestic markets, and total gains are increasing in $\varphi$.*

The reduction in transportation costs unambiguously hurts domestic managers' income because it increases competition, but has a positive effect for exporters by decreasing their costs of serving foreign markets. Let $\Delta\pi_h$ and $\Delta\pi_x$ denote the change in profits that occurs after a change in $\tau_x$. Taking advantage of the linearity in $\varphi^{\sigma-1}$ of both expressions, figure 3.3.2 illustrates two possible cases: In the economy with the dotted $\Delta\pi_x$ curve, the first effect dominates so all entrepreneurs have losses. By contrast, in the economy corresponding to the solid $\Delta\pi_x$ curve there exists an ability threshold $\hat{\varphi}$, such that the second effect dominates for all entrepreneurs with abilities greater than $\hat{\varphi}$, and gains are increasing in $\varphi$.

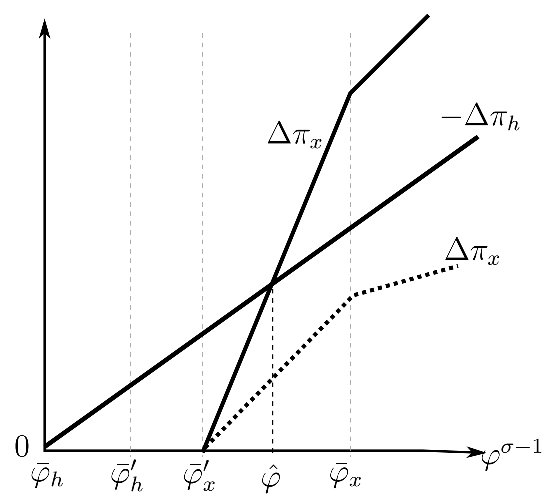


Figure 3.3.2: Economies with and without superstar effects after a decrease in trade barriers (solid and dotted line, respectively). Absolute (left) vs. relative (right) income changes

Condition $\psi\tau_x > 1$ should hold for any reasonable parametrization of the model, since it is natural to expect that $\bar{\varphi}_x > \bar{\varphi}_h$. It is in this second case that we observe what authors have referred to as the *superstar effects* of trade, since the richest, most talented entrepreneurs have the largest gains from the fall in trade barriers.

However, larger absolute gains for better managers is not a sufficient condition for an increase in inequality. It is easy to come up with numerical examples in which the income share of the top percentiles drops despite larger absolute gains. The reason is that gains relative to initial income are larger for exporters who are not at the top. This is illustrated in figure 3.3.3. Relative income change peaks for the entrepreneur with the least ability among those that were previously exporting and decreases for higher levels of ability, as described in the next lemma.

**Lemma 3.** *[Relative gains from trade] If there is a reduction in $\tau_x$, then*

*(i) domestic income falls for all managers relative to its initial level; the size of this loss is the same for any level of $\varphi$ as long as the manager stays in business.*

*(ii) export income increases for all managers of exporting firms relative to its initial level; the size of this gain is decreasing in the level of $\varphi$.*

So what we have here is polarization in one hand, as the least talented entrepreneurs move into the workforce, while the remaining entrepreneurs' benefits expand; on the other hand, we have middle-tier entrepreneurs catching up with the most talented ones, at least in relative terms, at the same time that the gap in absolute terms is widening. The final outcome of this process in terms of inequality is less clear than might have first appeared. In the following sections I try to shed light into this question first by determining the size of these shifts as predicted by the model in a simple calibration exercise. I later contrast predictions of the model with executive compensation data.

### 3.3.4 Calibration

I evaluate in this section whether quantitative predictions of the model square well with what is observed in the data by performing a calibration

Table 3.2: Parametrization of symmetric model, $n = 1$.

| Parameter | Value | Target | Value | Source |
|---|---|---|---|---|
| $\tau_{1975}$ | 2.37 | Exports/GDP 1975 | 6% | NIPA |
| $\tau_{2005}$ | 1.95 | Exports/GDP 2005 | 11% | NIPA |
| $\gamma$ | 3.6 | – | 33% | Ghironi and Melitz (2005) |
| $F_x$ | 0.53 | Fraction of exporters | 21% | Bernard et al. (2003) |
| $\sigma$ | 3.8 | – | – | Ghironi and Melitz (2005) |

of the model. I take common values available in the literature for both the elasticity of substitution parameter $\sigma$ and the dispersion of talent parameter $\gamma$. These are taken from Ghironi and Melitz (2005). The entry cost for entrepreneurs $F_h$ is set to zero, so that the only cost of entry is actually the foregone worker's salary. Otherwise the fraction of entrepreneurs seemed to be unrealistically low. The fixed cost of exporting $F_x$ is set to match the fraction of exporting firms in 1992 (21% according to Bernard et al. (2003), who analyze data from that year's Census of Manufacturers). I then calibrate a series of trade barrier levels to match the exports/GDP ratio from 1970 to 2005 (data from the NIPA). The exports/GDP ratio moves from around 6% in 1970 to about 11% in 2005, which in the model implies a drop in $\tau_x$ from 2.37 to 1.95. These values (including only the most relevant values of the $\tau_x$ series) are listed in table 3.2.

In order to appreciate the effects of this drop in trade barriers on firm managers' pay, I simulate a sample of 10.000 entrepreneurs and follow their income levels throughout the period of simulation. Table 3.3 features a comparison of income shares in the model versus observed income shares from the study of Piketty and Saez (2004). The main result is the *change* in inequality after the fall in trade barriers. The effects of increased trade on income inequality at the top in this very simple setting appear to be tiny and explain little of the changes observed in the data. What seems to explain this result is the simultaneous high elasticity of openness and low elasticity of the top income shares with respect to $\tau_x$, so that a small change in this parameter is enough to achieve the observed changes in trade, but accounts for only very little of the observed changes in income shares. Another way to see this is illustrated in figure 3.3.4. The picture in the left shows the evolution of top CEO income levels, here the changes are almost imperceptible. Notice the huge difference with the picture on the right, which takes a closer look at these changes in the data and illustrates the superstar effect. Higher ranked CEOs have large gains over time, however these gains are very small relative to their levels of income. The top three lines in table 3.3 indicate that the model consistently underestimates the income shares of the higher percentiles, which suggests that the simple Pareto distribution does not do a great job at reproducing the observed distribution of income at higher levels. Using a generalized Pareto distribution, which allows me to make the variance in ability levels as large as necessary, improves the fit of the income distribution at the top, but it doesn't affect the changes in income shares of the top percentiles after the trade liberalization episode significantly.

Results in the preceding section are also tested for robustness to small variations in the model parameters and calibration targets. They were also tested for the introduction of significant asymmetries between countries. None of these tests altered the results qualitatively. There is also a possibility that the fall in trade barriers occurred quite differently for different sectors of the economy. Results from a multi-sector calibration of the model[4] presented in section 3.3.1, which allows for heterogeneity in trade barriers across sectors, lead to the same conclusions presented in the simple one-sector version of the model calibration.

[4] Available by request.

## 3.4 Empirical Evidence

### 3.4.1 Data

To test this theory I use executive compensation data from the Execucomp database, which has entries for top executives of firms in the Compustat database. Execucomp features several measures of executive compensation of differing breadth. I use three of these measures as targets in this study, from narrowest to broadest:

- $SALARY$: the base salary earned by the executive officer during the fiscal year,
- $TOTALCURR$: total current compensation, including salary plus bonus earned by the executive officer during the fiscal year, and
- $TDC1$: total compensation comprised of salary, bonus, other annual compensation not properly categorized as salary or bonus, total value of restricted stock granted to the executive, total value of stock options granted (using Black-Scholes), long-term incentive payouts, and others such as severance payments, payment for unused vacation, etc.

I deflate all three using CPI data from the Bureau of Labor Statistics. Executive compensation is not particularly smooth on a yearly basis; in order to smooth measures out in the data I take three year averages of the 1992-1994 period as initial values and 2003-2005 averages as final values. This has another advantage: since many firms have missing values for some of the years in the sample, I take the average of whatever is available, in order to keep sample size as large as possible. I then take logs of these averages and use the difference as the left hand side of my equation. I follow the same procedure for the variables in the right hand side. There are 1134 firms from manufacturing sectors in the database, about a third of these have compensation data for both time points.

I use value of shipments as a measure of industry output (variable $OUTPUT$), available from the NBER-CES Manufacturing Industry Database[5] at the 6-digit NAICS level up to 2005. I adjust for inflation using the industrial GDP deflator. I use industry-level openness ($OPEN$) as a proxy for barriers to trade[6]. This variable is constructed by adding imports and exports and dividing by the total value of shipments in each industry (using the export-to-GDP ratio leaves results qualitatively unchanged). Imports and exports at the 6-digit NAICS level for the 1989-2005 period are available from Peter K. Schott's website[7]. I also use FDI data from the OECD as a measure of openness since one could easily reinterpret the model in this way (Pica and Mora, 2007) or one could easily extend the model to have both at the same time as in Helpman et al. (2004). FDI data at the industry level is unfortunately aggregated at a much higher level than trade data (2-digit ISIC3 categories which I convert to 3-digit NAICS using the concordance provided by the U.S. Census Bureau) and it is also fairly incomplete prior to 1994, so I use 1994-1996 averages as my initial period whenever I include FDI in the model.

I use a two-stage approach as my estimation procedure. There is a large amount of evidence in the international trade literature pointing towards a strong relationship between firm productivity and firm size (&CITATIONS). I exploit this relationship to construct a measure of productivity ($PROD$) using firm-level data for sales from Compustat in a two-stage approach. Sales are adjusted for inflation using the industrial GDP deflator. Since sales could also be affected by a fall in trade barriers and industry growth, I regress sales on $OUTPUT$ and $OPEN$ (or $FDI$) in a first stage and I then use residuals from this regression as my measure of productivity in my second stage.

[5]http://www.nber.org/data/nbprod2005.html.

[6]Alternatively one could use tariff data, something I intend to add in future versions

[7]http://www.som.yale.edu/faculty/pks4/sub_international.htm.

### 3.4.2 Results

Execucomp provides compensation data for more than one executive per firm and it is not possible to identify in each case which of the executives in the data is the CEO. I therefore aggregate data to the firm level in two different ways: I first take the sum of all executive payments available, this would amount to interpreting the manager in the model as representing the body of top executives in the firm. Results from this strategy are presented in table 3.4. As an alternative route I take the maximum compensation per year of each firm. In most cases this should coincide with the compensation of the CEO. Results from this strategy are presented in table 3.5.

Contrasting both sets of results we observe that the model fits the data from the first strategy better, as the R-squared is consistently higher across all three models. In both tables the fit worsens as the income measure becomes broader. Consistent with the model presented, changes to the productivity proxy are an important predictor of changes in CEO pay. Clearly, it is essential to control for what is going on at the firm level. Moving on to industry level variables, all models estimated also have in common a strong negative effect from industrial output growth, a somewhat striking result that is quite robust. Controlling for firm-level productivity, executive compensation growth has been slower in those industries that have grown fastest over the period of interest[8]. This is in stark contrast with the predictions of the model, and is possibly explained by competition among managers who are eager to participate in thriving industries. The promise of higher earnings due to large productivity gains potentially attracts a lot of managerial talent to these industries. Firms in other industries thus have

[8]Some examples of the fastest growing industries over this period include semiconductor and related device manufacturing, electronic computer manufacturing, computer peripheral manufacturing, semiconductor machinery manufacturing, copper wire drawing, etc.

Table 3.3: Experimental results.

| *'92 Income share of...* | Model | Data |
|---|---|---|
| Top percentile | 13.5% | 13.5% |
| Top quintile | 20.8% | 27.9% |
| Top decile | 25.7% | 39.8% |
| *1980-2001 change in income share of...* | | |
| Top 1% | 0.8 | 9.4 |
| Top 5% | 0.3 | 12.0 |
| Top 10% | 0.0 | 12.0 |

Data sources: NIPA, Piketty & Saez (2004).

Table 3.4: Regression results (sum of all executive pay available by firm).

| | Salary | Total Current | TDC1 |
|---|---|---|---|
| *Intercept* | 0.252*** | 0.376*** | 0.697*** |
| | (0.019) | (0.022) | (0.035) |
| Industry Openness | −0.015 | −0.005 | 0.013 |
| | (0.024) | (0.029) | (0.045) |
| Industry Output | −0.024 | −0.071** | 0.049 |
| | (0.019) | (0.023) | (0.036) |
| Productivity | 0.229*** | 0.305*** | 0.396*** |
| | (0.017) | (0.020) | (0.031) |
| R-squared | 0.317 | 0.366 | 0.303 |
| N | 412 | 412 | 404 |

*** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$

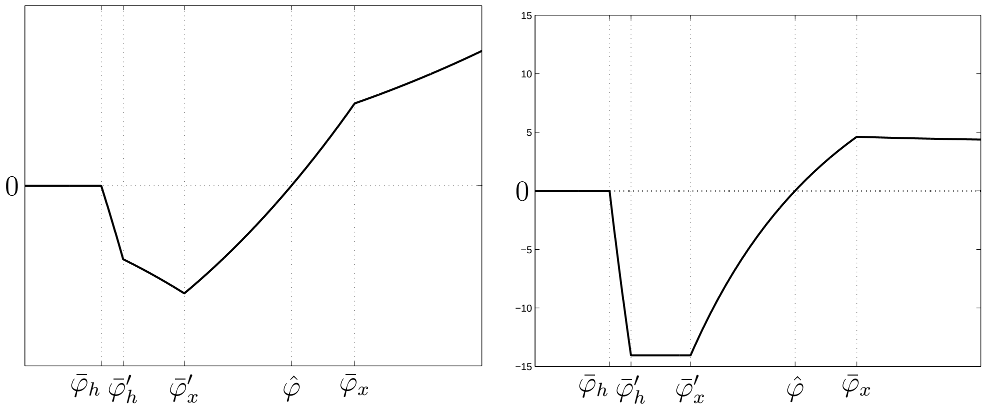


Figure 3.3.3: Absolute (left) vs. relative (right) income changes after decrease from $\tau$ to $\tau'$.

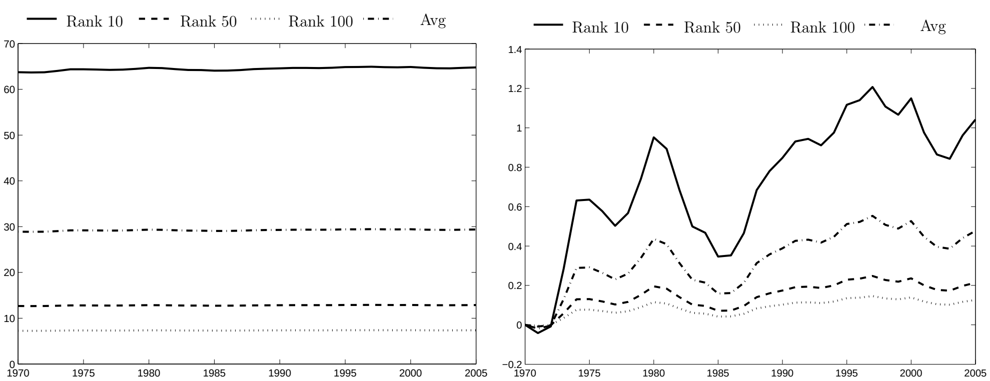


Figure 3.3.4: Top CEO income levels (left) and absolute changes (right) (simulated).

Table 3.5: Regression results (maximum executive pay available by firm).

| | Salary | Total Current | TDC1 |
|---|---|---|---|
| *Intercept* | $0.263^{***}$ | $0.441^{***}$ | $0.698^{***}$ |
| | (0.018) | (0.027) | (0.039) |
| Industry Openness | $-0.049^{*}$ | $-0.036$ | $-0.025$ |
| | (0.023) | (0.035) | (0.052) |
| Industry Output | $-0.044^{*}$ | $-0.092^{**}$ | 0.022 |
| | (0.018) | (0.028) | (0.040) |
| Productivity | $0.202^{***}$ | $0.289^{***}$ | $0.382^{***}$ |
| | (0.016) | (0.024) | (0.035) |
| R-squared | 0.286 | 0.264 | 0.237 |
| N | 412 | 412 | 404 |

$^{***}\ p < 0.001$ $^{**}\ p < 0.01$ $^{*}\ p < 0.05$

to raise earnings faster in order to keep up and secure the quality of their management. In the model the manager is inseparable from the firm so this element of competition for scarce managerial talent is completely absent. A model in the lines of Gabaix and Landier (2008) is probably better suited to capture this effect.

Finally, consider the effects of increasing openness at the industry level. In table 3.4 this effect is small and not significant for any of the three measures of income. In table 3.5 this effect is slightly larger but still only significant at the 5% level for the narrowest measure of income. In fact, with the only exception of the third column in table 3.4, all estimates have the opposite sign to what the theory suggests. Note that more international trade has stronger negative effects on salary growth for narrower measures of compensation. Interestingly, this appears to be consistent with results by Cuñat and Guadalupe (2009), who suggest that increased competition for imports forces firms to move away from compensation schemes that emphasize fixed compensation towards compensation schemes that empha-

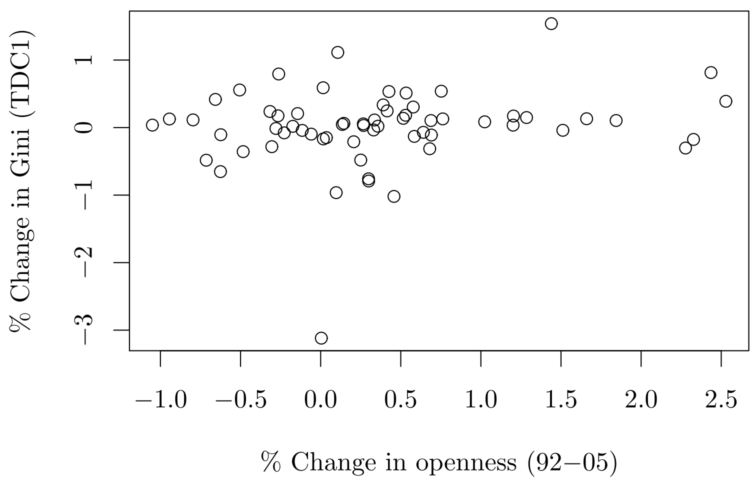


Figure 3.4.1: Change in pay inequality as measured by Gini index (using TDC1) vs. change in openness by six-digit NAICS code.

size pay-for-performance. The magnitudes of these effects do not appear to be symmetric: the positive effect on $TDC1$ appears to be much more meaningful than the negative effects on $Salary$, which appears to be quite small.

I also find no evidence suggesting that inequality in executive pay has increased more in those industries where trade has grown more rapidly, as the theory would suggest. Figure 3.4.1 plots percentage changes in the Gini index of executive pay (TDC1) against percentage changes in openness by six-digit industry in manufacturing for the period between 1992 and 2005. There appears to be no relationship between these two variables, a result that is robust to the use of other compensation measures and periods.

These results appear to be consistent with those in the previous section: While firm-level changes explain a large fraction of the growth in executive compensation, changes that affect industrial trade aggregates do not seem to be meaningfully related to compensation changes.

## 3.5 Conclusions

In an environment with heterogeneous entrepreneurs and monopolistic competition, trade liberalization may induce superstar effects on the pay of top firm executives. However, if the model is adjusted to reflect some observed characteristics of the US economy, this effect seems to be modest and only explains a small fraction of the observed increases in income inequality at the top of the income distribution. Furthermore, it has been shown that changes in executive compensation observed in firm level data are only weakly related to changes in industry-level changes in trade volumes, suggesting that trade liberalization is not by itself an important driver of rising executive compensation or increasing income inequality.

In all experiments, the changes in trade barriers required to match observed shifts in the volume of trade are too small to produce any noticeable changes in the dispersion of income levels among the highest paid executives. This would appear to conflict with the obvious fact that many firms have grown tremendously over the past few decades by expanding their sales to foreign markets. But this is not ruled out by this result, it does not imply that increases in firm level exports have nothing to do with the level of executive compensation. If a manager can increase export market participation, and this in turn has an effect over firm size, then by Gabaix and Landier's argument this could lead to a significant rise in the manager's pay. Firms can individually grow in domestic as well as foreign markets by finding out ways to make their products better or more affordable to consumers (in the model this is equivalent to an increase in productivity). However what this paper suggests is that a fall in trade barriers can not account for the rise in executive compensation inequality. In other words, increases in executive compensation levels as well as higher inequality of pay among managers should not be attributed to increasing openness in trade. It follows that changes that have occurred primarily at the firm level are the most likely source of the rise in executive pay inequality. Globalization leverages these changes in unprecedented ways, but it is not by itself the cause of increased inequality, nor is trade openness necessarily the main driver of globalization; technology, the possibility for corporations to scale up internationally, or outsourcing are equally likely culprits. It is also important to keep in mind that this result could change if increases in the level of trade had a significant impact on competition for scarce executive talent in labor markets or, as argued by Cuñat and Guadalupe (2009), if trade elicits changes in the structure of executive compensation. I believe these are questions that merit further research.

# Mathematical Proofs

### Lemma 1

From (3.3.6) follows:

$$\frac{\partial \bar{\varphi}_h}{\partial \tau} = -\bar{\varphi}_h \frac{\psi^{\sigma-\gamma-1}\tau_x^{-\gamma-1}}{1+\psi^{\sigma-\gamma-1}\tau_x^{-\gamma}} < 0.$$

Then since $\bar{\varphi}_x = \psi\tau_x\bar{\varphi}_h$:

$$\frac{\partial \bar{\varphi}_x}{\partial \tau} = \psi\bar{\varphi}_h + \psi\tau_x\frac{\partial \bar{\varphi}_h}{\partial \tau} = \psi\bar{\varphi}_h\left[1 - \frac{\psi^{\sigma-\gamma-1}\tau_x^{-\gamma}}{1+\psi^{\sigma-\gamma-1}\tau_x^{-\gamma}}\right] > 0$$

because the expression in brackets is clearly positive. This completes the proof of lemma 1.

**Lemma 2**

Now let $\tilde{\varphi} = \kappa\bar{\varphi}_h$, where $\kappa$ is a constant following (3.3.7), so that $\partial\tilde{\varphi}/\partial\tau = \kappa\,\partial\bar{\varphi}_h/\partial\tau$. Then from (3.3.4) one obtains:

$$\frac{\partial\pi_h}{\partial\tau} = \frac{\sigma-1}{\sigma}\left(\frac{\varphi}{\tilde{\varphi}}\right)^{\sigma-1} E\frac{\psi^{\sigma-\gamma-1}\tau_x^{-\gamma-1}}{1+\psi^{\sigma-\gamma-1}\tau_x^{-\gamma}} > 0.$$

Together with

$$\frac{\partial\pi_h}{\partial\tau\,\partial\varphi} = \frac{\sigma-1}{\varphi}\frac{\partial\pi_h}{\partial\tau} > 0,$$

the last result proves part $i$ of lemma 2.

To prove part $ii$ one has to split $\pi_x$ in two intervals. In the first interval there is everyone who wasn't exporting before and becomes an exporter after a decrease in trade barriers. These entrepreneurs obviously have some gains given by (3.3.5), which are increasing in $\varphi$. For everyone already exporting, one proceeds in a similar way to the previous lemma and shows:

$$\frac{\partial\pi_x}{\partial\tau} = \frac{\sigma-1}{\sigma}\left(\frac{\varphi}{\tilde{\varphi}}\right)^{\sigma-1} E\tau_x^{-\sigma}\left[\frac{\psi^{\sigma-\gamma-1}\tau_x^{-\gamma}}{1+\psi^{\sigma-\gamma-1}\tau_x^{-\gamma}} - 1\right] < 0,$$

which holds because as argued above the expression in brackets is negative. This result together with

$$\frac{\partial\pi_x}{\partial\tau\,\varphi} = \frac{\sigma-1}{\varphi}\frac{\partial\pi_x}{\partial\tau} < 0.$$

completes the proof of part $ii$.

Finally, it was argued in part $iii$ that export market gains dominate domestic market losses for all individuals with ability levels greater than $\hat{\varphi}$. One obtains this threshold from the equality $\pi_x' = \pi_h - \pi_h'$, which gives

$$\hat{\varphi} = \left(\frac{F_x}{\left(1+\tau_x'^{\,1-\sigma}\right)\bar{\varphi}_h'^{\,1-\sigma} - \bar{\varphi}_h^{1-\sigma}}\right)^{\frac{1}{\sigma-1}}.$$

Existence of this threshold requires

$$\frac{\partial m}{\partial\tau} = \frac{d\pi_h}{d\tau} + \frac{d\pi_x}{d\tau} = \frac{\sigma-1}{\sigma}\left(\frac{\varphi}{\tilde{\varphi}}\right)^{\sigma-1} E\tau_x^{-\sigma}\left[(1+\tau_x^{\sigma-1})\frac{\psi^{\sigma-\gamma-1}\tau_x^{-\gamma}}{1+\psi^{\sigma-\gamma-1}\tau_x^{-\gamma}} - 1\right] < 0.$$

For this to hold the expression in brackets must be negative. It is easy to show that this is the case whenever $\tau_x \psi > 1$. If this is true then it must also be the case that

$$\frac{\partial m}{\partial \tau \, \partial \varphi} = \frac{\sigma - 1}{\varphi} \frac{\partial m}{\partial \tau} < 0,$$

which completes this proof.

**Lemma 3**

Using log-derivatives to approximate relative changes:

$$\frac{\partial \pi_h / \partial \tau}{\pi_h} = (\sigma - 1) \frac{\psi^{\sigma-\gamma-1} \tau_x^{-\gamma-1}}{1 + \psi^{\sigma-\gamma-1} \tau_x^{-\gamma}}$$

This expression is positive and not dependent on $\varphi$, then it must be the same for all individuals, which proves part *(i)*.

Analogously for export income, since absolute changes are positive then relative changes must be positive too:

$$\frac{\frac{\partial \pi_x}{\partial \tau}}{\pi_x} = \frac{\frac{\sigma-1}{\sigma} \left(\frac{\varphi}{\tilde{\varphi}}\right)^{\sigma-1} E \tau_x^{-\sigma} \left[\frac{\psi^{\sigma-\gamma-1} \tau_x^{-\gamma}}{1+\psi^{\sigma-\gamma-1} \tau_x^{-\gamma}} - 1\right]}{\frac{1}{\sigma} \left(\frac{\varphi}{\tilde{\varphi}}\right)^{\sigma-1} E \tau_x^{1-\sigma} - F_x}.$$

Taking the derivative of this expression with respect to $\varphi$:

$$\frac{K_1(\sigma - 1)\varphi^{\sigma-2} \left(K_2 \varphi^{\sigma-1} - F_x\right) - K_1 \varphi^{\sigma-1} K_2 (\sigma - 1) \varphi^{\sigma-2}}{\pi_x^2} = -\frac{K_1(\sigma - 1)\varphi^{\sigma-2} F_x}{\pi_x^2},$$

where $K_1$ and $K_2$ are positive constants, hence this expression is negative. Note that it is also decreasing as long as $\sigma > 2$.

# Bibliography


AHN, J. (2011): "A Theory of Domestic and International Trade Finance," *IMF Working Papers*.

AHN, J., M. AMITI, AND D. WEINSTEIN (2011): "Trade finance and the great trade collapse," *The American Economic Review*, 101, 298–302.

AMARAL, P. S. AND E. QUINTIN (2005): "Finance matters," Center for Latin America Working Papers 0104, Federal Reserve Bank of Dallas.

AMITI, M. AND D. WEINSTEIN (2009): "Exports and financial shocks," *NBER Working Paper*.

ASMUNDSON, I., T. DORSEY, A. KHACHATRYAN, I. NICULCEA, AND M. SAITO (2011): "Trade Finance in the 2008–09 Financial Crisis: Evidence from IMF and BAFT–IFSA Surveys of Banks," *Trade Finance During the Great Trade Collapse, The World Bank, Washington DC*, 89–116.

——— (2009b): "Restoring trade finance during a period of financial crisis: Stock-taking of recent initiatives," *World Trade Organization (WTO) Economic Research and Statistics Division (December)*.

BACKUS, D., P. KEHOE, AND F. KYDLAND (1992): "International real business cycles," *The Journal of Political Economy*, 100, 745–775.

——— (1994): "Dynamics of the trade balance and the terms of trade: The J-curve?" *The American Economic Review*, 84, 84–103.

Backus, D. and G. Smith (1993): "Consumption and real exchange rates in dynamic economies with non-traded goods," *Journal of International Economics*, 35, 297–316.

Backus, D. K. and M. J. Crucini (2000): "Oil prices and the terms of trade," *Journal of International Economics*, 50, 185–213.

Bakija, J., A. Cole, and B. T. Heim (2010): "Jobs and Income Growth of Top Earners and the Causes of Changing Income Inequality: Evidence from U.S. Tax Return Data," .

Baxter, M. and M. Crucini (1995): "Business Cycles and the Asset Structure of Foreign Trade," *International Economic Review*, 36, 821–854.

Bennedsen, M., F. Pérez-González, and D. Wolfenzon (2009): "Do CEOs Matter?" .

Berman, N., J. de Sousa, P. Martin, and T. Mayer (2011): "Time to ship during financial crises," Tech. rep., Mimeo.

Berman, N. and P. Martin (2010): *The vulnerability of sub-Saharan Africa to the financial crisis: the case of trade*, Centre for Economic Policy Research.

Bernard, A. B., J. Eaton, J. B. Jensen, and S. Kortum (2003): "Plants and Productivity in International Trade," *American Economic Review*, 93, 1268–1290.

Chaney, T. (2005): "Liquidity constrained exporters," Mimeo, University of Chicago.

Corsetti, G., L. Dedola, and S. Leduc (2008): "International risk sharing and the transmission of productivity shocks," *Review of Economic Studies*, 75, 443–473.

Cuñat, V. and M. Guadalupe (2009): "Globalization and the Provision of Incentives Inside the Firm: The Effect of Foreign Competition," *Journal of Labor Economics*.

Eaton, J., S. Kortum, B. Neiman, and J. Romalis (2009): "Trade and the Global Recession," Tech. rep., mimeo.

Egger, H. and U. Kreickemeier (2009): "Firm Heterogeneity And The Labor Market Effects Of Trade Liberalization*," *International Economic Review*, 50, 187–216.

——— (2011): "Fairness, Trade, and Inequality," *Journal of International Economics*.

Ellingsen, T. and J. Vlachos (2009): "Trade finance in a liquidity crisis," *World Bank Policy Research Working Paper*, 5136.

Engel, C. and J. Wang (2011): "International trade in durable goods: Understanding volatility, cyclicality, and elasticities," *Journal of International Economics*, 83, 37–52.

Eozenou, P. (2008): "Financial Integration and Macroeconomic Volatility: Does Financial Development Matter?" Mpra paper, University Library of Munich, Germany.

Feenstra, R. and G. Hanson (1996): "Globalization, outsourcing, and wage inequality," *The American Economic Review*, 86, 240–245.

Feenstra, R., Z. Li, and M. Yu (2011): "Exports and credit constraints under incomplete information: Theory and evidence from china," Tech. rep., National Bureau of Economic Research.

Fisman, R. and I. Love (2003): "Trade credit, financial intermediary development, and industry growth," *The Journal of Finance*, 58, 353–374.

Fontagné, L. and G. Gaulier (2009): "French exporters and the global crisis," in *The Great Trade Collapse: Causes, Consequences and Prospects*, ed. by R. Baldwin, CEPR for VoxEU.org, chap. 16, 143–150.

Gabaix, X. and A. Landier (2008): "Why has CEO pay increased so much?" *Quarterly Journal of Economics*, 49–100.

Ghironi, F. and M. J. Melitz (2005): "International Trade and Macroeconomic Dynamics with Heterogeneous Firms," *The Quarterly Journal of Economics*, 120, 865–915.

Greenwood, J., Z. Hercowitz, and G. Huffman (1988): "Investment, capacity utilization, and the real business cycle," *The American Economic Review*, 402–417.

Heathcote, J. and F. Perri (2002): "Financial autarky and international business cycles," *Journal of Monetary Economics*, 49, 601–627.

Helpman, E., O. Itskhoki, and S. Redding (2010): "Inequality and unemployment in a global economy," *Econometrica*, 78, 1239–1283.

Helpman, E., M. Melitz, and S. Yeaple (2004): "Export versus FDI with heterogeneous firms," *American Economic Review*, 94, 300–316.

Humphrey, J. (2009): "Are exporters in Africa facing reduced availability of trade finance?" *IDS Bulletin*, 40, 28–37.

Iacovone, L. and V. Zavacka (2009): "Banking Crises and Exports: Lessons from the Past," *World Bank*.

Johnson, D., S. B. Reed, and K. J. Stewart (2006): "Price measurement in the United States: a decade after the Boskin Report," *Monthly Lab. Rev.*, 129, 10.

Kalemli-Ozcan, S., E. Papaioannou, and F. Perri (2012): "Global banks and crisis transmission," *Journal of International Economics*.

Kaplan, S. and J. Rauh (2010): "Wall Street and Main Street: What Contributes to the Rise in the Highest Incomes?" *Review of Financial Studies*, 23, 1004.

Kose, M., E. Prasad, and M. Terrones (2003a): "How does globalization affect the synchronization of business cycles?" *The American Economic Review*, 93, 57–62.

Levchenko, A., L. Lewis, and L. Tesar (2009): "The Collapse of International Trade During the 2008-2009 Crisis: In Search of the Smoking Gun," *University of Michigan, mimeo.*

Levine, R. (2005): "Finance and growth: Theory and evidence," *Handbook of economic growth*, 1, 865–934.

Love, I., L. Preve, and V. Sarria-Allende (2007): "Trade credit and bank credit: evidence from recent financial crises," *Journal of Financial Economics*, 83, 453–469.

Lucas, R. E. (1978): "On the Size Distribution of Business Firms," *Bell Journal of Economics*, 9, 508–523.

Malouche, M. (2009): "Trade and trade finance developments in 14 developing countries post September 2008-a World Bank survey," .

Manasse, P. and A. Turrini (2001): "Trade, wages, and 'superstars'," *Journal of International Economics*, 54, 97 – 117.

Mandelman, F., P. Rabanal, J. Rubio-Ramírezc, and D. Vilán (2011): "Investment-specific technology shocks and international business cycles: An empirical assessment," *Review of Economic Dynamics*, 14, 136–155.

——— (2008b): "Credit constraints, heterogeneous firms, and international trade," .

Manova, K., S.-J. Wei, and Z. Zhang (2009): "Firm Exports and Multinational Activity under Credit Constraints," Tech. rep.

Melitz, M. J. (2003): "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 71, 1695–1725.

Monte, F. (2010): "Skill Bias, Trade, and Wage Dispersion," *Journal of International Economics*, doi: 10.1016/j.jinteco.2010.11.004.

Mora, J. and W. Powers (2009): "Did trade credit problems deepen the great trade collapse?" in *The Great Trade Collapse: Causes, Consequences and Prospects*, ed. by R. Baldwin, CEPR for VoxEU.org, chap. 14, 115–125.

Morel, F. (2010): "Credit insurance in support of international trade: Observations throughout the crisis," in *Trade Finance during the Great Trade Collapse*, ed. by J.-P. Chauffour and M. Malouche, The World Bank, chap. 20, 337–355.

Murphy, K. (1999): "Executive compensation," in *Handbook of Labor Economics*, Elsevier, vol. 3, 2485–2563.

Nguyen, B. and K. Nielsen (2010): "What Death Can Tell: Are Executives Paid for Their Contributions to Firm Value?" .

Papaioannou, E. (2007): "Finance and growth-a macroeconomic assessment of the evidence from a European angle," *Working Paper Series*.

Paravisini, D., V. Rappoport, P. Schnabl, and D. Wolfenzon (2011): "Dissecting the effect of credit supply on trade: Evidence from matched credit-export data," Tech. rep., National Bureau of Economic Research.

Pica, G. and J. Mora (2007): "Who is afraid of a globalized world? FDI and the allocation of talent," .

Piketty, T. and E. Saez (2004): *Income and Wage Inequality in the United States, 1913-2002*, Oxford University Press, chap. 5, 141–195.

Raffo, A. (2008): "Net exports, consumption volatility and international business cycle models," *Journal of International Economics*, 75, 14–29.

——— (2010): "Technology shocks: novel implications for international business cycles," *International Finance Discussion Papers*.

Rosen, S. (1981): "The Economics of Superstars," *American Economic Review*, 71, 845–58.

Schott, P. K. (2009): "US trade margins during the 2008 crisis," in *The Great Trade Collapse: Causes, Consequences and Prospects*, ed. by R. Baldwin, CEPR for VoxEU.org, chap. 15, 127–142.

Stockman, A. and L. Tesar (1995): "Tastes and Technology in a Two-Country Model of the Business Cycle: Explaining International Comovements," *The American Economic Review*, 85, 168–185.

Van der Veer, K. (2011): "The Private Credit Insurance Effect on Trade," *DNB Working Papers*.

Wasshausen, D. and B. Moulton (2006): "The role of hedonic methods in measuring real GDP in the United States," *BEA Papers*.

WILNER, B. (2000): "The exploitation of relationships in financial distress: The case of trade credit," *The Journal of Finance*, 55, 153–178.

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