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# Essays on Information Technology, Multinational Firms and Asset Prices

A dissertation submitted in partial satisfaction
of the requirements for the degree
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by

Manolis Chatzikonstantinou

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ABSTRACT OF THE DISSERTATION

Essays on Information Technology, Multinational Firms and Asset Prices

by

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Doctor of Philosophy in Economics
University of California, Los Angeles, 2021
Professor Pierre Olivier Weill, Chair

In the first chapter of this dissertation I study the implications of Information Technology for Asset Prices. Using a comprehensive index of industry-level IT intensity, I uncover several empirical regularities in the cross section of equity returns over the past three decades: 1. Controlling for other commonly used factors, portfolios with exposure to industries with high IT intensity have on average 7% higher annual stock returns, suggesting industry-level IT intensity affects industry risk in a systematic way, 2. These risk premia are driven by firms in industries with a large presence of foreign multinationals, 3.These excess returns are not driven by High Tech sectors or the dot.com bubble. I formalize these empirical regularities through a two-country general equilibrium model with heterogeneous industries, allowing for differential IT adoption across industries and time variation in entry of multinational firms. Multinational firms operating outside of their headquarters are larger and more productive and adopt IT to operate more efficiently. The entry of multinational firms

increases competition for domestic producers and displaces sales of unproductive incumbents. This framework emphasizes the channel of displacement risk through large productive multinational firms consistent with the literature on the effect of Information Technology on the expansion of large productive firms. Investors in industries with IT intensity, if incompletely diversified across countries and sectors, require larger returns to hold portfolios of smaller domestic firms in IT intensive industries and industries with a large share of sales dominated by multinational firms. Consistent with the model, the risk premium is higher for smaller firms and the effect of IT is amplified in industries with a larger share of foreign firms or more product substitutability.

In the second chapter of this dissertation, I examine the relationship between information and communication technology, multinational activity and displacement risk for firms in United States. I use detailed data from Compustat on all public firms to create consistent measures of foreign sales of firms in the United States and abroad and present a description of how IT affects the level of overall concentration in the United States and foreign entry and competition. My results indicate a positive relation between foreign competition and IT adoption rates across US industries, that potentially explains the negative effects of IT on market shares of US domestic firms. The results challenge the common wisdom about IT and dominant firms in the United States economy and shed light on the observed productivity gaps between leaders and laggards. In particular, the mechanism supported from the data is one where large multinational firms gain from IT and displace domestic firms' market shares leading to a reallocation of sales to incumbent multinationals that become more productive.

The dissertation of Manolis Chatzikonstantinou is approved.

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2021

*To my family, and my wife Ioanna*

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# CHAPTER 1

# Information Technology, Multinational Firms and Asset Returns

## 1.1 Introduction

The impact of commercial IT adoption in the United States and other developed countries has received renewed interest as these countries experienced a large increase in the share of large multinational firms, as measured using the sales share of top 4 or top 20 firms within industries or the entry of foreign multinationals in the United States. During the wave of computerization, the United States economy witnessed a large increase in sales of foreign multinationals. Firms engaged in foreign operations, enabled by lower communication frictions due to the IT revolution, entered new markets and expanded their operations.

Analyzing sales data of domestic and foreign firms across industries in the United States, I show that the increase in the IT intensity of sectors at the national level is accompanied by a large increase of the share of foreign firms, while sectors with a higher level of IT adoption, are consistently dominated by foreign multinational firms. The growth in IT use, driven by large domestic and multinational firms undertaking large IT investments,[1] affects the level of price competition faced by smaller less productive domestic firms[2]. These trends in IT adoption and the growing importance of large firms is hypothesized to be partly driving the higher valuation of firms in some sectors of the economy. In this paper I ask the question, is it true that differential costs in the adoption of IT across industries affects small firms negatively, due to displacement of their market share?[3] If so, how do lower IT costs affect investors and the valuation of public firms in these sectors? Can we use variation from available foreign firms' operations statistics to understand the effect of IT on displacement and stock returns?

I contribute to the literature studying the impact of the IT revolution, first by providing evidence that the level of IT intensity of an industry systematically predicts larger equity risk premia in the cross section and that these risk premia are driven by industries with high foreign competition. I rationalize the empirical findings by incorporating the decision to invest in IT and operate foreign establishments in a production based asset pricing model. Controlling for factors that may drive industry risk premia, I document that industries that use IT intensively have on average 7% annual stock returns in excess of the returns of industries that do not

[1] Business software and big data centers are prominent examples of technologies with declining prices, enabling firms to expand geographically. The growth of such IT inputs in firms' production has been exponential. Software investments during this decade account for 18% of corporate investments, while they were only 3% in 1980 (BEA).

[2] IT investments are mostly implemented by large firms due to the presence of large fixed costs, and thus productivity gains from IT are not shared more broadly beyond the top firms. Similarly, in contemporaneous work, Bessen (2020b) provides evidence that the share of the top 4 incumbent firms in an industry is larger in industries that use IT more intensively.

[3] See for example `https://www.schroders.com/de/sysglobalassets/digital/insights/2019/pdfs/2019_nov_rise-of-the-superstar-firms_cs2060.pdf` for a market analysis of the recent trends in concentration and their implications for investors.

use IT intensively and that this risk premium in increasing in the level of foreign competition. This fact is not sufficient to determine the pricing of industry risk faced by investors exposed to IT intensive industries and foreign competition. A model incorporating the decision to adopt IT by multinational firms is consistent with the evidence on the increasing share of foreign firms and provides testable implications that help pin down if the excess returns are due to higher risk of displacement of relatively less productive domestic firms. I test the predictions of the model and provide evidence that excess returns are even larger for smaller firms and more competitive sectors, due to a larger elasticity of substitution of goods, consistent with a mechanism emphasizing the risk of displacement.

To understand the impact that the IT revolution, such as the internet and communications revolution in the 1990 has on product and financial markets, I measure the level of IT intensity at the industry level based on information of IT use in the description of different occupations and the relative employment of those occupations across industries in the United States. In particular, I create a measure of IT intensity based on the description of occupations and the labor - occupation - composition in each industry using data from the U.S. Census Current Population Survey. Using this measure of IT intensity, which reflects the extend to with which industries employ workers that use frequently IT, I provide evidence on the impact IT has on foreign multinationals' market share, profitability and risk premia. I then explore the effect of IT intensity on asset prices. I sort stocks into five portfolios, based on the extend of the IT intensity at the corresponding industry each year, as measured by my index.[4] I find that an investment strategy with a long

[4]The portfolios are formed according to quintiles of a measure of IT intensity, based on the labor composition of each industry and the level of IT use at each occupation, which is described with

position in the high IT quintile and a short position in the low IT quintile had on average large annual excess returns the last thirty years. Investors command a risk premium of approximately 4% and a Sharpe ratio of 0.3. Controlling for common industry factors, these expected returns become 7%, implying that common industry factors do not explain the sizable risk premia driven by IT intensity at the industry level. Splitting the sample into manufacturing and service industries or removing industries related to the production of IT and high technology goods does not affect the estimated impact of IT adoption on excess returns. Using different sub-samples over time shows that the risk premium remains significant over the sample period 1991-2013, with the exception of the period 2009-2013. Lastly, I sort stocks both based on the extend of the IT intensity at the corresponding industry each year and the sales share of foreign firms at each industry and I find that the IT related risk premia are increasing in the level of concentration by foreign multinationals, as proxied by their market share.

The empirical analysis begs the question: what drives the excess returns to IT-heavy industries, why are the excess returns increasing in the level of multinationals' market share, and why, in the absence of arbitrage, investors require higher premia for holding stocks in industries whose operations depend more on IT? If IT amplifies the reaction of the sales share of large, multinational firms across markets to aggregate productivity shocks, this implies that the use of IT systematically affects the risk faced by smaller, domestic only, firms within the more IT intensive industries and as a result, also systematically increases the risk faced by investors holding equity in these firms. To investigate the economic mechanism driving the differences in risk

more detail in section 3.

premia across industries, I formalize this intuition developing a production based asset pricing model with endogenous establishment entry across two countries, and a choice for firms to use IT technology to enhance their productivity in a foreign country. Firms may operate across countries, choosing whether to operate outside of their headquarters' market, and earn monopolistic rents from their operations. Firms decide whether to create an establishment in a country based on the monopoly rents they earn and the corresponding operating cost . Lastly, firms choose whether to adopt IT based on the operating cost of IT and the efficiency gains associated with transferring know how to a different country. Firm rents and the dynamics of consumption across countries jointly determine firms' valuations.

I derive predictions for the effect of aggregate foreign and domestic productivity shocks on profits of small and large firms, and the consumption and wealth effects to the representative consumer in each country. Based on the reaction of profits[5] and consumption to aggregate shocks, the model provides empirical tests that help identify how investors perceive the IT-related displacement risk[6] and how it is priced in the cross-section of equity returns. In particular, the difference in excess returns across industries with different IT intensity should be higher for smaller and less productive firms, which are the firms hit the hardest by foreign multinationals. Using these model predictions, I show how asset prices inform us about the risk of increased competition across industries, induced by the revolution in IT. In summary, the results are consistent with the production asset pricing theories emphasizing the risk faced by investors due to the threat of entry and competition (Barrot et al. (2019);

[5]In the model, profits and dividends move one to one, since firms do not make dynamic decisions.

[6]Displacement risk is driven by large firms expanding to different markets after positive aggregate productivity shocks, and it differs based on the level of IT adoption of each industry.

Loualiche (2020)).

## 1.2 Literature Review

This paper relates to three main strands of the literature. First, the paper relates to the extended literature that studies the IT revolution and its implications on product markets. In the international trade literature, a large number of papers document the importance of IT on the internationalization of firms. Keller and Yeaple (2013) provide evidence on the impact IT has on the organization of the international operation of firms.

Several recent papers in macroeconomics, document also the contribution of IT on the increase in sales concentration and profitability of large firms. Crouzet and Eberly (2020) show that intangibles affect the productivity of leading U.S. public firms. Bessen (2017); Bessen et al. (2020) find that sectors experiencing a greater increase in concentration use more intensively intangible capital and Information Technology. Firm-level evidence on how IT affects sales of firms by increasing scale economies at the firm level, is provided in Lashkari et al. (2020) and De Ridder (2020).

I contribute empirically to this literature relating the intensity with which IT is used across industries with the displacement risk for smaller firms and excess returns for investors, while I provide novel facts on the relationship of foreign multinationals' operations in the United States and the employment of IT intensive occupations across different industries. In addition, theoretically I model a two-country economy with firm heterogeneity and differential IT use at the industry level and test the theoretical asset pricing implications. In contemporaneous work, Aghion et al. (2020)

present a model where the rise of IT complements managerial productivity, and thus ex-ante productive firms grow larger. In contrast, firms in my model grow larger because of productivity enhancements in operation of different establishments. Similarly, they emphasize how as IT becomes cheaper, firms become more likely to face productive competitors. In a similar vein, De Ridder (2020) shows that the IT revolution gains are concentrated among a small group of high-intangible firms, that grow larger.

There is a much smaller literature in Empirical Finance related to asset prices that this paper relates to, due to the emphasis on the risk faced by investors with exposure on industries with high IT intensity. This literature developed after the early waves of IT adoption and examines the asset pricing implication of IT capital deepening. Greenwood and Jovanovic (1999) claim that in the early years of the IT revolution, young firms gained competitive advantage due to differences in vintage capital and the lower adjustment costs they faced. Consistent with this view, Hobijn and Jovanovic (2001) provide empirical support, showing that the stock-market incumbents of the day were not ready to implement IT. As a result, entering firms that would bring in the new technology after the mid-1980s would displace incumbent firms. In contrast, I emphasize a different channel due to the adoption of IT by large firms and the profit displacement it caused to smaller domestic firms. The paper that is most closely related to mine is Chun et al. (2008). As in my empirical analysis, they show that traditional U.S. industries that use Information Technology (IT) more intensively have larger average firm-level stock returns. I complement these facts by analysing the relationship of IT and excess returns at a more dis-aggregated level than they do and empirically showing that the risk premia are not driven by unexpected events or pricing errors of investors, but by the displacement risk that smaller firms face in these industries. In addition, I provide evidence that the risk premia associated with IT are amplified by the level of foreign competition. In contrast to the mechanism put forth in my paper, they argue that the risk is driven by small and young firms adopting IT and displacing established incumbents. In contrast, I explore a mechanism where IT requires large operating costs and thus mostly large incumbents adopt adding more establishments and displacing smaller incumbents. Consistent with the model mechanism, I provide evidence that the IT risk premia are larger for smaller firms.

Last but not least, the empirical facts and the theoretical framework in my model is related to a fast-growing literature on competition, entry and asset prices at the intersection of finance and international macroeconomics. Examples of papers studying the implications of production across locations on asset prices, include Fillat and Garetto (2015b) and Fillat et al. (2015). These papers explore the cross sectional returns of firms in models that incorporate endogenous decisions by firms on whether to engage in multinational production, similar to the choice to operate multiple establishments in this paper. One of the main findings in these papers is that multinational corporations earn higher excess returns than non multinationals. This literature emphasizes the impact that the sunk costs of multinational entry has as a source of increasing riskiness for firms operating in multiple markets. In contrast, in my framework, production across locations leads to higher displacement risk for firms that have concentrated sales geographically, as the span of control for managers in large firms increases. In that sense, the paper is related among others with an emerging production asset pricing literature with emphasis on firm entry and displacement risk, see Loualiche (2020), Corhay et al. (2020) and Bustamante and Donangelo (2016). This literature shows that the risk coming from firm entry is priced in the cross-section of expected returns. In a recent and closely related paper, Barrot et al. (2019) focus on risks associated with import competition and find that firms more exposed to import competition command a sizeable positive risk premium. They create a methodology to uncover if the risk from globalization is priced positively or negatively by investors. I follow their methodology to show that the pricing of risk associated with the industry level IT intensity is negative and is related to displacement of smaller firms by large firms.

## 1.3 Data and Measurement

This section provides a short summary of variables used for the analysis of equity returns. More details can be found in the Appendix.

### 1.3.1 Firm-level Data

#### 1.3.1.1 Measuring IT Intensity across industries

To analyse the impact IT had in the riskiness of industries in the United States, measures of Information Technology adoption at the firm level would be required. This would allow to have a measure of exposure to the differential adoption of Information Technology across industries using firm level variation. Such a measure[7] is not available for a large panel of firms in the U.S. This paper, following an extensive literature in Macroeconomics and Labor (see for example Gallipoli and Makridis (2021)), provides a measurement strategy to account for the differential use of IT

[7]For example, prices of intangible inputs like software is not measured in observed financial and census data for United States.

across industries, using the relative employment share of occupations within each industry that use IT more frequently.

The primary source used to measure the intensity that different occupations use IT is the O*NET survey. The O*NET survey is conducted by the U.S. Department of Labor and incorporates information on tasks, skills, and work characteristics.[8] Every responder completes a questionnaire about the importance and the frequency of certain tasks in their respective occupation. As in Bretscher (2018), the product of the importance and frequency weights (if available) is calculated to generate an overall intensity index for each task, and skills related to IT. Then these indices are matched to the Occupational Employment Statistics (OES) national time series. Using the matched data-set, employment-weighted IT intensity for tasks, skills, and knowledge are constructed at the five digit occupation level[9].

Lastly, I combine this information with information on employment from the annual Current Population Survey(CPS) [10] to create a measure of IT intensity at the industry level. In particular, I first aggregate occupation scores at the industry level. This can be done since occupations in the CPS data are measured at a five-digit level of aggregation, which is matched directly with the index constructed from O*NET. Finally, I aggregate occupation IT intensity, at the industry level as follows:

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[8]This survey has been used extensively in previous work to measure the risk of automation for workers across industries, or the risk associated with globalization (see for example Zhang (2019) measuring the routine intensity at the industry level, or Bretscher (2018) measuring the share of tasks that can be off-shored across industries)

[9]see the Appendix for a detailed description of this process. In the Appendix, I complement the analysis using other measures based on measures of IT intensity, where the IT score of an occupation is discrete, 0,1 and thus an occupation would be identified as only using IT or not.

[10]The sample from the CPS data is restricted to full-time workers with age between 20 and 65.

$$IT_{i,t} = \sum_j it_j \times \frac{\text{emp}_{i,j,t}}{\sum_j \text{emp}_{i,j,t}}$$

where $\text{emp}_{i,j,t}$ is the employment in industry $i$ occupation $j$ and year $t$ from the CPS database. Lastly, $IT_{i,t}$ is standardized in each year to be between zero and one in order to account for aggregate trends in the use of IT, driven by the relative price of IT. Thus the cross sectional variation captures the extend at which IT is adopted at the industry level within a year and not across year.

#### 1.3.1.2 Foreign multinationals operations Data

The level of foreign competition at the industry level is calculated using sales and employment data from the FDIUS data (BEA's surveys of foreign direct investment (FDI) in the United States). The published FDIUS database report data on the number of firms, employment, sales among other statistics, and the primary industry ( approximately 3-digit SIC code) for foreign multinational firms operating in the US for each year from 1977 through 2018. I combine this information with information on the sales and employment of all firms across industries in manufacturing and services from NBER-CES and the Annual Services Survey from the Census and I create measures of the foreign market share at the national level across industries. The definitions of the variables used in the empirical analysis of asset returns are included here. More details can be found in the Appendix.

I measure foreign competition, by the multinationals' sales share, both at the national level. This measure is defined as:

$$\text{FCI}_{mt} = \sum_{f \in F(m)} \frac{x_{ft}}{X_{mt}}$$

where $F(m)$ denotes the set of foreign firms in market-product $m$ (United States 3-digit SIC) and $X_{mt}$ total sales/expenditures in market-product $m$. I have constructed the measures of foreign sales shares at the 3-digit SIC classification and then I match this measure with the IT index, balance sheet and equity returns data. Below, I describe the financial and accounting data I am using.

#### 1.3.1.3 Financial and Accounting Data

For the empirical analysis of returns across industries, I use monthly stock prices for US public firms from the Center for Research in Security Prices (CRSP) and annual balance sheet information from Compustat. The sample of firms includes all NYSE-, AMEX-, and NASDAQ-listed securities that are ordinary common shares (with share codes 10 and 11) for the period between January 1991 and December 2013. Following the empirical finance literature, firms in highly regulated (SIC codes between 4900 and 4999) industries and financial (SIC codes between 6000 and 6999) firms are excluded from the sample. I also exclude observations with negative or missing sales and book assets. Firm-level accounting data and returns are winsorized at the 1% level in every sample year. All nominal variables are normalized at the price level of 1991, using a standard GDP price deflator. Historical segment data and foreign income information is used from COMPUSTAT to classify firms as conglomerate and multinational firms, similar to Fillat and Garetto (2015b) and the literature in empirical finance. Finally, I construct the following data on stock characteristics from the CRSP-Compustat merged database. Market Equity(ME) is the average portfolio market capitalization over the sample period converted into 1991 constant billions dollars. BE/ME is book-to-market equity, defined as book value of equity (item CEQ) divided by market value of equity (item CSHO $\times$ item PRCC_F). Return on assets (ROA) is defined as operating income after depreciation and amortization (item OIBDP−item DP) divided by total assets. I/K is capital expenditures (item CAPX) divided by property, plants, and equipment (item PPENT). Market leverage is total debt (item DLC + item DLTT) divided by the sum of total debt and market value of equity. A detailed overview of the variable definitions can be found in the Appendix. In addition to stock returns, I use data on analysts' annual earnings forecasts from the Institutional Brokers Estimates System (I/B/E/S) database.[11] These data will be used to form equally and value weighted stock portfolios of firm equity returns based on the level of IT intensity and the foreign market share (in the previous year of operation) in firms' main industry operation.

### 1.3.2 Summary Statistics

Table 1.1 in the Appendix provide summary statistics related with the measure of IT intensity, along with characteristics of the firms and information on the share of foreign firms in the United States using establishment data. The definitions of these variables are included in the Appendix. I split the firm sample, in two based on the industry level IT intensity, in high IT intensity industries versus low IT intensity industries each year from 1991 to 2013. This table confirms also that there is a relationship of IT with operating costs of firms. In particular, firms that

[11]Earnings and forecasts are all split-adjusted.

each year operate in industries with higher IT intensity are those with a higher share of administrative and operating costs on sales and a lower share of cost of goods sold over sales. The level of IT intensity, within manufacturing industries, is unrelated with other industry characteristics such as the level of openness, industry employment, or value added calculated using the data from the NBER-CES database.

## 1.4 Empirical Evidence

In this section, the empirical results related with IT intensity and asset prices are presented. First, it is documented that average portfolio excess returns are increasing in the use of IT intensity across industries. To do so, equally-weighted and value-weighted stock portfolios are formed based on quintiles of IT intensity in the previous year.[12] Second, the returns are analysed across different subsamples of the data and it is documented that the effect of IT intensity is not driven by High Tech industries, the inclusion or not of public firms with stocks traded in NASDAQ and is not concentrated in manufacturing industries. In addition, it is not driven by multinational firms or by manufacturing industries with lower shipping costs, and thus is not driven by the increasing threat of foreign competition due to trade and the China shock. Lastly, I show that the risk premia are increasing in the level of foreign competition as measured by the average, across products, share of foreign firms ($FCI$).

[12] The fact that the quintiles are measured each year implies that the industries are sorted across different quintilies every year. As is common in the empirical asset pricing literature, I apply this method to make sure that I measure the exposure of investors on IT adoption in the cross section of stock returns. If an industry changes quintile of IT intensity in a year, then it should belong on a different portfolio.

### 1.4.1 Portfolio Analysis

For each year, I assign industry IT intensity in the previous year to each individual stock based on each firm's core industrial classification[13], where industries are defined at a consistent way across years at the 4-digit SIC level between 1991 and 2013 [14]. In addition, I follow Zhang (2019) and Bretscher (2018) and calculate unlevered returns as

$$r_{i,t}^{un} = r_t^f + \left(r_{i,t} - r_t^f\right) \times (1 - lev_{i,t-1})$$

where $r_{i,t}$ are the stock returns of firm $i$ each year-month $t$ and $lev_{i,t-1}$ is the leverage ratio[15] of the firm the year ending before the month when the different portfolios are formed. In every year, I sort industry returns into five portfolios based on IT industry quintiles. Finally, the industry returns of each portfolio are reported either equally- or value- weighted. The weights assigned to compute the portfolios are based on market capitalization. In the analysis below, industry excess returns and excess returns are used interchangeably.

Tables 1.2 summarize the excess returns related to the use of IT intensity across industries. The table reports the equally- and value-weighted excess returns of the five portfolios, where the last column H-L represents the portfolio consisting of industries which is long the firms in industries with high IT intensity and short the low IT intensity industries, while the first 5 columns represent the 5 portfolios that consist of firms sorted in the 5 different quintiles. As is common in linear

[13]see detailed analysis in the appendix

[14]I use the industry correspondence tables developed by Eckert et al. (2199).

[15]The leverage ratio of the firm is defined as the book value of debt over the sum of book value of debt plus the market value of equity at the end of year.

factor regression models, to make sure that the spreads do not reflect the differential exposure of industries to other risk factors that are unrelated to the ability of firms across industries to employ IT, the estimated regression includes several commonly used factors and developed by Fama and French in a series of papers. In each table, the first row is associated with the $\alpha$ of each portfolio. The estimated alphas for the different industry quintiles do show a monotonic pattern for both equally- and value- weighted returns. Moreover, the strategy of investing in the high IT intensive firms, and going short the low IT intensive firms yields irrespective of the weighting method statistically significant $\alpha$. Firms operating within industries with high intensity in the use of IT have on average large equally-weighted and value-weighted) monthly excess returns, 12-13 percent, while industries that correspond to the low IT intensive industries do not have statistically significant $\alpha$. The corresponding excess returns are large independently of the measure of IT intensity. Overall, despite the short sample period, $t$-tests using Newey-West standard errors confirm that the H-L spread is statistically significant both in equally- and value-weighted portfolios. In summary, investing in industries with high IT intensities provide large equity premia to investors.

**Robustness** In this section, I describe how the premium is affected by restricting the industries considered in the analysis. In particular, one may worry given the emphasis on IT, these differential returns are driven by the High Tech giants or by the firms traded in the NASDAQ index and is thus associated with the technology bubble of the early 2000s. Table 1.3 in the Appendix restrict the analysis to firms with stocks not traded in NASDAQ or those firms that are associated with the production of IT and High Tech products.[16] Excluding these industries, and re-estimating the returns across the different portfolios still yields irrespective of the method a statistically significant positive return (see row $\alpha_1, \alpha_2, \alpha_3$). In addition, the estimated alphas from the regression again show a monotonic pattern.

Restricting the sample to manufacturing firms, I test whether the estimated expected returns are driven by firms in manufacturing industries, which would imply that the factor may capture the fact that within manufacturing there were differential trends in the US associated with globalization and the dominance of China in less IT intensive industries. As can be seen in rows $\alpha_M, \alpha_S$ in Table 1.3, the large excess returns are not driven by which sector one looks at and is present both in manufacturing and non manufacturing industries.

Lastly, given the emphasis on the literature on the difference between multinational and non multinational firms and the empirical analysis using the level of competition by foreign multinational, categorizing firms as multinational or not by whether or not they report foreign income I test whether the level of IT intensity affects differentially these firms (see row $\alpha_{MNE}$,$\alpha_D$).[17] Then, the sample is split based on the multinational nature or not of the firms. The returns are higher in the Information Technology intensive industries irrespective of the global operations of firms, which implies that the results are not driven by sunk costs of FDI and a larger share of multinational firms in IT intensive industries that is emphasized in the literature as a driver of risk for multinational firms. Consistent with the theory presented in the

[16] The industries are defined as High Tech based on their industrial description and a set of keywords associated with the use of Information Technology: "software", "communications", "internet", "telephone", "computer",...

[17] Categorizing firms as multinational firms is done using the variable for pre-tax foreign income, with code FIPO, in the Compustat data.

paper, domestic firms in the IT intensive industries exhibit across all portfolios larger returns.

**IT intensity and multinational operations in the United States** In this section, I relate the IT premium to the risk of being displaced by large multinational competitors similarly to the trade related displacement risk emphasized in Barrot et al. (2019). I describe now the intuition. Due to the effect of IT on communication frictions and the effect on the expansion strategy of large firms, emphasized in the literature in international trade, industries with a larger intensity of IT, will be dominated by large multinational firms. This makes smaller firms more vulnerable to movements in foreign productivity. In the first chapter, of my dissertation I study the dynamics of the ratio of sales of foreign firms to total sales in an industry, and show that it is consistently higher in IT intensive sectors. These patterns are informative of the different structure of product markets across sectors, consistent with the enhancing role of IT for large multinational firms.

Motivated by this evidence, I examine how the results on the premia related to IT are affected by the level of foreign competition. Table 1.4 panel A reports conditional double sorts on foreign penetration and IT intensity. I find that the HL $\alpha$ increases with foreign firms' market shares which is consistent with the interpretation that the ability to use IT is affecting risk more in industries that are exposed to foreign competition from multinational firms.

A potential concern, given the emphasis on multinational firms' operations could be that the differences in returns across industries with different IT intensity are driven by differential exposure of risks in foreign exchange markets and they are not due to differences in the structure of product markets. To address this concern, I re-estimate the specification three times, every time including both the 5 Fama-French factors and either the dollar factor, the carry factor (both from Verdelhan (2018)) or the excess return for a strategy of sorting industries with high trade costs and investing in industries with low trade costs (from Barrot et al. (2019)). The inclusion of FX-factors does not change the results (see Appendix Table 1.4 bottom panel): the IT premium is positive and statistically significant independent of the inclusion of other risk factors.

**Expected returns versus ex-post realized returns.** In this section, given the unexpected nature of technological progress within these industries that had a large increase in IT adoption, I deal with the potential concern that the observed excess returns across the different IT quintiles could be due to unforeseeable components, related to the IT technological revolution and the effects it had on the performance of firms. Components that would mean that these returns may be driven by the different investors' perceptions of the evolution of those industries and not due to the threat faced by small domestic firms. This then implies that the excess returns would be related with pricing errors and would not reflect systematic displacement risk faced by equity holders of those firms. In Tables 1.5 and 1.6, the evidence imply that the excess returns are not driven by pricing errors due to the fact that first the returns of the high and low IT portfolios are not concentrated around earnings announcements and so the information re-veiled in those announcements did not cause a large change in the perception of investors, and second as can be seen in equity analysts forecasts', analysts correctly estimated the effect that IT intensity had on firms earnings per share between 1991 and 2013.

**Subperiods** Table 1.7 reports the results of the portfolio sorts for different time subsamples. Panel A (Columns 1 to 7) tabulates results for equal-weighted returns and Panel B(Columns 8 to 14) for value-weighted returns. The returns remain large across all those year, with the exception of the period 2009-2013, where the risk premia change sign but become insignificant.

## 1.5 Theory

This section describes a two-country general equilibrium model of multinational production with firm and industry heterogeneity, as in the theories offirms like Helpman et al. (2004), augmented to include dynamics as in Barrot et al. (2019). The model economy consists of two countries. The firms have headquarters in one of the two countries. Firms differ in their idiosyncratic productivity, which is fixed, and in addition each country is affected by aggregate productivity shocks. This means the two countries are different in the pool of establishments operating in the domestic economy(in terms of productivity). Firms may operate establishments across both countries and supply goods locally.

In each country, there is a representative consumer. The consumer enjoys the consumption of goods supplied by establishments locally. The model abstracts from trade in differentiated goods, and thus all local consumption across sectors is being produced by either firms headquartered in the domestic market or branches-establishments of firms from a different country. There is establishment exit and entry across periods, due to fixed costs of operating establishments in a foreign country. Productivity of these establishments is impacted by borders. If a firm wants to operate in a country, not where its headquarters is located, it has to transfer technology in the foreign country, which in the model will affect firm productivity and so productivity differs across establishments of the same firm. These efficiency costs associated with multinational productions may be reduced if a firm adopts IT in each period by paying a fixed cost and thus the firm trades off the efficiency gains of IT with a fixed cost of employing IT. Modelling these efficiency costs, thus links this model with theories of multinational production as in Cravino and Levchenko (2017).

I contribute to the literature on multinational production and macroeconomic dynamics by adding a cross-section of industries with heterogeneous efficiency costs and a firm's decision to adopt IT in a model with horizontal Foreign Direct Investment.

The basic description of the model is provided in the next Section, then predictions about the relation of IT fixed costs and IT intensity across industries are derived, along with predictions on the effect of higher IT adoption at the industry level on asset prices, profits and industry risk. Lastly, the empirical facts presented in the last section are compared with the predictions of the model and new model-based empirical tests are presented.

### 1.5.1 Demand Side

The model consists of two countries. The two countries will be referred as "home" and "foreign". The "home" country will represent the United States and the "foreign " country will represent the Rest of the World (ROW). These countries face aggregate "home" and "foreign" shocks. In what follows, I denote variables in the "foreign" country by $^*$. Each country is populated by infinitely lived, atomistic households of measure $L$ and $L^*$. Households maximize continuation utility $J_t$ over sequences of the consumption index $C_t$,

$$J_t = \left[(1-\beta)C_t^{1-\psi} + \beta\left(\mathrm{R}_t\left(J_{t+1}\right)\right)^{1-\psi}\right]^{\frac{1}{1-\psi}}$$

where $\beta$ is the time-preference parameter, $\psi$ is the inverse of the inter-temporal elasticity of substitution (IES) and

$$\mathrm{R}_t\left(J_{t+1}\right) = \left[\mathbf{E}_t\left\{J_{t+1}^{1-v}\right\}\right]^{1/(1-v)}$$

is the risk-adjusted continuation utility, $v$ the coefficient of relative risk aversion.[18]

The aggregate consumption bundle in each region is given by $C_t$[19]. The consumption bundle is an aggregate of individual consumption of goods produced in each of the $\mathcal{J}+1$ sectors. Sector 0 provides a single homogeneous good, as in Chaney (2199). The other $\mathcal{J}$ sectors are made of a continuum of differentiated goods. If quantity $c_0$ of the homogeneous good is consumed, along with $c_J(\omega)$ units of each variety $\omega$ in sector $J$, the consumption aggregate is given by:

$$C = c_0^{1-a_0}\left[\sum_J\left(\int_{\Omega_J} c_J(\omega)^{\frac{\sigma_J-1}{\sigma_J}}d\omega\right)^{\frac{\sigma_J}{\sigma_J-1}\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}a_0}$$

where $0 < a_0 < 1$ represents the expenditure share on the differentiated goods sector, $\theta > 1$ is the elasticity of substitution across sectors, $\sigma_J$ is the elasticity of

[18]In the case of time-separable preferences with constant relative risk aversion (CRRA), the IES is equal to the inverse of the coefficient of risk aversion. The only role of Epstein and Zin (1989) preferences is to allow for a separate role of the IES and the coefficient of risk aversion in the calibration exercise.

[19]In the description I remove the $t$ subscript from any static choice that follows, for notational simplicity.

substitution across varieties within asector $J$ (which is assumed to be higher than $\theta$) and $\Omega_J$ is the set of establishments producing in the domestic economy in sector $J$, which is determined in equilibrium. Households get revenues from their inelastic labor supply in quantity $L$ and from ownership of a mutual fund that redistributes profits of both "home" and "foreign" firms. Their budget constraint is then given by:

$$p_0 c_0 + \sum_J \int_{\Omega_J} p_J(\omega) c_J(\omega) d\omega \leq wL + \Pi$$

where $p_J(\omega)$ is the price of variety $\omega$ in industry$J, w$ is the wage, and $\Pi$ is the profit redistributed to domestic consumers through ownership of the equity shares.

### 1.5.2 Supply Side

The homogeneous good 0 is freely traded and is used as the numeraire in each region. It is produced under constant returns to scale with one unit of labor producing 1 units of good and its price is set equal to 1.[20] This assumption greatly simplifies the discussion of the model and its implications but it is not crucial for the results.

#### 1.5.2.1 Differentiated Varieties

Each firm in the differentiated sectors $J \in \mathcal{J}$ produces a variety $\omega$. The quantity produced is denoted $q_J(\omega)$. Production of goods requires labor input. Labor is the only factor of production in the model, and its use by a firm producing variety

[20]This assumption is made so that the two regions have the same level of wages. More generally one can assume that one unit of labor produces $w$ units of good, in which case the wages differ across regions. This assumption is extended in the Appendix and will not affect the results of the paper.

$\omega$ is $l_J(\omega)$. Firms are heterogeneous in productivity and produce each variety with an efficiency parameter denoted by $\varphi$. This productivity is the firm's idiosyncratic efficiency at the headquarters' country. Idiosyncratic productivity at HQ is fixed overtime but is randomly assigned across firms. As in Helpman et al. (2004), the distribution of idiosyncratic productivity in each industry is Pareto with tail parameter $\gamma_J > \sigma_J - 1$. The probability of a firm's productivity being below a given level $\varphi$ in industry $J$ is $Pr\{\tilde{\varphi} < \varphi\} = G_J(\varphi) = 1 - \left(\varphi/\underline{\varphi}_J\right)^{-\gamma_J}$. The lower bound of idiosyncratic productivity for sector $J$ is $\underline{\varphi}_J$. A larger $\gamma_J$ corresponds to a more homogeneous sector, in the sense that more output is concentrated among the smallest and least productive firms.[21] Each country is also characterized by an aggregate productivity parameter, that is denoted by $A_t$. Hence, a local firm with idiosyncratic productivity $\varphi$ produces $A_t\varphi$ units of variety $\omega$ per unit of labor in year $t$. Productivity in each region, $(A, A^*)$, follow an AR(1) process as follows, $\log A_{t+1} = \mu_A + \rho_A \log A_t + \varepsilon^A_{t+1}$ and $\log A^\star_{t+1} = \mu_{A^*} + \rho_{A^\star} \log A^\star_t + \varepsilon^{A^\star}_{t+1}$.

There are different levels of productivity across countries, due to the differences in the mean of aggregate productivity, $\mu_A$ and $\mu_{A^*}$ and shocks $\varepsilon^A_{t+1}$ and $\varepsilon^{A^*}_{t+1}$. Most theoretical predictions are derived with respect to a shock in a "foreign" location on "domestic" firms.

#### 1.5.2.2 Firm establishments

Firms may operate establishments on both their headquarters country and the "foreign" country. Operations of an establishment located in a foreign country requires that

[21] The assumption of a Pareto distribution for productivity induces a size distribution of firms that is also Pareto, which fits well the empirical distribution.

the firm pays an operating fixed cost $f_J$ measured in "domestic" labor efficiency units paid every period. Given fixed costs of entry, this determines a firm-specific threshold productivity level below which firms do not operate establishments, other than the HQ. This threshold moves around with aggregate economic conditions. The second assumption in contrast to models with sunk costs, is that this cost makes the operation of a second establishment a period-by-period decision. This simplifies the model's solution considerably since it removes any evolving endogenous state variables related to multinational operations.

I provide now details related to the adoption of IT and the efficiency costs of operating an establishment in a different country. In particular, the efficiency losses in equilibrium will be given by $\exp(-\kappa \mathbb{I}_a(\varphi \geq \underline{\varphi}_{ITJ}))$ where $\mathbb{I}_a(\varphi \geq \underline{\varphi}_{ITJ})$ determines if firm productivity is above of below the cutoff of IT adoption by a firm. In particular, the efficiency costs are zero, if a firm adopts IT and $\kappa$ otherwise. This means, the firm each period can increase its "foreign" productivity, but this requires a fixed cost $f_{ITJ}$ that differs across sectors. When deciding whether or not to adopt IT, firms trade off benefits from lower efficiency costs against higher operating costs. Operating costs are associated with the costs of creating, for example, an IT services office that provides support to the main function of the firm. [22]

[22] Alternatively, these costs can also represent any intangible fixed investment that increases the ability of firm to expand geographically. Allowing firms to choose the production location and decide whether or not to trade from the HQ location is realistic but increases model complexity substantially and is not relevant for the interpretation of the results.

#### 1.5.2.3 Profits

Establishments set prices under monopolistic competition in each industry. Given a constant elasticity of substitution, prices are a constant markup over marginal cost. An establishment of a firm with productivity $\varphi$ sets the following price if it operates in firms' headquarters:

$$p_J(\varphi) = \frac{\sigma_J}{\sigma_J - 1}/(A\varphi)$$

and the following price when it does not operate in firms' headquarters:

$$p_{NJ}(\varphi) = \frac{\sigma_J}{\sigma_J - 1}/\Big(A^{1-\zeta}A^{*\zeta}\varphi\exp(-\kappa\mathbb{I}_a(\varphi < \underline{\varphi}_{ITJ})\Big)$$

The productivity of establishments in the two different countries differ by assumption. In particular, the establishment productivity is a weighted average of the productivity of the firm at the headquarter's country $A\varphi$ and at the establishment location $A^*\varphi$. Under the assumption that $\zeta = 0$ the establishment inherits the productivity of the firm at the headquarter's [23] $A\varphi$ with an efficiency cost $\exp(\kappa\mathbb{I}_a(\varphi < \underline{\varphi}_{ITJ}))$. This cost represents costs of technology transfer or more generally any efficiency losses due to managing an establishment in a distant environment. Efficiency costs depend on the IT decision, given by the indicator function $\mathbb{I}_a(\varphi \geq \underline{\varphi}_{ITJ}) = 1 - \mathbb{I}_a(\varphi < \underline{\varphi}_{ITJ})$.[24] In what follows, I will be using the following expression for prices set by domestic

[23] This assumption is made for simplicity here presenting the theoretical results. In the Appendix of the paper, a more general specification of the productivity process $(A\varphi)^{\zeta}(A^*\varphi^*)^{1-\zeta}$ is used as in Cravino and Levchenko (2017)

[24] The IT adoption dummy $\mathbb{I}_a(\varphi \geq \underline{\varphi}_{ITJ})$ equals 1 when the firm adopts IT and 0 otherwise.

multinational firms in the "foreign" country:

$$p_{NJ}(\varphi) = K_J(\varphi)p_J(\varphi),$$

where

$$K_J(\varphi) \equiv \exp(\kappa \mathbb{I}_a(\varphi < \underline{\varphi}_{ITJ}))$$

Firms earn total profits $\pi_J(\varphi)$ from their sales of establishments in the "home" country, and if they operate in the "foreign" country they earn $\pi_{NJ}(\varphi)$ in profits. Sales in the "home" region do not require a fixed cost of investment. Thus, profit functions are defined as:

$$\pi_J(\varphi) = \frac{1}{\sigma_J}\left(\frac{p_J(\varphi)}{P_J}\right)^{1-\sigma_J} P_J C_J$$

where $P_J$ is industry's $J$ price index and $C_J$ is the industry composite good, aggregated from the set of differentiated goods. Profits from the second establishment are calculated after operating costs, which include the cost of operating IT, if the firm chooses to do so[25]. Hence, the level of profits of a second establishment are given by:

$$\pi_{NJ}(\varphi) = \frac{1}{\sigma_J}\cdot\left(\frac{p_{NJ}(\varphi)}{P_J^*}\right)^{1-\sigma_J}\cdot P_J^* C_J^* - \frac{f_J}{A} - \frac{f_{ITJ}\mathbb{I}_a(\varphi \geq \underline{\varphi}_{ITJ})}{A}$$

Profits from operating a second establishment are increasing in idiosyncratic productivity, and hence there exists a productivity cutoff in each industry under which a firm decides to create a second establishment. Similarly, there is a cutoff related to the decision to adopt IT. I make the relevant parametric assumptions

[25]By assumption, then, the firm will IT only if the firm runs a second establishment.

such that the cutoff for IT adoption is always larger than that of operating a second establishment.

#### 1.5.2.4 Decision to operate second establishment and adopt IT

In this section, I describe the cutoffs that determine the decisions of the firms. I define the following cutoff level for firms that operate a second establishment as

$$\underline{\varphi}_{NJ} = \min_{\varphi}\{\varphi \mid \varphi \text{ implies that firm is operating a second establishment}\}.$$

Similarly, for firms that choose to use IT, I have:

$$\underline{\varphi}_{ITJ} = \min_{\varphi}\{\varphi \mid \varphi \text{ is adopting IT}\}.$$

I impose the relevant restrictions such that there is always a positive mass of firms, operating a second establishment but do not adopt IT. The derivation of cutoffs for IT adoption and for multinational production is included in the Appendix. A very useful property in models where productivity is drawn from a Pareto distributions, is that relative ratio of the cutoffs of firms adopting IT and being multinational will be constant. In particular, the two cutoffs satisfy:

$$\underline{\varphi}_{ITJ}/\underline{\varphi}_{NJ} = \left(\frac{1}{\exp(\kappa)^{\sigma_J-1}-1}\right)^{1/(\sigma_J-1)} (f_{ITJ}/f_J)^{1/(\sigma_J-1)} \equiv \Gamma_J$$

The relevant parametric assumptions are imposed to ensure that $\Gamma_J > 1$. From the expression above, it is evident that the two cutoffs move proportionally with the fluctuations in the economy which is an important property useful to derive the analytical results below.

Instead of keeping track of the distribution of productivity and prices, it is sufficient for the analysis of the aggregate economy and asset prices to keep track of the average productivity of the three different groups of firms. First for the whole domestic market, the average productivity of producers is $\bar{\varphi}_J$, second for the subset of firms with two establishments it is $\bar{\varphi}_{NJ}$ and third for the subset of firms that adopt IT $\bar{\varphi}_{ITJ}$. These quantities are sufficient to define the equilibrium and are given by:

$$\bar{\varphi}_J := \left[\int_{\underline{\varphi}_J}^{\infty} \varphi^{\sigma_J - 1} \mathrm{d}G_J(\varphi)\right]^{\frac{1}{\sigma_J - 1}} = \nu_J \cdot \underline{\varphi}_J$$

$$\bar{\varphi}_{NJ} := \left[\int_{\underline{\varphi_{NJ}}}^{\infty} \varphi^{\sigma_J - 1} \mathrm{d}G_J(\varphi)\right]^{\frac{1}{\sigma_J - 1}} = \nu_J \cdot \underline{\varphi}_{NJ}$$

$$\bar{\varphi}_{ITJ} := \left[\int_{\underline{\varphi_{ITJ}}}^{\infty} \varphi^{\sigma_J - 1} \mathrm{d}G_J(\varphi)\right]^{\frac{1}{\sigma_J - 1}} = \nu_J \cdot \underline{\varphi}_{ITJ}$$

where $\nu_J$, the average of firm productivity under a Pareto distribution, is given by $\nu_J = \left(\frac{\gamma_J}{\gamma_J - (\sigma_J - 1)}\right)^{\frac{1}{\sigma_J - 1}}$ and depends only on the elasticity of substitution, and the tail parameter of the productivity distribution. Observe here that given the fact that

$$\underline{\varphi}_{ITJ} / \underline{\varphi}_{NJ} \equiv \Gamma_J$$

then the average productivity of firms is also proportional and it satisfies:

$$\bar{\varphi}_{ITJ} / \bar{\varphi}_{NJ} \equiv \Gamma_J.$$

The fraction of firms operating multiple plants is denoted by $\zeta_{NJ}$ and the fraction of firms adopting IT is $\zeta_{ITJ}$. Similarly, due to the Pareto distribution it is easy to show that these variables satisfy:

$$\zeta_{ITJ}/\zeta_{NJ} \equiv \Gamma_J^{-\gamma_J}$$

#### 1.5.2.5 Industry aggregation

If total industry profits for "home" firms in a sector $J$ are defined as the sum of the profits of firms in the "home" and the "foreign" market:

$$\Pi_J := N_J \left[ \int_{\underline{\varphi}_J}^{\infty} \pi_J(\varphi_J)\, \mathrm{d}G_J(\varphi) + \int_{\underline{\varphi}_{NJ}}^{\infty} \pi_{NJ}(\varphi_J)\, \mathrm{d}G_J(\varphi) \right]$$

Using the expressions for the profit functions and the cutoffs, aggregate profits can be written as:

$$\Pi_J := N_J \left[ \pi_J(\bar{\varphi}_J) + \zeta_{NJ}\pi_{NJ}(\bar{\varphi}_{NJ}) + \zeta_{NJ}\Gamma_J^{-\gamma_J}\Delta\pi_{NJ}(\Gamma_J\bar{\varphi}_{NJ}) \right]$$

[26]

This implies that I need to keep track only the cutoff for the operation of a second establishment and not that for the IT adoption. The same aggregation property

[26] The following function is defined, representing additional profits from the decision to adopt IT:

$$\Delta\pi_{NJ}(\varphi) \equiv \pi_{NJ}^1(\varphi) - \pi_{NJ}^0(\varphi) = \frac{B_J^{*-1}}{A}\left[ (\varphi)^{-1+\sigma_J} - K_J^{1-\sigma_J}(\varphi)^{-1+\sigma_J} \right] - \frac{f_{ITJ}}{A}$$

where $B_J^* = \sigma_J \left(\frac{\sigma_J}{\sigma_J - 1}\right)^{\sigma_J - 1} \cdot A^{-\sigma_J} \cdot (P_J^*)^{-\sigma_J} (C_J^*)^{-1}$ and $K_J = exp(\kappa)$.

simplifies the expression for the sectoral price index $P_J$ :

$$P_J = \left(N_J \cdot p_J\left(\bar{\varphi}_J\right)^{1-\sigma_J} + \zeta^*_{NJ} N^*_J \cdot p^*_{NJ}\left(\bar{\varphi}^*_{NJ}\right)^{1-\sigma_J} + \zeta^*_{NJ} \Gamma^{*-\gamma_J}_J N^*_J \Delta p^*_{NJ}\left(\Gamma^*_J \bar{\varphi}^*_{NJ}\right)^{1-\sigma_J}\right)^{\frac{1}{1-\sigma_J}}$$

where the following function is used, determining the difference in the price of a firm with a productivity $\varphi$, in the case it adopts Information Technology or not:

$$\Delta p^*_{NJ}(\varphi) = (1 - \exp(\kappa^*))p^*_{NJ}(\varphi)$$

As a result in equilibrium:

$$P_J = \left(N_J \cdot p_J\left(\bar{\varphi}_J\right)^{1-\sigma_J} + \zeta^*_{NJ} N^*_J \cdot p^*_{NJ}\left(\bar{\varphi}^*_{NJ}\right)^{1-\sigma_J} H^*_J\right)^{\frac{1}{1-\sigma_J}}$$

where $H^*_J \equiv H\Bigg(\exp(\kappa)^*, \Gamma^*_J, \gamma_J, \sigma_J\Bigg)$ which is a variable determining the impact of IT on the price index through the sales share of large foreign firms in the "home" market.

### 1.5.3 Equilibrium

In equilibrium, the aggregate budget constraint of the representative household is given in terms of the aggregate price index $P$, composite consumption $C$, labor income $L$ and a share of revenues from each location and sector $J$, $\Pi_J$ and $\Pi^*_J$ :

$$PC \leq L + (1 - \chi)\Pi_{\text{AUT}} + \chi\Pi_{\text{RS}}$$

The definition of aggregate profits $\Pi(\chi)$ that are returned as dividents to investors is as follows. The exogenous parameter $\chi \in [0,1]$ controls the level of risk sharing across locations in the economy. The degree of risk-sharing from financial autarky, $\chi = 0$, to full risk-sharing, $\chi = 1$.[27]

If $\chi = 0$, then households receive only dividends from "home" headquartered firms, such that

$$\Pi_{\text{AUT}} = \sum_J \Pi_{J.}$$

Under perfect risk-sharing, $\chi = 1$, households receive a share of "home" sectoral profits relative to their capital endowments

$$\Pi_{\text{RS}} = \sum_J \frac{N_J}{N_J + N_{\text{J}}^\star} \cdot (\Pi_J + \Pi_J^\star)$$

The mass of firms $N_J$ in each sector is assumed to be fixed. There is no entry or exit of firms. However, the set of producers in a given market, $\Omega_J$, does vary over time due to entry and exit of establishments across countries. The number of varieties across countries fluctuates, since $\zeta_{NJ}$ fluctuates over time. An equilibrium in this economy is a collection of prices $(p_J, p_{M,J}, P_J, P_T, P)$, output $q_J(\varphi)$, consumption $c_J(\varphi)$, and labor demand $l_J(\varphi)$ such that (i) each firm maximizes profit given consumer demand and operating costs, (ii) consumers maximize their intertemporal utility given prices, and (iii) markets for goods and for labor clear. In sum, there are $2 \cdot (\mathcal{J} + 1)$ endogenous variables in the model: the aggregate consumption level in each location, $(C, C^\star)$, and the industry-level cutoffs, $(\varphi_{NJ}, \varphi_{NJ}^\star)$. Knowing these

[27]The parameter that determines risk sharing $\chi$ is assumed to be constant and exogenous. Evidence for limited risk sharing for portfolios of US investors can be found in Lewis (2011) and the literature therein.

quantities is sufficient to solve for the equilibrium at each point in time. [28]

### 1.5.4 Asset Prices

The representative household in each country owns a portfolio that consists of equity of firms in the economy. By assumption, they are assumed to own all equity of the firms in their "home" country. The equities, then are priced using the stochastic discount factor (SDF) of the "home" household.[29] Due to the static nature of the firms, [30] all profits are distributed as dividends. In this section, I derive predictions for all asset prices of firms across different industries. The representative household maximizes utility subject to the budget constraint, which includes shares $x_{J,t}(\varphi)$ in firms of sector $J$ of variety $\varphi$ at price $v_{J,t}(\varphi)$, which is equal to the value of the firm. Then, optimality conditions for the consumer leads to the following consumption-CAPM equation that determines each firm's valuation:

$$v_{J,t}(\varphi) = \mathbf{E}_t \left\{ M_{t,t+1} \left( v_{J,t+1}(\varphi) + \pi_{J,t+1}(\varphi) \right) \right\}$$

where $M_{t,t+1}$ is the one-period-ahead stochastic discount factor. To understand pricing by investors in this economy the impact of IT on the correlation between productivity shocks and the marginal utility of investors is considered in the next subsection. In particular, first some results are summarized related to IT intensity

[28]The fact that I do not need to keep track of$(\varphi_{ITJ}, \varphi^{\star}_{ITJ})$ comes from the proportionality property $\varphi_{ITJ} = \Gamma_J \varphi_{NJ}$

[29]There is an implicit assumption here about the specific form of market segmentation that leads to this result.

[30]There is no capital and investment in the model or sunk costs of operation.

across industries, and later the reaction of cash flows to these shocks is considered as the economy faces aggregate shocks in productivity in the two countries.

### 1.5.5 Mechanism

In this section, the link between the IT intensity of a sector, and the impact of shocks to aggregate productivity on firms' cash flows, the marginal utility of investors and asset prices is determined theoretically. In particular, the differential response of firms to these shocks across the size distribution and across industries with different degrees of foreign firm share is emphasized. This determines the mechanism behind the excess premia presented above. As expected, the joint dynamics of cash flows and aggregate consumption determine the risk across industries and how investors price the risk of firms in these different industries in the economy. Before describing the implications of the model for asset prices, some further results are discussed that help with the interpretation of the dynamics of the economy. The proofs of the predictions discussed here can be found in the Appendix where more details on the theory and several additional predictions are included.

**Lemma 1.** *IT intensity, measured by the share of IT labor within a sector, is decreasing in IT adoption costs* $f_{ITJ}$ *with an elasticity* $(\gamma_J - \sigma_J + 1)/(\sigma_J - 1)$.

As expect as the fixed cost of IT increases, there should be a reduction in IT intensity in each industry. However, this result is not immediate given that fixed costs are expressed in terms of labor. The reason driving this negative relationship is due to the extensive margin of adjustment as in the models of international trade or multinational operations. The extensive margin of adjustment also determines the differential response of IT adoption at the industry level, if two sectors face the same decline in IT fixed costs.

**Foreign firms' multinational operations** I first define competition from foreign firms as

$$\mathcal{I}_J = \frac{\zeta_J^* N_J^* \cdot p_{NJ}^* \left(\bar{\varphi}_{NJ}^*\right)^{1-\sigma_J} H_J}{P_J^{1-\sigma_J}}$$

This represents the marginal impact of large foreign multinational firms operating an establishment in a region away from the firms' HQ on the local price index for a given industry. Given the definition of $P_J$,this measure is bounded: $\mathcal{I}_J \in [0,1]$.

**Lemma 2.** *The level of $\mathcal{I}_J$ is decreasing with fixed costs $f_{ITJ}^*$. This means that this level is increasing in IT intensity.*

The lemma above, is a result of the fact that in high fixed costs $(f_{ITJ}^*)$ costs industries, large multinational firms set a less competitive price. As a result the impact of global production, the price index is lower in these industries with higher average efficiency costs and the displacement of small "domestic" firms higher. Now given these results, the analysis of the effect on asset prices follows. Proposition 1 and 2 summarize differences in firms' profit elasticity across industries with different IT intensity levels. In addition, the differential exposure of industries with different underlying elasticity of substitution is discussed along with results for firms with different size. The analysis follows closely Barrot et al. (2019) to provide testable predictions that would help rationalize the observed excess returns.

#### 1.5.5.1 Effect on cash flows

An elasticity of variable $x$ is denoted by $\mathcal{E}^*(x)$ and are with respect to an aggregate shock $A^*$, that is it is defined as $\mathcal{E}^*(x) = \frac{d \log x}{d \log A^*}$. The elasticity derived here are approximate and do not account for general equilibrium effects through the effects on aggregate demand [31]. After defining the index level of multinational firms $\mathcal{I}_J$, I consider the effect of an increase in productivity in the rest of the economy on domestic only "home" firms. The effect of a shock to labor productivity in the rest of the world affects both demand for individual varieties and total industry expenditures. The entry of foreign multinational firms lowers the industry price index, thus increases the expenditures at the industry level. Since by assumption, the within industry substitution elasticity is higher within industries than across, the productivity shock in the rest of the economy reduces demand for locally produced goods. In addition, the aggregate productivity shocks affect aggregate demand, through the effect on wealth of consumers in the local economy. In particular, this channel determines the effect on aggregate consumption and determines the price of assets in equilibrium. Now, I have the following results for the elasticity of profits to a productivity shock in the rest of the economy[32]:

**Lemma 3.** *The elasticity of profits generated in the home market for a home firm with productivity $\phi$ to a productivity shock $A^*$ is:*

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[31] Using a calibrated version of the model, it is confirmed that the general equilibrium effect through aggregate demand is small and the results are qualitatively in the same directions as the results described here.

[32] For simplicity of notation, I assume $\zeta = 0$ but results follow more generally, see Online Appendix.

$$\mathcal{E}^*\left(\pi_J(\varphi)\right) = -\left(\sigma_J - \theta\right) \cdot \left(-\mathcal{E}^*\left(P_J\right)\right) + \frac{1 - a_0 - \theta}{a_0} \cdot \left(-\mathcal{E}^*(P) + \mathcal{E}^*(C)\right)$$

Ignoring for now the second term, related to aggregate variables, the profits and cash flows are affected by the shock through industry prices as follows:

$$\mathcal{E}^*\left(\pi_J(\varphi)\right) = -\left(\sigma_J - \theta\right) \cdot \mathcal{I}_J \cdot \left[1 + \left(\frac{\gamma_J}{\sigma_J - 1} - 1\right)\left(-\mathcal{E}^*\left(\underline{\varphi_{NJ}^*}\right)\right)\right]$$

This term summarizes the threat firms face from increasing competition which depends on the following variables: (a) the level of elasticity determines the impact of competition; (b) the foreign firms competition index that represents how much firms in the rest of the world affect local firms. It is larger when IT costs are smaller and thus a large number of firms operate multiple establishments. Lastly, productivity affects the extensive margin of horizontal FDI, summarized by $\mathcal{E}^*\left(\underline{\varphi_{NJ}^*}\right)$.

In contrast, large multinational firms operating establishments with HQ in the "home" country may benefit from such a shock. Here I summarize this effect. If a firm is large enough to be a multinational firm then profits react as follows[33]:

$$\mathcal{E}^*\left(\pi_{NJ}(\varphi)\right) = \left(\mathcal{E}^*\left(C_J^*\right) - \sigma_J\left(-\mathcal{E}^*\left(P_J^*\right)\right)\right) \cdot \left(1 + \ell_J(\varphi)\right)$$

The sign depends both on how demand reacts and the level of competition, through the price index. The effect of the first variable is positive, while the effect

[33]Remember here the assumption on the inherited productivity of an establishment. These results are generalized in the Appendix in the case that the productivity term is a weighted average of productivity in the "home" and "foreign" economy.

of the second negative. In addition, the firms that are closer to the cutoff will face a stronger effect. In particular this reaction comes from the fact that operating leverage as in every model with these type of fixed costs, amplifies the effect of these productivity shocks. In summary, the average effect to the industry cash flows depends on the relative size of these effects on smaller "home" firms and larger multinational firms.

Across industries, as firms have higher level of IT intensity [34], the share of multinational firms will be larger and as a result exposure of investors to sales risk due to global competition, can be understood better by studying the reaction of asset prices of firms with different size. Looking across the size distribution, in the model, and in particular looking at the reaction of asset prices for smaller firms that can not pay the fixed costs and become multinational firms is informative about the reaction of firms with a lower level of sales. Observing the reaction of the excess returns for these firms only, it is possible to isolate the IT effect on industry risk. In particular, the following proposition summarises this intuition.

**Proposition 1.** *Consider two industries $J_1$ and $J_2$ in the same region, affected by a shock to productivity in the rest of the world. If industries differ only in the fixed cost of IT, with industry 2 having a lower fixed cost of adoption, then multinational firms share is greater in industry $J_2$ than $J_1$, or $\mathcal{I}_2 > \mathcal{I}_1$. (ii) The elasticity of profits for small firms (only local) firms is more negative in industry $J_2$. (iii) The difference in the elasticity of profits between large multinational and small local firms to this shock to productivity is greater in industry $J_2$. Lastly, if industries have different firm distributions, i.e. their Pareto parameter is such that $\gamma_1 > \gamma_2$ , then: the elasticity*

[34] which is the case if industries have lower fixed costs of operating IT

*of average profit to a shock to productivity in the rest of the economy is greater in* $J_1$ *than in* $J_2$.

The first result follows from the definition above and the definition of $\Gamma_J$. The second statement is specific to smaller firms facing more competition. Lower entry costs go with higher sales shares for large multinational firms. The effects if one considers domestic profits follows from the previous Lemma. Finally, the tail of the Pareto distribution, implies that productivity of firms is more dense among smaller, less productive firms, below the cutoff. This means that the mass of firms that have multinational operations is relatively smaller, and thus the positive effect due to sales of large firms is lower. In that case the total industry profit elasticity declines.

#### 1.5.5.2 Effect on SDF

To assess how aggregate shocks affect equity prices of the firms in the economy, the risk channel should be evaluated to understand also how marginal investors react after a potential productivity shock impacts firm profits. In particular, the reaction of prices will depend on their marginal utility. To understand then the effect on the marginal utility of investors, I study the effect of a productivity shock on aggregate consumption. So first the elasticity of consumption is discussed.

**Lemma 4.** *The elasticity of consumption to a productivity shock* $A^*$ *is:*

$$\mathcal{E}^*(C) = -\mathcal{E}^*(P) + \frac{\Pi}{L + \Pi} \cdot \mathcal{E}^*(\Pi)$$

Thus to determine the effect on aggregate consumption, there are two competing effects, a price effect where a positive shock outside of the HQ increases competition through the price index, due to lower prices and entry of varieties. In addition, there is a wealth effect, since household receive the profits from the operation of firms in the form of dividends. The sign of the wealth effect is ambiguous and depends on the share of firms that do not operate in the "foreign" country and are owned by "home" households and on the effect of the shock on total profits for only local( non multinational) firms. The price of the industry risk then depends on the size of the price and wealth effects.

As in Barrot et al. (2019), this paper does not analyze explicitly the sign of the price of risk, but inference about investors' pricing behavior is based on the following intuition similar to models with international trade(Barrot et al. (2019)). If the price of risk is positive, firms in industries where the multinational firms' entry margin and the profits react more to this productivity shocks will require a higher positive risk premium and will lead to higher excess returns.

Again, then the focus is on productivity shocks, in the rest of the world, as the only shock affecting dynamics in the economy. Now, asset prices are determined by the investment decision of households, through the Euler equation household. The Euler equation prices all the relevant risk factors in the model, and the expected returns are equal to the price of consumption risk multiplied by the relative riskiness of profits (exposure to IT adoption) of each firm, i.e. the IT intensity of an industry and the foreign share of multinational firms.

As a result, the empirical results can not help determine the price of the risk exposure associated with a larger sales share of multinational firms. For example, if investors consider the risk exposure as a factor that should be priced positively, then the firms in high IT intensity industries should be the ones with strongly pro cyclical returns (if there is only one shock for the aggregate economy affecting consumption, the aggregate "foreign" shock) and thus the ones affected positively by such a shock. The opposite is true if the price of risk is negative. Then, the following idea, from Barrot et al. (2019) is used to understand if the expected returns of the high-low IT portfolio are driven by industries more likely to benefit or lose by aggregate productivity shocks outside the "home" country. In particular, the following prediction will be used to test for the two different channels.

**Proposition 2.** *After a foreign shock, if the profits of "home" multinational firms generated outside in the "foreign" country react positively, then the price of the risk for investors is negative:1. If expected returns differ more comparing smaller firms to large firms as the IT intensity of the industry increases. 2. If expected returns differ more comparing smaller firms to large firms as the elasticity of substitution* $\sigma_J$ *of the industry increases.*

In particular, the intuition for this result is based again on the discussion above. Firms that do not operate in both regions are relatively more exposed (negatively) if the level of IT adoption in the industry is higher. In addition the large multinational firms' profits do not fall from operations outside of the HQ location. Finally, a greater elasticity of substitution means that cash-flows react more to changes in prices.

Again, analyzing the expected returns of high-minus-low IT portfolios in high and low demand elasticity industries would be informative of the drivers of risk premia and whether or not the cash flows of industries co-vary with a factor that increases the growth of consumption.

To check whether this is indeed the case, and given the fact that the expected returns remain unchanged for the sample of manufacturing firms, the sample is restricted to manufacturing firms and stocks are sorted based both on the level of their IT intensity and their associated within sector elasticity aggregated at the SIC4 level. This is done due to the fact that elasticity parameters for services are not available.

## 1.6 Testing Model Predictions

The identification strategy to determine whether the price of the risk related to the adoption of IT is positive or negative relies on testing the prediction of the model, and the heterogeneity in firms' response to shocks to the foreign economy. Research finds support on the cross-sectional heterogeneity in firms' adoption of IT and firms' propensity to be displaced by large productive firms entering markets across the United States. Bessen (2017) tests the prediction that proprietary Information Technology is used by systematically larger and more productive firms. In addition, Rossi-Hansberg et al. (2018) document recent facts about the dynamics of local and national concentration providing support to the mechanism related to the adoption of IT by large firms. I confirm in the Online Appendix that the level of information technology is also associated with entry or expansion of foreign multinationals in the U.S. economy.

### 1.6.1 Size, product substitutability and expected returns

I then take the additional predictions of the model to the data. Whether the expected returns are driven by small firms will determine the sign the investors assign to the risk exposure, due to the differential level of IT intensity. Table 1.8 in the Appendix provide direct evidence that the effect is more important when portfolio formation is done using only the sample of small firms, compared to the one using the sample of large firms[35]. As predicted by the model, the expected returns are declining with size. In Table 1.8 at the bottom, results are reported where again portfolios are doublesorted based both on the level of Information Technology use and now the estimate of the elasticity of substitution. Consistent with the model predictions, the risk premia in manufacturing industries are larger in industries with a high elasticity of substitution for smaller firms.

In summary, all these results together imply that the excess returns are concentrated among the smaller firms, and for those firms excess returns are amplified by the pareto and elasticity parameters. Given that all those predictions are confirmed, the data lead to the conclusion that price of risk is negative.

## 1.7 Calibration and Model Dynamics

### 1.7.1 Model Parameters

For the calibration, I associate the Home country with the United States and the Foreign Country with the other OECD countries[36] which have the biggest share of foreign direct investment to the U.S.. The calibration of the primitives then follows from statistics of aggregate variables in 2013. In detail, $L$ and $L^*$ are determined by

[35]Size is measured either using the level of profitability(Returns on Assets) or the level of the market capitalization, at the end of the previous calendar year of the month considered.

[36]I restrict the set of countries that consist the “foreign” economy to be the following OECD members: Australia, Austria, Belgium/Luxemburg, Canada, Chile, Colombia, Czech Republic, Denmark, Estonia, Spain, Finland, France, United Kingdom, Germany, Greece, Hungary, Italy, Israel, Iceland, Mexico, Japan, South Korea, Netherlands, Norway, New Zealand, Poland, Portugal, Sweden, Switzerland, Slovenia, Slovakia.

the ratio of the working age population in the U.S. and the set of OECD economies, 320 million and 1.2 billion (Penn World Table, version 9). The number of firms operating in each economy, $N$ and $N^*$, is chosen to match the ratio of the market capitalization for the U.S. based firms to the rest of the world of approximately 40 percent. Wage costs are normalized to 1.

The headquarter transmission parameter in the two industries, $\zeta$, are set to 0.5, following Cravino and Levchenko (2017) . This parameter, given the baseline calibration, implies that a shock to the foreign country is such that the competition effect from multinational firms dominates the demand effect. Elasticity across industries $\theta = 1.2$ from Barrot et al. (2019) and within industries $\sigma = 3.8$, across goods from Broda and Weinstein (2006). The firm distribution Pareto parameter is set equal to 3.4, as in Ghironi and Melitz (2007). The subjective discount factor is 0.99, and the inter temporal elasticity of substitution is 1.5, as in Broda and Weinstein (2006). The risk aversion parameter is set to match the U.S. equity premium. Finally, parameters related to aggregate productivity in the Home and Foreign country are chosen to reflect GDP in the U.S. (Foreign Sales from OECD countries to the U.S.).

It remains to calibrate the IT and multinationals' cost parameters ( $f_J, f_{ITJ}$) along with the knowledge transmission cost parameter $\kappa$.[37] These parameters are set to match the average foreign market shares observed in the data. In addition, the calibration tries to match: (i) the fact that the United States accounts for approximately 20 % of world GDP, (ii) the earnings-to-price ratios and the returns that the model generates. The calibrated values for the parameters are summarized in Table 1.9. The calibration procedure and data are described in more detail in the

[37]I assume that there is no heterogeneity in terms of $f_J$.

Appendix, as well as a sensitivity analysis around parameters.

Given the calibration, the interaction of country size, fixed cost parameters, and the stochastic properties of country shocks determine the share of firms' foreign affiliates. In turn, these patterns affect how IT intensity and MP flows jointly affect the consumption risk premium. I use this calibrated version of the model to perform counterfactual exercises that highlight the effect of IT and foreign operations on risk premia. In Table 1.10 , I report the results of the simulations. The calibration does not specifically target firms' cash flows across industries and asset prices but does fit qualitatively the patterns in the data.

## 1.8 Conclusion

This paper studies how the adoption of IT across industries affects the cost of capital for firms in the United States. Using a novel measure of IT intensity, I find that industries that use intensively IT, have large and sizable risk premia. I confirm that IT systematically has been a determinant of industry risk in recent decades. The IT risk premia are increasing in the level of multinational firms penetration. A framework incorporating the decision to adopt IT and the decision to operate multiple establishments provides a theoretical explanation for the risk premia, which are consistent with the trends in IT driven concentration, and the threat of competition from large multinational firms. Intuitively, large firms being able to operate modern Information Technology , makes smaller firms more exposed to competition. The model provides testable predictions that are used to understand whether the mechanism in the model is present in the data, and how aggregate consumption co-varies with industry profits. The predictions of the model are confirmed in the cross section of stock returns. In contrast to common belief that IT benefited small young firms, I provide evidence that IT in the last decades benefited large productive multinational incumbents in the expense of small local firms.

## 1.9 Appendix: Figures and Tables

Figure 1.1: No risk sharing

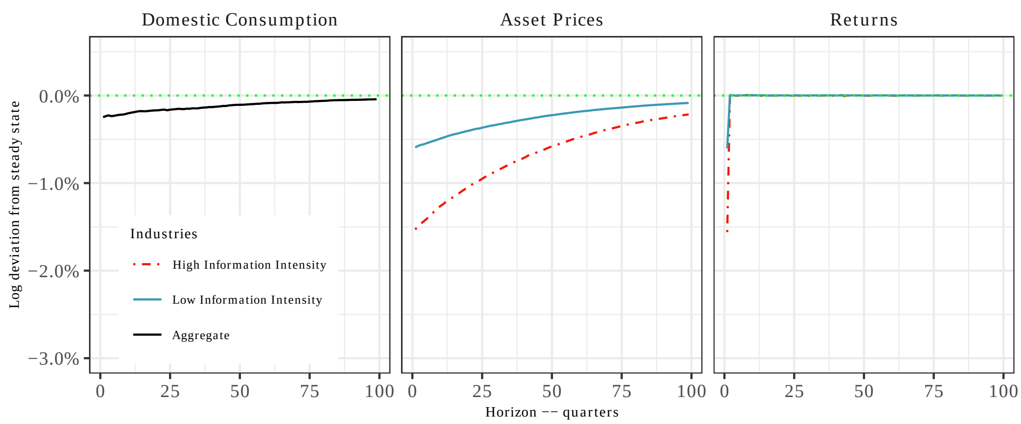


Table 1.1: Cross-Sectional Statistics

| | Full Sample | Low IT | High IT |
|---|---|---|---|
| IT Share | 0.08 | 0.04 | 0.12 |
| **Balance Sheet** | | | |
| Book-to-market | 0.81 | 0.91 | 0.72 |
| Gross profitability | 0.37 | 0.39 | 0.35 |
| SGA/Sales | 0.34 | 0.25 | 0.43 |
| COGS/Sales | 0.53 | 0.59 | 0.48 |
| **Industry Controls** | | | |
| Total imports and exports | 9.45 | 9.11 | 9.69 |
| Industry Employment | 3.91 | 3.73 | 4.04 |
| Industry Value Added | 8.78 | 8.39 | 9.05 |
| Industry Total Factor Productivity | 1.07 | 1.02 | 1.10 |
| Foreign Affiliates Share | 0.09 | 0.07 | 0.10 |

*Notes*: This table presents summary statistics for the firm-year sample covering public firms in 670 industries (excluding FIRE, and highly regulated industries), out of which approximately 450 are in manufacturing industries (with four-digit SIC codes between 2000 and 3999). Each column corresponds to the two samples, split according to the level of IT intensity every year. Information Technology intensity is measured at the industry-year level as described in the data and measurement section. Industrly variables are obtained from the NBER-CES data sets for manufacturing industries. Using the establishment data from NETS, Average Sales per employee, and the concentration indices are measured at the industry(SIC4)-year level, as weighted averages of the SIC8-county-year statistics. All variables are winsorized at the first 99th percentiles. The sample period is 1991 to 2013.

Table 1.2: IT intensity Premia

| **Equally Weighted** | Low (1) | 2 (2) | 3 (3) | 4 (4) | High (5) | H-L (6) |
|---|---|---|---|---|---|---|
| $\alpha$ | −1.948 | 1.433 | 6.449*** | 8.761*** | 13.216*** | 15.163*** |
| | (2.406) | (2.119) | (2.472) | (2.614) | (3.327) | (3.508) |
| $\beta^{MKT}$ | 0.999*** | 1.057*** | 0.979*** | 1.073*** | 1.013*** | 0.013 |
| | (0.063) | (0.060) | (0.037) | (0.057) | (0.076) | (0.067) |
| $\beta^{HML}$ | 0.462*** | 0.388*** | 0.029 | −0.277** | −0.263** | −0.725*** |
| | (0.089) | (0.095) | (0.082) | (0.113) | (0.130) | (0.117) |
| $\beta^{SMB}$ | 0.831*** | 0.801*** | 0.813*** | 0.771*** | 0.854*** | 0.023 |
| | (0.090) | (0.074) | (0.070) | (0.108) | (0.096) | (0.090) |
| $\beta^{RMW}$ | 0.306*** | 0.155 | −0.398*** | −0.604*** | −0.776*** | −1.082*** |
| | (0.099) | (0.113) | (0.052) | (0.133) | (0.142) | (0.106) |
| $\beta^{CMA}$ | −0.188 | −0.163 | 0.160 | 0.208 | −0.322 | −0.134 |
| | (0.193) | (0.198) | (0.110) | (0.221) | (0.292) | (0.175) |

| **Value Weighted** | Low (1) | 2 (2) | 3 (3) | 4 (4) | High (5) | H-L (6) |
|---|---|---|---|---|---|---|
| $\alpha$ | 4.501*** | 5.927*** | 8.602*** | 10.110*** | 16.814*** | 12.313*** |
| | (1.449) | (1.242) | (1.413) | (1.571) | (3.431) | (3.066) |
| $\beta^{MKT}$ | 0.938*** | 1.002*** | 0.888*** | 1.052*** | 1.034*** | 0.096 |
| | (0.045) | (0.027) | (0.039) | (0.055) | (0.065) | (0.078) |
| $\beta^{HML}$ | 0.049 | −0.012 | −0.076 | −0.335*** | −0.335*** | −0.385*** |
| | (0.075) | (0.044) | (0.055) | (0.085) | (0.106) | (0.127) |
| $\beta^{SMB}$ | 0.151*** | 0.136*** | −0.100* | −0.041 | 0.038 | −0.114 |
| | (0.054) | (0.045) | (0.059) | (0.097) | (0.083) | (0.102) |
| $\beta^{RMW}$ | 0.501*** | 0.429*** | 0.150* | −0.229* | −0.368*** | −0.869*** |
| | (0.067) | (0.040) | (0.089) | (0.119) | (0.109) | (0.133) |
| $\beta^{CMA}$ | 0.028 | 0.248*** | 0.364*** | 0.248 | −0.486*** | −0.513*** |
| | (0.095) | (0.067) | (0.132) | (0.170) | (0.182) | (0.167) |

| **Equally Weighted** | Low (1) | 2 (2) | 3 (3) | 4 (4) | High (5) | H-L (6) |
|---|---|---|---|---|---|---|
| $\alpha$ | −0.475 | 1.491 | 3.595 | 5.002** | 7.006** | 7.481** |
| | (1.737) | (1.280) | (2.249) | (2.495) | (2.801) | (3.492) |
| $\beta^{MKT}$ | 0.710*** | 0.791*** | 0.885*** | 1.025*** | 1.127*** | 0.417*** |
| | (0.053) | (0.041) | (0.049) | (0.071) | (0.069) | (0.092) |
| $\beta^{HML}$ | 0.337*** | 0.260*** | −0.092** | −0.342*** | −0.607*** | −0.944*** |
| | (0.075) | (0.069) | (0.045) | (0.057) | (0.094) | (0.133) |
| $\beta^{SMB}$ | 0.485*** | 0.498*** | 0.780*** | 0.799*** | 0.950*** | 0.465*** |
| | (0.102) | (0.078) | (0.064) | (0.063) | (0.070) | (0.123) |

| **Value Weighted** | Low (1) | 2 (2) | 3 (3) | 4 (4) | High (5) | H-L (6) |
|---|---|---|---|---|---|---|
| $\alpha$ | 5.558*** | 7.556*** | 8.760*** | 7.398*** | 11.486*** | 5.928* |
| | (1.386) | (1.219) | (1.368) | (1.449) | (3.070) | (3.022) |
| $\beta^{MKT}$ | 0.667*** | 0.670*** | 0.671*** | 0.937*** | 1.103*** | 0.436*** |
| | (0.041) | (0.029) | (0.048) | (0.073) | (0.041) | (0.051) |
| $\beta^{HML}$ | 0.168* | 0.158*** | 0.079 | −0.261*** | −0.670*** | −0.838*** |
| | (0.089) | (0.060) | (0.073) | (0.046) | (0.094) | (0.145) |
| $\beta^{SMB}$ | −0.043 | −0.023 | −0.148*** | 0.054 | 0.077 | 0.120 |
| | (0.078) | (0.049) | (0.051) | (0.068) | (0.057) | (0.102) |

*Notes*: This table presents excess returns ($\alpha$) over a five-factor Fama-French model and over a three-factor Fama-French model of portfolios sorted based on measures of Information Technology.

Table 1.3: Industry Subsamples, Multinational Firms and Excl. High Tech Firms

| **Equally weighted** | Low (1) | 2 (2) | 3 (3) | 4 (4) | High (5) | H-L (6) |
|---|---|---|---|---|---|---|
| $\alpha_1$ | $-3.848^{**}$ | $-1.345$ | $-0.055$ | $3.421^{*}$ | $5.400^{**}$ | $9.248^{***}$ |
| | (1.539) | (1.365) | (1.445) | (1.892) | (2.624) | (2.464) |
| $\alpha_2$ | $-1.737$ | 0.911 | $5.399^{**}$ | $7.300^{***}$ | $7.468^{***}$ | $9.206^{***}$ |
| | (1.768) | (1.569) | (2.325) | (2.403) | (2.801) | (2.474) |
| $\alpha_3$ | $-1.737$ | 0.911 | $5.387^{**}$ | $6.868^{***}$ | $9.236^{***}$ | $10.264^{**}$ |
| | (1.768) | (1.569) | (2.327) | (2.436) | (3.437) | (3.990) |

| **Value weighted** | Low (1) | 2 (2) | 3 (3) | 4 (4) | High (5) | H-L (6) |
|---|---|---|---|---|---|---|
| $\alpha_1$ | $2.537^{*}$ | $3.460^{***}$ | $3.737^{***}$ | $3.987^{***}$ | $9.219^{***}$ | $6.683^{**}$ |
| | (1.378) | (1.053) | (0.982) | (1.426) | (3.294) | (3.101) |
| $\alpha_2$ | $2.999^{**}$ | $4.484^{***}$ | $6.746^{***}$ | $7.779^{***}$ | $11.719^{***}$ | $8.720^{**}$ |
| | (1.377) | (1.077) | (1.226) | (1.792) | (4.144) | (3.808) |
| $\alpha_3$ | $2.999^{**}$ | $4.484^{***}$ | $6.746^{***}$ | $7.407^{***}$ | $8.139^{*}$ | 5.777 |
| | (1.377) | (1.077) | (1.226) | (1.831) | (4.803) | (4.602) |

| **Equally Weighted** | Low (1) | 2 (2) | 3 (3) | 4 (4) | High (5) | H-L (6) |
|---|---|---|---|---|---|---|
| $\alpha_M$ | $-0.127$ | $-0.342$ | $7.126^{***}$ | $7.445^{**}$ | $11.801^{***}$ | $12.026^{**}$ |
| | (1.916) | (1.658) | (2.705) | (3.092) | (4.122) | (4.845) |
| $\alpha_S$ | $-3.309$ | $5.446^{**}$ | $-6.103$ | $11.527^{***}$ | $15.595^{***}$ | $20.044^{***}$ |
| | (2.145) | (2.752) | (5.422) | (3.415) | (3.945) | (4.232) |
| $\alpha_D$ | 2.829 | $9.781^{***}$ | $16.567^{***}$ | $13.523^{***}$ | $35.287^{***}$ | $32.458^{***}$ |
| | (2.672) | (2.017) | (2.388) | (4.407) | (7.292) | (7.409) |
| $\alpha_{MNE}$ | 1.930 | $3.215^{**}$ | $5.216^{***}$ | $8.576^{***}$ | $13.540^{***}$ | $11.611^{***}$ |
| | (1.479) | (1.245) | (0.949) | (1.976) | (3.214) | (3.456) |

| **Value Weighted** | Low (1) | 2 (2) | 3 (3) | 4 (4) | High (5) | H-L (6) |
|---|---|---|---|---|---|---|
| $\alpha_M$ | 0.950 | $2.999^{**}$ | $7.147^{***}$ | $9.216^{***}$ | $14.676^{***}$ | $15.355^{***}$ |
| | (1.466) | (1.237) | (1.409) | (2.254) | (4.005) | (5.025) |
| $\alpha_S$ | 0.260 | $6.153^{***}$ | 0.701 | $12.902^{**}$ | $21.544^{***}$ | $22.094^{***}$ |
| | (2.755) | (2.228) | (4.084) | (5.162) | (4.974) | (5.575) |
| $\alpha_D$ | $3.334^{*}$ | $8.695^{***}$ | $8.599^{***}$ | $6.812^{***}$ | $22.144^{***}$ | $18.811^{***}$ |
| | (1.954) | (1.821) | (2.316) | (1.836) | (4.822) | (4.456) |
| $\alpha_{MNE}$ | 1.871 | $3.993^{***}$ | $5.524^{***}$ | $11.259^{***}$ | $16.298^{***}$ | $14.428^{***}$ |
| | (1.383) | (1.534) | (1.725) | (2.007) | (3.259) | (4.054) |

*Notes*: This table presents excess returns ($\alpha$) over a five-factor Fama French model of portfolios sorted based on measures of Information Technology. Returns are calculated using data on U.S. public firms' stocks traded on the Amex, NASDAQ, or NYSE. Monthly Unlevered returns are multiplied by 12 to make the magnitude comparable to annualized returns. IT intensity is measured and normalized yearly at the industry-year level. In any given month, stocks are sorted into five portfolios based on their IT quintile in the 12-month period before. A given portfolio's return is regressed in excess of the risk-free rate on the market portfolio minus the risk-free rate, the size factor (small minus big), the value factor (high minus low), the profitability factor (robust minus weak), and the investment factor (conservative minus aggressive), all obtained from Kenneth French's website. Standard errors are in parentheses and estimated using Newey-West with 12 lags. ***, **, and * indicate significance at the 0.1%, 1%, and 5% level, respectively. The sample period is 1991 to 2013. Each row represents a different sub-sample $\alpha_1$,$\alpha_2$,$\alpha_3$: Excluding Nasdaq, or High Tech firms,$\alpha_M$: Only Manufacturing Industries,$\alpha_S$: Only services,$\alpha_{MNE}$: Only Multinational firms,$\alpha_D$:Only purely domestic firms.

## Table 1.4: The impact of Foreign Competition

Panel A: Conditional on Foreign Share

| IT Intensity | Low (1) | 2 (2) | 3 (3) | 4 (4) | High (5) | H-L (6) | Low | 2 | 3 | 4 | High | H-L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\alpha_1$ | −0.700 | 4.390** | 4.834 | 5.469* | 1.001 | 3.305 | 2.935 | 9.826*** | 6.969** | 7.900** | 9.510 | 9.915 |
| | (2.534) | (2.173) | (3.459) | (3.067) | (5.078) | (4.700) | (1.786) | (1.960) | (2.789) | (3.148) | (7.163) | (7.965) |
| $\alpha_2$ | 1.416 | −1.073 | 4.403 | −4.401 | 1.036 | 0.925 | 2.457 | 2.353 | 5.851** | −1.581 | 2.021 | 1.935 |
| | (3.461) | (2.816) | (3.001) | (4.741) | (5.218) | (4.639) | (2.255) | (2.038) | (2.647) | (6.927) | (5.322) | (5.283) |
| $\alpha_3$ | −1.535 | 0.472 | 1.214 | 8.722** | 27.913*** | 35.918*** | 0.122 | 3.763 | 4.670** | 8.959*** | 24.831** | 24.929* |
| | (3.166) | (2.762) | (2.152) | (4.095) | (8.428) | (8.433) | (2.587) | (2.694) | (1.900) | (3.359) | (10.366) | (12.764) |

Panel B: International Risk Factors

| IT Intensity | Low (1) | 2 (2) | 3 (3) | 4 (4) | High (5) | H-L (6) |
|---|---|---|---|---|---|---|
| $\alpha$ | 3.141** | 4.749*** | 6.737*** | 7.886*** | 15.008*** | 11.867*** |
| | (1.366) | (1.026) | (1.209) | (1.472) | (3.355) | (2.951) |
| $\beta^{FX}$ | −0.099** | 0.026 | −0.001 | 0.176*** | 0.026 | 0.126* |
| | (0.040) | (0.033) | (0.040) | (0.062) | (0.069) | (0.076) |
| $\alpha^{Carry}$ | 3.172* | 4.973*** | 6.408*** | 8.290*** | 17.528*** | 14.355*** |
| | (1.763) | (1.138) | (1.383) | (1.736) | (3.351) | (2.582) |
| $\beta^{Carry}$ | −0.076 | −0.012 | 0.049 | 0.095 | 0.009 | 0.085 |
| | (0.059) | (0.044) | (0.068) | (0.082) | (0.079) | (0.117) |
| $\alpha^{Trade}$ | 2.828** | 5.052*** | 6.190*** | 7.558*** | 14.676*** | 11.848*** |
| | (1.372) | (1.028) | (1.034) | (1.469) | (3.158) | (2.723) |
| $\beta^{Trade}$ | 0.019 | −0.029 | 0.060 | 0.064 | 0.041 | 0.022 |
| | (0.042) | (0.025) | (0.055) | (0.046) | (0.045) | (0.052) |

*Notes*: This table presents excess returns ($\alpha$) over a five-factor Fama-French model of portfolios double-sorted based on measures of Information Technology and the level of foreign firms' sales share. Returns are calculated using data on U.S. public firms' stocks traded on the Amex, NASDAQ, or NYSE. Monthly unlevered returns are multiplied by 12 to make the magnitude comparable to annualized returns. IT intensity is measured and normalized yearly at the industry-year level. In any given month, stocks are sorted into five portfolios based on their IT quintile in the 12-month period before. A given portfolio's return is regressed in excess of the risk-free rate on the market portfolio minus the risk-free rate, the size factor (small minus big), the value factor (high minus low), the profitability factor (robust minus weak), and the investment factor (conservative minus aggressive), all obtained from Kenneth French's website. Standard errors are in parentheses and estimated using Newey-West with 12 lags. ***, **, and * indicate significance at the 0.1%, 1%, and 5% level, respectively. The sample period is 1991 to 2013. The lower table presents excess returns ($\alpha$) after controlling for common factors related to foreign markets.

Table 1.5: Forecast errors

| | Actual | Forecast | Error | Actual | Forecast | Error |
|---|---|---|---|---|---|---|
| IT intensity | 0.232*** | 0.238*** | −0.000* | 0.171*** | 0.166*** | −0.000 |
| | (0.079) | (0.083) | (0.001) | (0.055) | (0.057) | (0.001) |
| $\beta$ | | | | −0.049*** | −0.047*** | −0.002 |
| | | | | (0.012) | (0.013) | (0.002) |
| Size | | | | 0.025*** | 0.018*** | 0.007*** |
| | | | | (0.006) | (0.006) | (0.001) |
| B-M Ratio | | | | 0.002 | 0.007 | −0.005 |
| | | | | (0.010) | (0.010) | (0.004) |
| Leverage | | | | 0.031 | 0.050 | −0.019 |
| | | | | (0.031) | (0.032) | (0.013) |
| I /K | | | | −0.012 | −0.013 | 0.000 |
| | | | | (0.014) | (0.014) | (0.002) |
| Observations | 30424 | 30424 | 30424 | 30424 | 30424 | 30424 |
| $R^2$ | 0.002 | 0.002 | 0.006 | 0.006 | 0.004 | 0.007 |

*Notes*:This table reports the coefficients from panel regressions of the forecast error in earnings per share, EPS, (defined as actual I/B/E/S EPS minus mean I/B/E/S consensus forecast of annual EPS) normalized by the stock price at the end of the last fiscal year. The 1-year horizon consensus forecast is measured as the average of the last forecast of each analyst covering the stock in the 8 months (from 1 year and 8 months to 1 year) before the end of the fiscal year. Columns 2-6 (8-12) report results for a 1-year (2-year) forecast horizon. IT is industry IT intensity at the end of the previous fiscal year. Standard errors are clustered at the industry and year level and reported in parentheses. R2 is adjusted for degrees of freedom. Significance levels are denoted by * = 10%, ** = 5%, and *** = 1%. The sample period is 1991-2013.

## Table 1.6: Announcement Returns

| | Equally weighted | | | | | | Value weighted | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Low | 2 | 3 | 4 | High | H-L | Low | 2 | 3 | 4 | High | H-L |
| (-5,1) | 0.068 * ** | 0.068 * ** | 0.068 * ** | 0.068 * ** | 0.066 * ** | 0.002 | 0.070 * ** | 0.070 * ** | 0.074 * ** | 0.072 * ** | 0.069 * ** | 0.001 |
| | (0.019) | (0.018) | (0.018) | (0.017) | (0.017) | (0.002) | (0.018) | (0.018) | (0.019) | (0.018) | (0.018) | (0.003) |
| (10,1) | 0.119 * ** | 0.119 * ** | 0.120 * ** | 0.119 * ** | 0.117 * ** | 0.002 | 0.124 * ** | 0.124 * ** | 0.128 * ** | 0.127 * ** | 0.124 * ** | 0.001 |
| | (0.032) | (0.032) | (0.032) | (0.031) | (0.030) | (0.003) | (0.031) | (0.031) | (0.033) | (0.032) | (0.032) | (0.004) |

*Notes*:This table reports returns around earnings announcements of stocks sorted into five IT intensity portfolios. The returns are cumulative excess returns (stock return minus the risk-free rate) over a 6-day (11-day) window from 5 days (10 days) prior to the quarterly earnings announcement day to 1 day after the announcement day, i.e. the (-5,1) (and (-10,1)) window. These announcement returns are either equal-weighted (columns 2-7) or value-weighted (columns 8-13) - using the stock market capitalization measured at the end of the calendar quarter prior to the earnings announcement. Standard errors reported in parentheses are adjusted for heteroscedasticity and autocorrelation (Newey-West with 12 lags).

## Table 1.7: Returns for different sub periods

| **IT Intensity** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Low | 2 | 3 | 4 | High | H-L | Low | 2 | 3 | 4 | High | H-L |
| 1991 : 07 − 1995 : 06 | −3.694 | −0.926 | 3.767*** | 7.651 | 11.184** | 14.879** | −2.400 | 2.266*** | 6.177*** | 10.244*** | 12.152*** | 14.551*** |
| | (3.556) | (1.554) | (1.245) | (4.810) | (5.141) | (7.171) | (2.765) | (0.746) | (1.186) | (3.041) | (2.912) | (4.465) |
| 1995 : 07 − 2000 : 06 | −5.331** | −2.082 | 3.884 | 8.316 | 13.572*** | 18.902*** | 6.767** | 1.319 | 11.733*** | 13.111*** | 31.793*** | 25.026*** |
| | (2.462) | (2.170) | (4.545) | (5.590) | (4.366) | (5.269) | (2.740) | (2.960) | (3.979) | (2.341) | (7.849) | (6.450) |
| 2000 : 07 − 2005 : 06 | 3.386 | 4.800* | 9.794** | 13.789** | 23.173*** | 19.787*** | 1.503 | 5.725*** | 4.701*** | 13.651*** | 17.120*** | 15.617*** |
| | (2.200) | (2.859) | (4.782) | (5.294) | (7.654) | (6.486) | (2.228) | (1.392) | (1.656) | (4.804) | (5.838) | (4.464) |
| 2005 : 07 − 2009 : 06 | 2.997 | 6.532** | 8.934 | 7.697 | 7.984 | 4.987** | 5.875*** | 8.733*** | 6.194*** | 8.154*** | 8.498* | 2.623 |
| | (4.660) | (3.035) | (7.360) | (5.283) | (5.005) | (2.267) | (1.973) | (1.364) | (1.499) | (2.772) | (4.336) | (3.947) |
| 2009 : 07 − 2013 : 06 | 4.717*** | 3.528*** | 6.742** | 3.425** | −2.243 | −6.959 | 3.404*** | 4.149*** | 5.969** | 3.719** | 4.862 | 1.458 |
| | (0.580) | (0.919) | (3.067) | (1.659) | (4.203) | (4.507) | (1.002) | (1.051) | (2.268) | (1.671) | (4.706) | (4.915) |

*Notes*: The table reports portfolio sorts controlling for other industry characteristics for different time periods. Columns 1:7 tabulate results for equal-weighted returns and Columns 8:14 for value-weighted returns. H-L is an investment strategy that is long the portfolio of firms with high IT intensity and short the portfolio of firms with low IT intensity. Standard errors are adjusted for heteroscedasticity and auto-correlation (Newey-West). Significance levels are denoted by * = 10%, ** = 5%, and *** = 1%. The sample covers the period July 1991 to June 2013.

## Table 1.8: Conditional on Size and elasticity of substitution

| | Equally weighted | | | | | | Value weighted | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Low | 2 | 3 | 4 | High | **H-L** | Low | 2 | 3 | 4 | High | **H-L** |
| $T1$ | 2.864 | 6.037** | 11.965*** | 13.663*** | 20.478*** | 17.614*** | 21.309*** | 24.200*** | 52.155*** | 44.690*** | 59.814*** | 38.506*** |
| | (3.014) | (2.850) | (4.290) | (4.201) | (4.864) | (4.782) | (3.212) | (2.890) | (9.057) | (7.353) | (10.616) | (9.705) |
| $T2$ | −3.379 | −1.299 | 2.995 | 5.858** | 7.541** | 10.920*** | 9.951*** | 12.336*** | 27.679*** | 28.312*** | 34.338*** | 24.387*** |
| | (2.079) | (1.595) | (2.662) | (2.860) | (3.410) | (3.272) | (2.234) | (2.228) | (5.866) | (4.981) | (5.416) | (5.225) |
| $T3$ | −4.108*** | −1.244 | 0.513 | 2.933 | 6.562** | 10.670*** | 2.651* | 4.299*** | 5.493*** | 7.430*** | 14.147*** | 11.496*** |
| | (1.570) | (1.393) | (1.546) | (2.002) | (2.855) | (2.673) | (1.376) | (1.086) | (1.041) | (1.552) | (3.348) | (2.989) |

| **Small Mkt Cap Only** | Equally weighted | | | | | | Value weighted | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Low | 2 | 3 | 4 | High | **H-L** | Low | 2 | 3 | 4 | High | **H-L** |
| Low-$\sigma$ | 2.336 | 5.113* | 1.983 | 7.985* | 12.271** | 9.935* | 22.479** | 19.469*** | 23.163*** | 26.206*** | 39.725*** | 17.246 |
| | (3.476) | (2.698) | (2.954) | (4.773) | (5.544) | (5.916) | (9.707) | (2.753) | (4.067) | (5.467) | (9.341) | (12.635) |
| High-$\sigma$ | 3.444 | 3.839 | 12.123** | 13.884*** | 9.287 | 5.843 | 16.108*** | 22.716*** | 47.883*** | 39.882*** | 45.912*** | 29.805*** |
| | (2.964) | (3.272) | (4.919) | (4.180) | (5.942) | (6.484) | (3.450) | (5.525) | (8.760) | (6.350) | (9.402) | (8.288) |

*Notes*: This table presents excess returns ($\alpha$) over a five-factor Fama-French model of information technology portfolios based on U.S. nonmultinational public firms' stocks traded on the AMEX, NASDAQ or NYSE. Monthly returns are multiplied by 12 to make the magnitude comparable to annualized returns. Returns are normalized based on the level of leverage of the previous calendar year to ensure that the results are not driven by leverage. IT intensity is measured and normalized yearly at the industry-year level. In any given month, stocks are sorted into five portfolios based on their Information Technology intensity in the 12-month period before. A given portfolio's return is regressed in excess of the risk-free rate on the market portfolio minus the risk-free rate, the size factor (small minus big), the value factor (high minus low), the profitability factor (robust minus weak), and the investment factor (conservative minus aggressive), all obtained from Kenneth French's website. Standard errors are in parentheses and estimated using Newey-West with 12 lags. ***, **, and * indicate significance at the 0.1%, 1%, and 5% level, respectively. The sample period is 1991 to 2013.

Table 1.9: Calibration

| Parameter | | Value | Target |
|---|---|---|---|
| **Industry Parameters:** | | | |
| Expenditure share | $a_0, a_0^*$ | $0.5, 0.5$ | |
| Elasticity across industries | $\theta$ | 1.2 | Loualiche (2015) |
| Elasticity across varieties | $\sigma_J$ | 3.8 | Broda and Weinstein (2006) |
| Pareto tail parameter | $\gamma_J$ | 3.6 | |
| Headquarter transmission parameter | $\zeta$ | 0.5 | Cravino and Levchenko (2017) |
| **Production** | | | |
| Labor supply | $L, L^*$ | $1, 4$ | ratio of w.age pop. in US, ROW |
| Mass of firms | $N_J, N_J^*$ | $1, (5, 2)$ | ratio of market cap in US, ROW |
| **Horizontal FDI Costs** | | | |
| Knowledge Transfer Costs | $K_J$ | 12 | Normalization |
| Fixed FDI costs | $f_J, f_J^*$ | $1 \times 10^{-4}, 3 \times 10^{-4}$ | avg "foreign" penetration |
| Fixed IT costs | $f_{ITJ}$ | $(1, 20)$ | avg IT intensity |
| Fixed IT costs | $f_{ITJ}^*$ | $(0.005, 0.1)$ | avg "foreign" penetration |
| **Aggregate Productivity:** | | | |
| United States | $\mu_A$ | 4 | US GDP |
| | $\sigma_A, \rho_A$ | $2\%, 0.98$ | US GDP |
| Rest of the World | $\mu_A^*$ | 1 | ROW GDP |
| | $\sigma_A^*, \rho_A^*$ | $8\%, 0.98$ | |
| **Preferences ( Dynamics ):** | | | |
| Discount factor | $\beta$ | 0.99 | Bansal and Yaron (2004) |
| Intertemporal Elasticity of Substitution | $\psi$ | 1.2 | Bansal and Yaron (2004) |
| Risk aversion parameter | $\nu$ | 20 | match U.S. equity premium |

*Notes*: This table presents the calibration of the model.

Table 1.10: Simulated Moments

Panel A: Targeted Moments

| | model | data |
|---|---|---|
| Share Market Capitalization ROW | 0.34 | 0.33 |
| Share Working Age Population ROW | 0.31 | 0.31 |
| Avg Foreign Penetration ROW - Mean | 13.68% | 12.39% |
| Avg Foreign Penetration ROW - Std | 8.67% | 6.13% |

Panel B: Macro Moments

| | Agg. Consumption | | Risk-free Rate | |
|---|---|---|---|---|
| | model | data | model | data |
| Mean | | | 3.51% | 3.32% |
| Std. dev | 1.81% | 2.63% | 0.31% | 2.21% |

Panel C: Sectoral Moments

| | Foreign Penetration | | Industry Profits | | Valuations | | Excess Returns | |
|---|---|---|---|---|---|---|---|---|
| | Low | High | Low | High | Low | High | Low | High |
| Mean | 6.57% | 18.91% | 0.50 | 0.36 | 1.53 | 1.23 | 0.25% | 0.61% |
| Std. dev | 2.13% | 9.36% | 4.41% | 8.13% | 1.15% | 0.66% | 5.75% | 10.08% |
| $\beta_A$ | $-0.05$ | $-0.10$ | 0.19 | 0.34 | 0.05 | 0.04 | 0.18 | 0.29 |
| $\beta_{A^*}$ | 0.14 | 0.49 | $-0.61$ | $-1.14$ | $-0.10$ | $-0.26$ | $-0.69$ | $-0.90$ |
| $\mathcal{E}_C$ | $-45.30$ | $-51.30$ | 22.76 | 12.87 | 2.41 | 5.55 | 14.51 | 17.48 |

*Notes*: This table presents the simulated moments from the model.

## 1.10 Theory Appendix

This Appendix includes the full derivations of the model and the theoretical predictions presented in the paper (Appendix 1), the computational approach(Appendix 2), details about measurement and data construction (Appendix 3), as well as a series of robustness tables and figures (Appendix 4).

In this section, I derive formally the competitive equilibrium of the model with $J$ industries and 2 countries. I extend the model in the main paper, to incorporate a different level of wages in the two locations, the fact that the productivity of an establishment may depend on the process of both "home" and "foreign" productivity. First, I solve the static allocation before setting up the aggregate optimization program for the participants in the economy: Households and Firms.

### 1.10.1 Model Equilibrium derivation

Most of the model derivations do not involve dynamic choices and thus in what follows I drop the $t$ subscript if they are no dynamic considerations. In addition, the following expressions are derived for one of the two countries, "home" ( for the other country, choices; cutoffs and relevant elasticities are symmetric).

#### 1.10.1.1 Static Consumption Choices

Given the nested demand, I derive the optimal allocations and decisions in three steps. First, I derive demand for the bundle $C_D$ of differentiated good sectors and the homogeneous good sector, $c_0$. The upper tier optimization program for consumers is

$$\max_{C_D, c_0} c_0^{1-a_0} \cdot C_D^{a_0}, \quad \text{s.t.} \quad P_D C_D + p_0 c_0 \leq Y$$

where $C_D$ is the consumption index from consumption in the $\mathcal{J}$ industries, $P_D$ the relevant price index, $p_0$ the price of the homogeneous good, and $Y$ the total income of consumers. From the first order conditions I derive the aggregate price index $P$ and demand for each type of goods:

$$P = \left(\frac{P_D}{a_0}\right)^{a_0} \left(\frac{p_0}{1-a_0}\right)^{1-a_0}$$
$$c_0 = (1-a_0)\frac{PC}{p_0}$$
$$C_D = a_0 \frac{PC}{P_D}$$

Given the allocation above, the consumer optimizes over the allocation across the $\mathcal{J}$ industries. Given the constant elasticity of substitution $\theta$, the optimization problem yields the usual expression for consumption under CES preferences:

$$\max_{\{C_J\}} \left(\sum_J C_J^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}} \quad \text{s.t} \quad \sum_J P_J C_J \leq P_D C_D$$

where $\{P_J\}$ represents the price level for each sector $J$. The optimal allocations are given by

$$C_J = \left(\frac{P_J}{P_D}\right)^{-\theta} \cdot C_D$$

and total expenditures in sector $J$ are

$$P_J C_J = \left(\frac{P_J}{P_D}\right)^{1-\theta} a_0 \cdot PC$$

This means that the price index for the differentiated goods is

$$P_D = \left[\sum_J P_J^{1-\theta}\right]^{\frac{1}{1-\theta}}$$

Finally, within each sector, the variety-level demand is given by $c_J(\omega)$, where $c_J(\omega)$ optimizes the following problem given the aggregated sectoral level consumption and prices in industry $J$ :

$$\max_{c_J(\omega)} \left[\int_{\Omega_J} c_J(\omega)^{\frac{\sigma_J - 1}{\sigma_J}} d\omega\right]^{\frac{\sigma_J}{\sigma_J - 1}} \quad \text{s.t.} \quad \int_{\Omega_J} p_J(\omega) c_J(\omega) d\omega \leq P_J C_J$$

From first-order conditions, individual variety expenditures and the price index across all varieties $\Omega$, with a price $p(\omega)$ of each variety, satisfies:

$$p(\omega) c_J(\omega) = p(\omega) \left(\frac{p(\omega)}{P_J}\right)^{-\sigma_J} \cdot C_J$$

$$P_J = \left[\int_{\Omega} p(\omega)^{1-\sigma_J} d\omega\right]^{\frac{1}{1-\sigma_J}}$$

In the following sections I describe the determination of the number of varieties $\Omega$ and prices $p(\omega)$ that determine the dynamics of the sales shares of firms and their correlation with aggregate consumption processes.

#### 1.10.1.2 Supply Side

***Sector 0*** By assumption, sector 0 produces a homogeneous good with a linear in labor technology and unit productivity. The homogeneous good 0 is freely traded and is used as the numeraire in each country. It is produced under constant returns to scale with one unit of labor producing $w$ units of good and its price is set equal to 1. Then each country has a different wage $w$ and $w^*$. This generalizes the case presented in the main body of the paper.

***Differentiated Sectors*** Firms in the other sectors operate under monopolistic competition and thus their prices are equal to the markup times the marginal cost. Given isoelastic demand in each industry, where the constant elasticity is given by $\sigma_J$, the markup is given by $\sigma_J/(\sigma_J - 1)$. An establishment of a firm with efficiency parameter $\varphi$ sets the following price if it operates in firms' headquarters, given the discussion on firm productivity:

$$p_J(\varphi) = \frac{\sigma_J}{\sigma_J - 1} w/(A\varphi)$$

and the following price when it does not operate in firms' headquarters:

$$p_{NJ}(\varphi) = \frac{\sigma_J}{\sigma_J - 1} w^* / \Big( (A\varphi)^{1-\zeta} (A^*\varphi)^{\zeta} \exp(-\kappa \mathbb{I}(\varphi < \underline{\varphi}_{ITJ}) \Big)$$

The productivity of establishments in the two different locations differ by assumption. In particular, the establishment productivity is a weighted average of the productivity of the firm at the headquarter's location $A\varphi$ and at the establishment location $A^*\varphi$ times an efficiency cost term $\exp(-\kappa \mathbb{I}_a(\varphi < \underline{\varphi}_{ITJ}))$. The idiosyncratic parameter of the productivity does not differ across locations. The efficiency cost represents costs of technology transfer or more generally any efficiency losses due to managing an establishment in a distant environment. Efficiency costs depend on the IT adoption decision $\mathbb{I}(\varphi \geq \underline{\varphi}_{ITJ})$ of the firm. In what follows, I will be using the following expression for prices:

$$p_{NJ}(\varphi) = K(\varphi)\frac{w^*}{w}(\frac{A}{A^*})^{\zeta}p_J(\varphi),$$

where

$$K(\varphi) \equiv \exp(\kappa\mathbb{I}(\varphi \geq \underline{\varphi}_{ITJ}))$$

These efficiency losses affect productivity and thus prices. Firm profits depend on chosen prices and quantities produced, and the number of establishments operated by the firms, along with the IT adoption decision. The local HQ - establishment profits are given by

$$\begin{aligned}\pi_J(\varphi) &= \frac{1}{\sigma_J} \cdot \left(\frac{p_J(\varphi)}{P_J}\right)^{1-\sigma_J} \cdot P_J C_J \\ &= \frac{p_J(\varphi)}{\sigma_J} \cdot \left(\frac{p_J(\varphi)}{P_J}\right)^{-\sigma_J} \cdot \left(\frac{P_J}{P_D}\right)^{1-\theta} \cdot a_0 \cdot PC\end{aligned}$$

The level of profits (or losses) of a second location are given by:

$$\pi_{NJ}(\varphi) = \frac{1}{\sigma_J} \cdot \left(\frac{p_{NJ}(\varphi)}{P_J^*}\right)^{1-\sigma_J} \cdot P_J^* C_J^* - \frac{f_J}{A} - \frac{f_{ITJ}\mathbb{I}(\varphi \geq \underline{\varphi}_{ITJ})}{A}.$$

Profits are increasing in idiosyncratic productivity, and hence there exists a productivity cutoff in each industry under which a firm decides to create a second establishment. Similarly, there is a cutoff related to the decision to adopt IT. The assumption for the fixed costs are such that the cuttof for IT adoption is always larger than that of operating a second establishment.

#### 1.10.1.3 Decision to operate second establishment and adopt IT

In this section, I describe the cutoffs that determine the decisions of the firms. I define the following cutoff level for firms that operate a second establishment as

$$\underline{\varphi}_{NJ} = \min_{\varphi}\{\varphi \mid \varphi \text{ implies that firm is operating a second establishment}\}.$$

Similarly, for firms that choose to use IT, I have:

$$\underline{\varphi}_{ITJ} = \min_{\varphi}\{\varphi \mid \varphi \text{ is adopting IT}\}.$$

I impose the relevant restrictions such that there is always a positive mass of firms, operating a second establishment but do not adopt IT. Now let's derive the cutoffs. The cutoff productivity for IT adoption is given by the lower bound of $\varphi$ such that:

$$\frac{1}{\sigma_J} \cdot \left( \frac{\frac{w^*}{w}(\frac{A}{A^*})^{\zeta} p_J(\varphi)}{P_J^*} \right)^{1-\sigma_J} \cdot P_J^* C_J^* - \frac{f_J}{A} - \frac{f_{ITJ}}{A} >$$

$$\frac{1}{\sigma_J} \cdot \left( \frac{\exp(\kappa)\frac{w^*}{w}(\frac{A}{A^*})^{\zeta} p_J(\varphi)}{P_J^*} \right)^{1-\sigma_J} \cdot P_J^* C_J^* - \frac{f_J}{A}$$

which is true if:

$$\frac{B_J^{*-1}}{A} \left[ (\varphi)^{-1+\sigma_J} - K^{1-\sigma_J} (\varphi)^{-1+\sigma_J} \right] - \frac{f_{ITJ}}{A} \geq 0$$

where $K = \exp(\kappa)$ and $B_J^*$ is the following helpful expression summarising the aggregate state of the economy:

$$B_J^* = \sigma_J \left( \frac{\sigma_J}{\sigma_J - 1} \frac{w^*}{w} (\frac{A}{A^*})^{\zeta} \right)^{\sigma_J - 1} \cdot A^{-\sigma_J} \cdot (P_J^*)^{-\sigma_J} (C_J^*)^{-1}$$

Then, the cutoff is such that:

$$(\underline{\varphi}_{ITJ})^{\sigma_J - 1} = \frac{B_J^* f_{ITJ}}{1 - K^{1-\sigma_J}}$$

Similarly, the cutoff productivity for operating an establishmentis given by

$$\left(\underline{\varphi}_{NJ}\right)^{\sigma_J - 1} = B_J^* f_J (K)^{\sigma_J - 1}$$

A very useful property in models where productivities are distributed Pareto, is that the relative ratio of the cutoffs will be constant. In particular, the two cutoffs satisfy:

$$\underline{\varphi}_{ITJ} / \underline{\varphi}_{NJ} = \left( \frac{1}{K^{\sigma_J - 1} - 1} \right)^{1/(\sigma_J - 1)} (f_{ITJ}/f_J)^{1/(\sigma_J - 1)} \equiv \Gamma_J$$

so the two cutoffs move proportionally with the aggregate productivity, $A$, which is an important property used to derive the results below. This property in particular implies that given that by assumption the parameters are assumed to be fixed, then the relationship between the cutoffs is constant over time and the only fluctuations in IT adoption and entry are due to aggregate productivity shocks. For what follows, the following equation will be useful

$$f_{ITJ} = f_J \Gamma_J^{\sigma_J - 1} (K^{\sigma_J - 1} - 1)$$

To derive an expression for the local sectoral price index I need to determine the mass of multianational firms operating in industry $J$, that their HQs are not in the "home" economy, $N^*_{NJ}$. These variables then summarize the supply side of the economy and given the aggregate productivity shocks $A$ and $A^*$ are essentially static. Lastly, total industry profits for "home" firms in a sector $J$ are defined as:

$$\Pi_J := \left[\int_{\Omega_J}^{\infty} \pi_J\left(\varphi_J\right) \mathrm{d}G_J(\varphi) + \int_{\Omega^*_{NJ}}^{\infty} \pi_{NJ}\left(\varphi_J\right) \mathrm{d}G_J(\varphi)\right]$$

The set of "home" products $\Omega^{\star}_{NJ}$ sold in the foreign country is determined by the cutoff in the previous section.

#### 1.10.1.4 Households Dynamic Problem.

The representative household has recursive Epstein - Zin preferences. Every period, the continuation utility $J_t$ is affected by the future sequence of consumption and the current aggregate consumption index $C_t$ :

$$J_t = \left[(1-\beta)C_t^{1-\nu} + \beta\left(\mathrm{R}_t\left(J_{t+1}\right)\right)^{1-\nu}\right]^{\frac{1}{1-\nu}}$$

where $\beta$ is the time preference parameter, $\nu$ is the inverse of the inter-temporal elasticity of substitution (IES) and $\psi$ is the coefficient of relative risk aversion. $\mathrm{R}_t\left(J_{t+1}\right) = \left[\mathbf{E}_t\left\{J_{t+1}^{1-\psi}\right\}\right]^{1/(1-\psi)}$ is the risk adjusted continuation utility. The representative household is subject to his sequential budget constraint as presented in the description of the model and repeated here for completeness. If there is risk sharing with parameter $\chi$, I have:

$$C_t + \sum_J \int_{\Omega_J^D} x_{J,t+1}(\varphi) v_{J,t}(\varphi) \mathrm{d}\varphi \leq w_t L + \sum_J \int_{\Omega_j^D} x_{J,t}(\varphi) \left( v_{J,t}(\varphi) + \pi_{J,t}(\varphi) \right) \mathrm{d}\varphi + \chi \Pi_M$$

Each household chooses $x_{J,t}$ equity holdings for domestically owned firms as described in the body of the paper and own shares in a mutual fund that is specialized in differentiated good "home" producers of each sector. In addition, they own shares in a non traded security that provides profits $\Pi_M$ and affects the degree of risk sharing. Households investment decision determines market prices for the firms in their country: $v_{J,t} N_{J,t}$. They also receive dividends from their ownership in these firms as income, $N_{J,t}\left(v_{J,t} + \pi_{J,t}\right)$ for consumption goods. $\Pi_M$ are the profits shared through the global mutual fund as described in the main body of the paper.

Here I describe the solution to the dynamic problem. The respective Lagrange multipliers for each equation is given by $\kappa_t$. Optimization conditions on respectively $C_{t+1}, C_t$, and $x_{J,t+1}$ are such that :

$$\kappa_{t+1} = \partial J_t / \partial C_{t+1}, \kappa_t = \partial J_t / \partial C_t$$

$$\kappa_t v_{J,t}(\varphi) = \mathbf{E}_t \left\{ \kappa_{t+1} \left( v_{J,t+1}(\varphi) + \pi_{J,t+1}(\varphi) \right) \right\}$$

In addition to the equity holdings of firms, in this environment it is also possible to price any asset in zero net supply by incorporating them to the sequential budget constraint. Given the non existence of arbitrage opportunities, the valuation of any asset in zero net supply would be given by the standard Euler equation as is the case for the innovators and the consumption good producers. Note that since households supply their endowment of labor in-elastically, the wage adjusts such that the budget constraint in each period holds exactly. In addition, given the constant supply of shares by firms, the budget constraint in equilibrium is as in the main body of the paper.

#### 1.10.1.5 Dynamic Equilibrium.

An equilibrium is a set of prices and allocations

$$(p_{Jt}, p_{NJt}, P_{Jt}, P_{Tt}, P_t), q_{Jt}(\varphi), c_{Jt}(\varphi), l_{Jt}(\varphi)$$

such that: (a) given prices, allocations maximize the households program; (b) given prices allocations maximize firms profits; (c) labor markets, good markets and asset markets clear.

To characterize the equilibrium, I derive the aggregate production function, firms' valuation and their dynamics through the Euler equation. But first I calculate the equilibrium profit of the differentiated varieties producers in each industry. Home demands and profits are given in equations as in the main body of the paper.

#### 1.10.1.6 Industry Aggregation

As in Helpman et al. (2004), for the solution of the equilibrium, it is enough to keep track only the mass and the average productivity for firms that choose to operate the same number of establishments, and that have the same technologies, i.e. they have adopted IT or not. This means for the aggregation, the theoretical predictions and for the numerical implementation of the model, I need at each period to keep track of:

1. The fraction of firms in industry $J$ that engage in production $\zeta_J$, the mass of firms that operate in two locations $\zeta_{NJ}$ and the mass of firms that have adopted IT $\zeta_{ITJ}$.

2. Derive average productivity levels for these different groups: 1) $\bar{\varphi}_J$, for all firms; 2) $\bar{\varphi}_{NJ}$, for firms that operate in two locations and 3) $\bar{\varphi}_{ITJ}$, for firms that adopt IT . Similarly I need to keep track the same cutoffs for the other region

3. Industry-wide profits and price indices can be calculated using probability masses and average productivity levels.

As I show below, the aggregation of industry variables is simplified even further since the relative cuttofs $\bar{\varphi}_{ITJ}$ and $\bar{\varphi}_{NJ}$ are given by a constant, as well as the ratio of the mass of firms $\zeta_{NJ}$ and $\zeta_{ITJ}$.

### 1.10.2 Aggregation

#### 1.10.2.1 Multi-national firms and IT adoption

Given the productivity cutoff for entering the foreign country $\varphi_{NJ}$, the fraction of ME firms, denoted $\zeta_{NJ}$, is given by

$$\zeta_{NJ} := Pr\left\{\tilde{\varphi} > \underline{\varphi}_{NJ}\right\} = \left(\frac{\underline{\varphi}_{NJ}}{\underline{\varphi}_{J}}\right)^{-\gamma_J}$$

Given the cutoffs described above, the fraction of firms that choose to adopt IT then satisfies:

$$\zeta_{ITJ} = Pr\left\{\tilde{\varphi} > \underline{\varphi}_{ITJ}\right\}$$

Due to the Pareto distribution assumption, the average productivity of firms with productivity higher than a cutoff value $\underline{\varphi}_{ITJ}$ would be equal to:

$$\overline{\varphi}_{ITJ} = \left[\frac{\int_{\varphi_{ITJ}}^{\infty} \varphi^{\sigma_J - 1} dG_J(\varphi)}{1 - G\left(\underline{\varphi}_{ITJ}\right)}\right]^{\frac{1}{\sigma_J - 1}} = \nu_J \underline{\varphi}_{ITJ}$$

where $\nu_J$ is defined as $\nu_J := \left(\gamma_J / \left(\gamma_J - (\sigma_J - 1)\right)\right)^{1/(\sigma_J - 1)}$ and so it depends only on the elasticity of substitution and the tail parameter of the distribution, which leads to the formulas described in the paper. The average productivity of firms with productivity higher than cutoff value $\underline{\varphi}_{NJ}$ also satisfies:

$$\bar{\varphi}_{NJ} = \nu_J \underline{\varphi}_{NJ}$$

where $\nu_J$ is defined as $\nu_J := \left(\gamma_J / \left(\gamma_J - (\sigma_J - 1)\right)\right)^{1/(\sigma_J - 1)}$ and so it depends only on the elasticity of substitution and the tail parameter of the distribution. Then, the local price indices for sector $J$ are given by:

$$P_J = \left(N_J \int_{\underline{\varphi}_J} p_J(\varphi)^{1-\sigma_J} d\varphi + (\zeta_{NJ}^* N_J^*) \int_{\underline{\varphi}_{NJ}^*} p_{NJ}^*(\varphi)^{1-\sigma_J} d\varphi\right)^{\frac{1}{1-\sigma_J}}$$

where the price of goods from an establishment of a firm not located in the same county satisfies the following expression:

$$p_{NJ}^*(\varphi) = \begin{cases} K^* \frac{w}{w^*} (\frac{A^*}{A})^{\zeta} p_J^*(\varphi) & \text{if } \underline{\varphi}_{NJ} < \varphi \leq \underline{\varphi}_{ITJ} \\ \frac{w}{w^*} (\frac{A^*}{A})^{\zeta} p_J^*(\varphi) & \text{if } \varphi > \underline{\varphi}_{ITJ} \end{cases}$$

Note that the price index of different industries reflects the decline in the price level from the IT adoption and thus the increase in competition, in industries of which the fixed cost of adoption is lower. Now the price index in industry $J$ reflects the effect of an increase in competition from the IT intensive firms leading to lower industry level prices.

#### 1.10.2.2 Aggregation

Instead of keeping track of the distribution of production and prices, it is sufficient to analyze average producers, first for the whole domestic market $\bar{\varphi}_J$ and second for the subset of multinational firms $\bar{\varphi}_{NJ}$ . The following quantities are sufficient to define the equilibrium:

$$\bar{\varphi}_J := \left[\int_{\underline{\varphi}_J}^{\infty} \varphi^{\sigma_J-1} \mathrm{d}G_J(\varphi)\right]^{\frac{1}{\sigma_J-1}} = \nu_J \cdot \underline{\varphi}_J$$

$$\bar{\varphi}_{NJ} := \left[\int_{\varphi_{NJ}}^{\infty} \varphi^{\sigma_J-1} \mathrm{d}G_J(\varphi)\right]^{\frac{1}{\sigma_J-1}} = \nu_J \cdot \underline{\varphi}_{NJ}$$

$$\bar{\varphi}_{ITJ} := \left[\int_{\varphi_{ITJ}}^{\infty} \varphi^{\sigma_J-1} \mathrm{d}G_J(\varphi)\right]^{\frac{1}{\sigma_J-1}} = \nu_J \cdot \underline{\varphi}_{ITJ}$$

where $\nu_J$, the average of firm productivity under a Pareto distribution, is given by $\nu_J = \left(\frac{\gamma_J}{\gamma_J-(\sigma_J-1)}\right)^{\frac{1}{\sigma_J-1}}$.

Average profits for "home" establishments in the "home" country in industry $J$ are $\pi_J\left(\bar{\varphi}_J\right)$ and for the establishments in the foreign country are given by $\pi_{NJ}\left(\bar{\varphi}_{NJ}\right)+\Delta\pi_{NJ}\left(\bar{\varphi}_{ITJ}\right)$ where $\Delta\pi_{NJ}\left(\bar{\varphi}_{ITJ}\right)$ are the additional realized profits if a firms adopts IT and is defined explicitly below[38]:

[38]This expression summarizes the additional profits of IT adopters, compared to a case where

$$\Delta\pi_{NJ}\left(\bar{\varphi}_{ITJ}\right) = \frac{B_J^{*-1}}{A}\left[\left(\bar{\varphi}_{ITJ}\right)^{-1+\sigma_J} - K^{1-\sigma_J}\left(\bar{\varphi}_{ITJ}\right)^{-1+\sigma_J}\right] - \frac{f_{ITJ}}{A}$$

and similarly for the prices, since we have:

$$p_{NJ}^*(\varphi) = \begin{cases} K^*\frac{w}{w^*}(\frac{A^*}{A})^\zeta p_J^*(\varphi) & \text{if } \underline{\varphi}_{NJ} < \varphi \leq \underline{\varphi}_{ITJ} \\ \frac{w}{w^*}(\frac{A^*}{A})^\zeta p_J^*(\varphi) & \text{if } \varphi > \underline{\varphi}_{ITJ} \end{cases}$$

and the realized reduction in the price in the case of IT adoption for a firm with productivity $\varphi$, we have $\Delta p_{NJ}^*(\varphi) = (1-K^*)\frac{w}{w^*}(\frac{A^*}{A})^\zeta p_J^*(\varphi)$. In addition, given the definition of mean levels, across different groups I have:

$$\bar{\varphi}_{ITJ}/\bar{\varphi}_{NJ} = \left(\frac{1}{K^{\sigma_J-1}-1}\right)\left(f_{ITJ}/f_J\right)^{1/(\sigma_J-1)} = \Gamma_J$$

The relative share of IT adopters also satisfies:

$$\zeta_{ITJ}/\zeta_{NJ} = \Gamma_J^{-\gamma_J}$$

which is independent of $A$ and $A^*$. Using the expressions for the profit functions and the cutoffs, aggregate profits can be written as:

$$\Pi_J := N_J\left[\pi_J\left(\bar{\varphi}_J\right) + \zeta_{NJ}\pi_{NJ}\left(\bar{\varphi}_{NJ}\right) + \zeta_{NJ}\Gamma_J^{-\gamma_J}\Delta\pi_{NJ}\left(\Gamma_J\bar{\varphi}_{NJ}\right)\right]$$

where I have substituted the expressions for $\bar{\varphi}_{ITJ}$ and $\zeta_{ITJ}$ which makes it immediate to see that the IT cutoffs are not important for aggregation given the

this option is not available.

results presented above. This implies that I need to keep track only the cutoff for the operation of a second establishment $\bar{\varphi}_{NJ} = v_J \underline{\varphi}_{NJ}$. The same aggregation property simplifies the expression for the sectoral price index $P_J$ :

$$P_J = \left(N_J \cdot p_J\left(\bar{\varphi}_J\right)^{1-\sigma_J} + \zeta^*_{NJ} N^*_J \cdot p^*_{NJ}\left(\bar{\varphi}^*_{NJ}\right)^{1-\sigma_J} + \zeta^*_{NJ} \Gamma_J^{*-\gamma_J} N^*_J \Delta p^*_{NJ}\left(\Gamma^*_J \bar{\varphi}^*_{NJ}\right)^{1-\sigma_J}\right)^{\frac{1}{1-\sigma_J}}$$

where $p^*_{NJ}\left(\bar{\varphi}^*_{NJ}\right) = K^* \frac{w}{w^*}(\frac{A^*}{A})^{\zeta} p^*_J(\bar{\varphi}^*_{NJ})$ and $\Delta p^*_{NJ}\left(\bar{\varphi}^*_{NJ}\right) = (K^* - 1)\frac{w}{w^*}(\frac{A^*}{A})^{\zeta} p^*_J(\bar{\varphi}^*_{NJ})$.

So simplifying even further

$$P_J = \left(N_J \cdot p_J\left(\bar{\varphi}_J\right)^{1-\sigma_J} + \zeta^*_{NJ} N^*_J \cdot p^*_{NJ}\left(\bar{\varphi}^*_{NJ}\right)^{1-\sigma_J}\left[1 + (K^{*\sigma_J - 1} - 1)\Gamma_J^{*-\gamma_J + \sigma_J - 1}\right]\right)^{\frac{1}{1-\sigma_J}}$$

or using the following definition

$$H\left(K^*, \Gamma^*_J, \gamma_J, \sigma_J\right) \equiv \left[1 + (K^{*\sigma_J - 1} - 1)\Gamma_J^{*-\gamma_J + \sigma_J - 1}\right] :$$

$$P_J = \left(N_J \cdot p_J\left(\bar{\varphi}_J\right)^{1-\sigma_J} + \zeta^*_{NJ} N^*_J \cdot p^*_{NJ}\left(\bar{\varphi}^*_{NJ}\right)^{1-\sigma_J} H\left(K^*, \Gamma^*_J, \gamma_J, \sigma_J\right)\right)^{\frac{1}{1-\sigma_J}}$$

#### 1.10.3 IT intensity

**Lemma 5.** *Proof of Lemma 1*

In particular, I have that IT labor hours in the "home" market are equal to the product of the number of producers, the amount required to operate IT and the endogenous percentage of firms that choose to operate IT:

$$L_J^{IT} = N_J \times f_{ITJ} \times \zeta_{ITJ} = N_J f_{ITJ} \Gamma_J^{-\gamma_J} \zeta_{NJ} =$$

$$= N_J f_{ITJ} \left( \frac{1}{K^{\sigma_J - 1} - 1} \right)^{-\gamma_J/(\sigma_J - 1)} (f_{ITJ}/f_J)^{-\gamma_J/(\sigma_J-1)} \zeta_{NJ}$$

$$L_J^{IT} = N_J \zeta_{NJ} \left( f_J (K^{\sigma_J-1} - 1) \right)^{\gamma_J/(\sigma_J-1)} \left( f_{ITJ} \right)^{1-\gamma_J/(\sigma_J-1)}$$

Given the fixed number of firms $N_J$, and the fact that $\zeta_{NJ}$ is independent of $f_{ITJ}$ and the coefficient of $f_{ITJ}$ is $-\frac{\gamma_J - \sigma_J + 1}{\sigma_J - 1}$, the proof of Lemma 1 is immediate.

The level of IT fixed costs reduces the number of IT workers and thus the IT intensity of the industry. In addition, the level of the fixed costs and the efficiency losses $K = \exp(\kappa)$ interact to determine the overall level of IT intensity of an industry. Figure 12 summarizes these forces. In addition, this key equation shows that the more heterogeneity there is in an industry, then the larger the IT intensity, conditional on the fixed cost of IT. Also the level of heterogeneity, determines how a shock to the cost of IT adoption affects the reaction of IT intensity, through the level of the elasticity. In addition, it is important to observe that the level of the IT intensity of each industry, corresponds to the labor based measures of IT intensity as the ones used for the empirical exercise based on the IT employment of industries in the U.S.

### 1.10.4 Multinational firm's share

First let us define the multinational firm's effect on the price index (competition) as:

$$\mathcal{I}_J = \frac{\zeta^*_{NJ} N^*_J \cdot p^*_{NJ} \left(\bar{\varphi}^*_{NJ}\right)^{1-\sigma_J} H^*_J}{P_J^{1-\sigma_J}}$$

It is useful to remember also that

$$p^*_{NJ}(\bar{\varphi}^*_{NJ}) = K^* \frac{w}{w^*} (\frac{A^*}{A})^{\zeta} p^*_J(\bar{\varphi}^*_{NJ})$$

This represents the marginal impact of multinational firms on the price index for a given industry. Given our definition of $P_J$, this variable is bounded: $\mathcal{I}_J \in [0, 1]$.

**Lemma 6.** *The level of $\mathcal{I}_J$ is a decreasing function of the cost of adoption $f^*_{ITJ}$.*

The proof of this proposition is immediate since it is a simple matter of observing that $f^*_{ITJ}$ appears only in the expression for $H^*_J$ and that $H^*_J$ is decreasing in $f^*_{ITJ}$.

### 1.10.5 Elasticities

All elasticitites $\mathcal{E}^*(X) \equiv \frac{\partial logX}{\partial logA^*}$ are with respect to an aggregate shock $A^*$ and $\mathcal{E}(X) = \frac{\partial logX}{\partial logA}$ with respect to an aggregate shock $A$. Elasticities related to total and sector price indices:

$$\mathcal{E}^*(P) = a_0 \mathcal{E}^*\left(P_D\right)$$
$$\mathcal{E}^*\left(P_D\right) = \sum_J \left(\frac{P_D}{P_J}\right)^{\theta-1} \mathcal{E}^*\left(P_J\right)$$

Elasticities related to total, sector and industry consumption:

$$\mathcal{E}^*(C) = -\mathcal{E}^*(P) + \frac{\Pi}{wL+\Pi}\mathcal{E}^*(\Pi)$$
$$\mathcal{E}^*(C_D) = \mathcal{E}^*(C) - (1-a_0)\,\mathcal{E}^*(P_D) = \mathcal{E}^*(C) - \left(\frac{1}{a_0} - 1\right)\mathcal{E}^*(P)$$
$$\mathcal{E}^*(C_J) = -\theta\mathcal{E}^*(P_J) + \theta\mathcal{E}^*(P_D) + \mathcal{E}^*(C_D) = ...$$

$$-\theta\mathcal{E}^*(P_J) + \mathcal{E}^*(C) + [\theta - (1-a_0)]\,\mathcal{E}^*(P_D)$$

**Productivity cutoff-** Using the definition of $\varphi^*_{NJ}$, I have to a first-order approximation

$$\varphi^*_{NJ} \propto (A^*)^{\zeta - \frac{\sigma_J}{\sigma_J - 1}} \cdot P_J^{-1} \cdot (PC)^{-\frac{1}{\sigma_J-1}}$$

where the coefficient of proportionality does not depend on $A^*$. Hence, the elasticity of the foreign productivity cutoff is given by

$$\mathcal{E}^*(\varphi^*_{NJ}) = \zeta - \frac{\sigma_J}{\sigma_J - 1} + \frac{\sigma_J}{\sigma_J - 1}\left(-\mathcal{E}^\star(P_J)\right) - \frac{1}{\sigma_J - 1}\mathcal{E}^\star(C_J)$$

where the first term increases the cutoff due to an increase in competition, and the second lowers it due to an increase in industry demand. The last term comes from aggregate demand and lowers the cutoff.

Now the derivation of the IT elasticity cutoff is simple, since in equilibrium we showed that the two cutoffs are proportional and the degree of proportionality is independent of the aggregate shocks, and this means we have:

$$\mathcal{E}^{\star}\left(\varphi_{NJ}\right)=\mathcal{E}^{\star}\left(\varphi_{ITJ}\right)$$

#### 1.10.6 Model implications

Let's recall the definition of the following variable:

$$\mathcal{I}_J=\frac{\zeta_{NJ}^{*}N_J^{*}\cdot p_{NJ}^{*}\left(\bar{\varphi}_{NJ}^{*}\right)^{1-\sigma_J}H_J^{*}}{P_J^{1-\sigma_J}}$$

and

$$p_{NJ}^{*}(\bar{\varphi}_{NJ}^{*})=K^{*}\frac{w}{w^{*}}(\frac{A^{*}}{A})^{\zeta}p_J^{*}(\bar{\varphi}_{NJ}^{*})$$

where the only effect of $f_{ITJ}^{*}$ is through $H_J^{*}$. In addition, $H_J^{*}$ is independent of the aggregate shocks, $A$ and $A^{*}$.

**Lemma 7.** *The elasticity of firms' local cash flows to productivity shocks is*

$$\mathcal{E}^{*}\left(\Pi_{LJ}\right)=\frac{-\mathcal{I}_J\cdot\left(\left(\sigma_J-1\right)\left(1-\zeta\right)+\xi_J\sigma_J-\xi_J\zeta(\sigma_J-1)\right)+\mathcal{E}^{*}(PC)}{1+\xi_J\mathcal{I}_J}$$

*where $\xi_J=\frac{\gamma_J}{\sigma_J-1}-1>0$ is a parameter defined for notational convenience and $\mathcal{I}_J$ is the level of global firms presence in industry $J$ defined above. If the second term due to demand effects is small enough, local firms' cash flows respond negatively to productivity shocks $A^{*}$. The elasticity is bigger if the level of IT fixed costs are lower, that is the elasticity is bigger, the bigger is the level of $\mathcal{I}_J$.*

Remember that profits of firms that operate establishments locally are given by

$$\Pi_{LJ}=N_J\int\pi_J(\varphi)d\varphi=N_J\pi_J(\bar{\varphi}_J)=\frac{1}{\sigma_J}\cdot\left(\frac{p_J(\bar{\varphi}_J)}{P_J}\right)^{1-\sigma_J}\cdot\left(\frac{P_J}{P_D}\right)^{1-\theta}\cdot a_0\cdot PC$$

A shock to $A^*$ leads to an increase in foreign entry, that leads to an increase in variety demand and total expenditures. The elasticity of local profits is [39]

$$\mathcal{E}^*\left(\Pi_{LJ}\right) = \mathcal{E}^*\left(\pi_J(\bar{\varphi}_J)\right) = -\left(\sigma_J - 1\right) \cdot \left(-\mathcal{E}^*\left(P_J\right)\right) + \quad \mathcal{E}^*(PC)$$

In addition it is useful to observe that irrespective of the firm size the elasticity of local profits is equalized across the size distribution and thus

$$\mathcal{E}^*\left(\Pi_{LJ}\right) \quad = \underbrace{-\left(\sigma_J - \theta\right)\left(-\mathcal{E}^*\left(P_J\right)\right)}_{\text{competition effect}} + \underbrace{\mathcal{E}^*\left(C\right) + \frac{1 - a_0 - \theta}{a_0}\left(-\mathcal{E}^*(P)\right)}_{\text{expenditure effect}}$$

Now, the separate components affecting the elasticity are analyzed.

*Competition effect.* Observe that the competition effect differs across industries. The elasticity for the price index in industry $J$ is:

$$\begin{aligned}\mathcal{E}^*\left(P_J\right) &= \frac{\zeta_{NJ}^* N_J^* \cdot p_{NJ}^*\left(\bar{\varphi}_{NJ}^*\right)^{1-\sigma_J} H_J^*}{P_J^{1-\sigma_J}} \cdot \left[(1-\zeta) + \frac{\partial \log p_{NJ}^*}{\partial \log \bar{\varphi}_{NJ}^*}\frac{\partial \log \bar{\varphi}_{NJ}^*}{\partial \log A^*} + \frac{1}{1-\sigma_J}\frac{\partial \log \zeta_{NJ}^*}{\partial \log A^*}\right] \\ &= -\mathcal{I}_J \cdot \left[1 - \zeta + \left(\frac{\gamma_J}{\sigma_J - 1} - 1\right)\left(-\mathcal{E}^*\left(\bar{\varphi}_{NJ}^*\right)\right)\right]\end{aligned}$$

where I use the following equality (from the definition of $\zeta_j^*$)

$$\mathcal{E}^*\left(\zeta_{NJ}^*\right) = -\gamma_J \cdot \mathcal{E}^*\left(\varphi_{NJ}^*\right)$$

**Productivity cutoff-** Using the definition of $\varphi_{NJ}^*$, I have to a first-order approximation

[39] There are second-order effects of redistribution through the industry shares. I verify that they are small in the calibration and ignore them in the the derivation that follows.

$$\varphi_{NJ}^{*} \propto (A^{*})^{\zeta-\frac{\sigma_J}{\sigma_J-1}} \cdot P_J^{-1} \cdot (PC)^{-\frac{1}{\sigma_J-1}}$$

where the coefficient of proportionality does not depend on $A^*$. Hence, the elasticity of the foreign productivity cutoff is given by

$$\mathcal{E}^*\left(\varphi_{NJ}^*\right) = \zeta - \frac{\sigma_J}{\sigma_J-1} + \frac{\sigma_J}{\sigma_J-1}\left(-\mathcal{E}^{\star}\left(P_J\right)\right) - \frac{1}{\sigma_J-1}\mathcal{E}^{\star}\left(C_J\right)$$

where the first term increases the cutoff due to an increase in competition, and the second lowers it due to an increase in industry demand. The last term comes from aggregate demand and lowers the cutoff. Combining, I obtain

$$\mathcal{E}^*\left(P_J\right) = -\frac{\mathcal{I}_J}{1+\xi_J\mathcal{I}_J} \cdot \left[(1-\zeta) + \xi_J\left(\frac{\sigma_J}{\sigma_J-1} - \zeta\right) + \frac{\xi_J}{\sigma_J-1} \cdot \mathcal{E}^*(PC)\right],$$

Combining all the expressions together, I obtain the effect of foreign shocks on domestic profits:

$$\mathcal{E}^*\left(\Pi_{LJ}\right) = \frac{-\mathcal{I}_J \cdot \left(\left(\sigma_J-1\right)\left(1-\zeta\right) + \xi_J\sigma_J - \xi_J\zeta(\sigma_J-1)\right) + \mathcal{E}^*(PC)}{1+\xi_J\mathcal{I}_J}$$

QED.

**Lemma 8.** *The elasticity of firms' foreign cash flows to productivity shocks* $A^*$ *is*

$$\mathcal{E}^*\left(\pi_{NJ}(\varphi)\right) = \left[-\left(\sigma_J-1\right) \cdot \frac{1-\mathcal{I}_J^*}{1+\xi_J\mathcal{I}_J^*} + \left(1-\zeta-\xi_J\frac{\mathcal{I}_J^*}{1+\xi_J\mathcal{I}_J^*}\right)\mathcal{E}^*\left(P^*C^*\right)\right] \cdot \left(1+o\ell_J(\varphi)\right)$$

*with* $o\ell_J(\varphi) =$ *is the operating leverage of multi national firms, and depend on the* *choice of IT use. MNE profits are affected by two opposite forces. When firms become more productive, MNEs from the country now facing a relatively lower productivity lose market share - a business stealing channel similar to the one affecting local cash flows. However, as the other market grows with productivity, there is also a market size effect that counteracts the first effect. The last term captures an operating leverage channel driven by the fixed costs associated with MNE and IT operations.*

**Proof** Profits for multinational firms are as follows in the foreign market:

$$\pi_{NJ}(\varphi) = \frac{1}{\sigma_J} \cdot \left( \frac{p_{NJ}(\varphi)}{P_J^*} \right)^{1-\sigma_J} \cdot P_J^* C_J^* - \frac{f_J}{A} - \frac{f_{ITJ} \mathbb{I}(\varphi \geq \underline{\varphi}_{ITJ})}{A}.$$

I also define the revenue function as

$$R_{NJ}(\varphi) = \pi_{NJ}(\varphi) + f_J/A + \frac{f_{ITJ} \mathbb{I}\left(\varphi \geq \varphi_{ITJ}\right)}{A}$$

First, elasticities are derived absent the fixed costs. Later, the implications of fixed costs are incorporated.

$$\mathcal{E}^*\left(R_{NJ}(\varphi)\right) = \zeta(\sigma_J - 1) - (\sigma_J) \cdot \left(-\mathcal{E}^*\left(P_j^*\right)\right) + \mathcal{E}^*\left(P^* C^*\right)$$

The elasticity of the price index in industry J in the foreign country is:

$$\begin{aligned}\mathcal{E}^*\left(P_J^*\right) = &-\frac{N_J^* p_J^* \left(\bar{\varphi}_J^*\right)^{1-\sigma_J}}{\left(P_J^*\right)^{1-\sigma_J}} + \zeta \frac{N_J \zeta_{NJ} p_{NJ} \left(\bar{\varphi}_{NJ}\right)^{1-\sigma_J} H_J}{\left(P_J^*\right)^{1-\sigma_J}} - \\ &- \left(\frac{\gamma_J}{\sigma_J - 1} - 1\right) \cdot \frac{N_J \zeta_{NJ} p_{NJ} \left(\bar{\varphi}_{NJ}\right)^{1-\sigma_J} H_J}{\left(P_J^*\right)^{1-\sigma_J}} \left(-\mathcal{E}^*\left(\bar{\varphi}_{NJ}\right)\right) \\ &= -\left(1 - (1-\zeta)\mathcal{I}_J^*\right) - \mathcal{I}_J^* \cdot \left(\frac{\gamma_J}{\sigma_J - 1} - 1 + \zeta\right) \cdot \left(-\mathcal{E}^*\left(\bar{\varphi}_{NJ}\right)\right)\end{aligned}$$

where $\mathcal{I}_J^*$ is MNE penetration. The first term comes from the direct effect of foreign productivity on prices of goods produced by local establishments. The second term comes from the extensive margin and is also negative since $\gamma_J > \sigma_J - 1$ and $\mathcal{E}^*\left(\bar{\varphi}_{NJ}\right) < 0$ Moreover, since the productivity cutoff is

$$\bar{\varphi}_{NJ} \propto \left(A^*\right)^{-\zeta} \left(P_J^*\right)^{-1} \cdot \left(P^* C^*\right)^{-\frac{1}{\sigma_J - 1}} :$$

$$\mathcal{E}^*\left(\bar{\varphi}_{NJ}\right) = -\zeta - \mathcal{E}^*\left(P_J^*\right) - \frac{1}{\sigma_J - 1} \cdot \mathcal{E}^*\left(P^* C^*\right)$$

Then, the elasticity of the foreign price index in industry J :

$$\mathcal{E}^*\left(P_J^*\right) = -\frac{1 - (1 - \zeta + \zeta \xi_J^{'})\mathcal{I}_J^*}{1 + \xi_J^{'} \mathcal{I}_J^*} - \frac{\mathcal{I}_J^*}{1 + \xi_J^{'} \mathcal{I}_J^*} \frac{\xi_J^{'}}{\sigma_J - 1} \mathcal{E}^*\left(P^* C^*\right)$$

Combining, I obtain the elasticity of multinational revenues:

$$\mathcal{E}^*\left(R_{NJ}(\varphi)\right) = -\left(\sigma_J - 1\right) \cdot \frac{1 - (1 - \zeta + \zeta \xi_J^{'})\mathcal{I}_J^*}{1 + \xi_J^{'} \mathcal{I}_J^*} + \left(\frac{\mathcal{I}_J^*}{1 + \xi_J^{'} \mathcal{I}_J^*} \xi_J^{'}\right) \mathcal{E}^*\left(P^* C^*\right)$$

Now given the definition of $\mathcal{E}^*\left(R_{NJ}(\varphi)\right)$ we have for non IT adopters

$$\mathcal{E}^*\left(\pi_{NJ}(\varphi)\right)=\mathcal{E}^*\left(R_{NJ}(\varphi)\right)\left(1+o\ell_J(\varphi)\right)$$

with $o\ell_J(\varphi)=\frac{1}{\left(\frac{\varphi}{\varphi_{NJ}}\right)^{\sigma_J-1}-1}$ representing the operating leverage. QED.

### 1.10.7 Proof of Proposition 1

Let us first recall Proposition 1 : Consider two industries in the same country and a shock to foreign productivity $A^\star$. If fixed costs of IT adoption are lower in industry $J_1$ then: (a) The elasticity of profit to $A^*$ for small firms is more negative in $J_1$ (b) The difference in the elasticity of profit comparing the two industries is larger (in absolute value) for smaller firms than for large firms: $\left(\mathcal{E}^*\left(\pi_{J_1}\right)-\mathcal{E}^*\left(\pi_{J_2}\right)\right)_{\text{below cutoff}}<\left(\mathcal{E}^*\left(\pi_L\right)-\mathcal{E}^*\left(\pi_H\right)\right)_{\text{above cutoff}}$ (c) The difference in the elasticity of profit to $A^*$ between low and high adoption industries for small firms $\left(\left(\mathcal{E}^*\left(\pi_{J_1}\right)-\mathcal{E}^*\left(\pi_{J_2}\right)\right)_{\text{below cutoff}}\right)$ is more negative i) in high $(\sigma)$ industries; and ii) in industries with more firm homogeneity, high $(\gamma_J)$ industries.

Proof of (a). To recall the result from Lemma 2 that the level of MNEs $\mathcal{I}_J$ is decreasing with the cost of adoption $f_{ITJ}$, all else equal. Moreover, a shock in $A^*$ has bigger impact on local profits if the share of large non local firms is higher from Lemma 2. It then follows that the elasticity of domestic profits is also larger (in absolute value) in industries with a lower cost of operating IT $f_{ITJ}$.

Proof of (b). Observe first from Lemma 3 that $\mathcal{E}^*\left(\Pi_{LJ_1}\right)<\mathcal{E}^*\left(\Pi_{LJ_2}\right)<0$.

Moreover, we have from Lemma 4 that $\mathcal{E}^*(\Pi_{NJ_1}) > \mathcal{E}^*(\Pi_{NJ_2})$. It follows that:

$$\mathcal{E}^*(\Pi_{LJ_2}) - \mathcal{E}^*(\Pi_{NJ_2}) > \mathcal{E}^*(\Pi_{LJ_1}) - \mathcal{E}^*(\Pi_{NJ_1})$$

In addition, the difference between the elasticity of the profit of a firm below the cutoff $\varphi_{NJ}$ and one above is:

$$\mathcal{E}^*(\Pi_L) - \mathcal{E}^*(\Pi_L + \Pi_N)_{\text{above the cutoff}} = \alpha_N \left(\mathcal{E}^*(\Pi_L) - \mathcal{E}^*(\Pi_N)\right)$$

where $\alpha_N$ the share of profits of large firms from sales outside of the local location, which it is immediate to show that, all else equal, $\alpha_{NJ_2} < \alpha_{NJ_1}$, as the share of sales outside of the local region, is smaller for firms in industries with high costs of doing IT. Using this inequality we conclude:

$$\mathcal{E}^*(\Pi_{NJ_1}) - \mathcal{E}^*(\Pi_{NJ_2}) < \mathcal{E}^*(\Pi_{LJ_1} + \Pi_{NJ_1})_{\text{above cutoff}} - \mathcal{E}^*(\Pi_{LJ_2} + \Pi_{NJ_2})_{\text{above cutoff}}$$

Proof of (c). The elasticity of local profits is more negative for high values of $\sigma_J$ and $\gamma_J$. These negative effects are amplified by $I_J$ .

### 1.10.8 Proofs of Proposition 2 and 3

Let us first recall Proposition 2 and 3:

Denote returns in low and high "adoption" industries, $R_{J_2}$ and $R_{J_1}$, respectively. Suppose that as in the data $\mathbf{E}\{R_{J_1}\} > \mathbf{E}\{R_{J_2}\}$. As in Barrot et al. (2019), observing whether the difference in expected returns is lower or larger between firms below or above the cutoff (small vs large firms); and across industries if the expected returns for small firms is lower or larger for (i) low or high $\sigma$ industries, and (ii) low or high $\gamma_J$ industries, allows to infer the sign of the price of risk. Specifically: (a) If $(\mathbf{E}\{R_{J_1}\} - \mathbf{E}\{R_{J_2}\})_{\text{below cutoff}} > (\mathbf{E}\{R_{J_1}\} - \mathbf{E}\{R_{J_2}\})_{\text{above cutoff}}$ then the price of risk is negative. Otherwise, it is positive. (b) If $(\mathbf{E}\{R_{J_1}\} - \mathbf{E}\{R_{J_2}\})_{\text{below cutoff, high-}\sigma} > (\mathbf{E}\{R_{J_1}\} - \mathbf{E}\{R_{J_2}\})_{\text{below cutoff, low-}\sigma}$, then the price of risk is negative. Otherwise, it is positive. (c) If

$$(\mathbf{E}\{R_{J_1}\} - \mathbf{E}\{R_{J_2}\})_{\text{below cutoff, high-}\gamma_J} > (\mathbf{E}\{R_{J_1}\} - \mathbf{E}\{R_{J_2}\})_{\text{below cutoff, low-}\gamma_J},$$

then the price of risk is negative. Otherwise, it is positive.

Proof. Let the price of risk for the productivity shock be $\lambda_{A^*}$, then, given that firms do not make dynamic decisions, any difference in expected returns is due to cash-flow risk, since

$$(\mathbf{E}\{R_{J_1}(\varphi)\} - \mathbf{E}\{R_{J_2}(\varphi)\}) = \lambda_{A^*}\left(\mathcal{E}^*\left(\Pi_{LJ_1}(\varphi) + \Pi_{NJ_1}(\varphi)\right) - \mathcal{E}^*\left(\Pi_{LJ_1}(\varphi) + \Pi_{NJ_1}(\varphi)\right)\right)$$

Thus if the price of risk is positive $(\lambda_{A^*} < 0)$, I have

$$(\mathbf{E}\{R_{J_1}\} - \mathbf{E}\{R_{J_2}\})_{\text{below cutoff}} < (\mathbf{E}\{R_{J_1}\} - \mathbf{E}\{R_{J_2}\})_{\text{above cutoff}}$$

would be a contradiction with the results in Proposition 1. Similarly the proof for the other results follows.

## 1.11 Computational Approach

### 1.11.1 Summary of the Model for Simulations

| Variable | $X$ | Equation |
|---|---|---|
| Aggregate Consumption | $C_t$ | $C_{Dt}^{a_0} C_{0t}^{1-a_0}$ |
| Differentiated Consumption | $C_{Dt}$ | $\left[\sum_j C_{Jt}^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}$ |
| Industry Expenditures | $P_{Jt}C_{Jt}$ | $(P_{Jt}/P_{Dt})^{1-\theta} a_0 PC$ |
| Entry Cutoff | $\underline{\varphi}_{NJ}$ | $\left(\mathrm{B}^*_J f_J\right)^{1/(\sigma_J-1)} K$ |
| IT Cutoff | $\underline{\varphi}_{ITJ}$ | $\Gamma_J \underline{\varphi}_{NJ}$ |
| Mass of MNEs | $\zeta_{NJ}$ | $1 - G(\underline{\varphi}_{NJ})$ |
| Mass of IT adopters | $\zeta_{ITJ}$ | $\zeta_{ITJ} = \Gamma_J^{-\gamma_J} \zeta_{NJ}$ |
| Wages | $w$ | Normalized to 1 |
| Local goods | $p_J(\varphi)$ | $\sigma_J w A^{-1} \varphi^{-1}/(\sigma_J - 1)$ |
| Non local goods | $p^*_{NJ}(\varphi)$ | $\begin{cases} K^* \frac{w}{w^*}(\frac{A^*}{A})^\zeta p^*_J(\varphi) & \text{if } \underline{\varphi}_{NJ} < \varphi \leq \underline{\varphi}_{ITJ} \\ \frac{w}{w^*}(\frac{A^*}{A})^\zeta p^*_J(\varphi) & \text{if } \varphi > \underline{\varphi}_{ITJ} \end{cases}$ |
| Industry price index | $P_J$ | $\left(N_J \cdot p_J\left(\bar{\varphi}_J\right)^{1-\sigma_J} + \zeta^*_{NJ} N^*_J K^* \frac{w}{w^*}(\frac{A^*}{A})^\zeta p^*_J\left(\bar{\varphi}^*_{NJ}\right)^{1-\sigma_J} H^*_J\right)^{\frac{1}{1-\sigma_J}}$ |
| Aggregate price index | $P_D$ | $\left[\sum_J P_J^{1-\theta}\right]^{\frac{1}{1-\theta}}$ |
| Local Profits | $\pi_J(\varphi)$ | $\left(\frac{p_J(\varphi)}{P_J}\right)^{1-\sigma_J} \left(\frac{P_J}{P_D}\right)^{1-\theta} a_0 PC/\sigma_J$ |
| Non-local Profits | $\pi_{NJ}(\varphi)$ | $\left(\frac{p_{NJ}(\varphi)}{P^*_J}\right)^{1-\sigma_J} P^*_J C^*_J/\sigma_J - f_J/A - f_{ITJ}/A\mathbb{I}(\varphi \geq \underline{\varphi}_{ITJ})$ |
| Valuations | $v_{J,t}(\varphi)$ | $\beta \mathbf{E}_t S_{t,t+1}\left(v_{J,t+1}(\varphi) + \pi_{J,t+1}(\varphi) + \pi_{NJ,t+1}(\varphi)\right)$ |

The model summarized above is solved using third-order approximations of the policy function around the deterministic steady-state of the model. The model is simulated 12000 periods, where the first 2000 are dropped, assuming that after that the variables follow their ergodic distribution. The moments, then, are calculated based on the data generated for the remaining periods of simulated data. The impulse response functions are calculated as the response of a model quantity with respect to a one standard deviation of the aggregate shocks $A$ or $A^*$. The plotted IRFs are calculated as the mean over 500 simulated IRFs.

## 1.12 Measurement and Data Construction

This Appendix contains additional information on the sample and data construction. In this section, I describe in detail the construction of the final dataset, starting from the firm- level dataset of stock returns, balance sheet data and multinational firms' employment and sales. Then, I describe the measurement of IT intensity at the occupation level and the aggregation of the index at the industry level. I conclude providing summary statistics for all of those data.

### 1.12.1 Firm level Data

I use monthly stock returns from the Center for Research in Security Prices (CRSP) and annual accounting information from the CRSP/COMPUSAT Merged Annual Files. The sample excludes FIRE (Finance, Insurance and Real Estate) industries and regulated firms (4-digit SIC codes between 4000 and 4999, as well as between 6000 and 6999). It includes only firms with ordinary shares (CRSP share codes 10 and 11) that are traded on either NYSE, AMEX, or NASDAQ for the period between

January 1991 and December 2013. Firm-level accounting variables are winsorized at the 1% level in every sample year to reduce the influence of possible outliers. Moreover, I rely on historical segment data of firms reporting foreign income from COMPUSTAT to classify firms in multinationals and non multinational firms as in Fillat and Garetto (2015a) and the industrial classification of those segment to define firms as conglomerates. In addition, I use analysts' split-adjusted annual earnings forecasts from the Institutional Brokers Estimates System (I/B/E/S) database. I define and construct the following variables for every firm:

- *Cost of goods sold* involves all direct costs involved with producing a good. This includes the cost of materials and other intermediate inputs, as well as the labor directly used to produce a good. It is observed on the income statement. The Compustat variable is COGS.

- *Selling, general and administrative expenses* are all direct and indirect selling, general and administrative expenses. They include overhead costs and costs such as advertisement or packaging and distribution. It is observed on the income statement. The Compustat variable is XSGA.

- *Operating expenses* are the sum of cost of goods sold and selling, general, and administrative expenses. The Compustat variable is XOPR.

- *Assets* is the logarithm of a firm's total book assets (AT).

- *PP&E* is net property, plant and investment (PPENT) scaled by total book assets (AT).

- *Size, Book-Market and Profitability* are calculated following Fama and French.

- *Market Leverage* is the firm's financial leverage and defined as the proportion of total debt of the market value of the firm. The market value of the firm is the market value of common equity defined as in Fama and French. Total debt is the book value of short-term (DLC) and long-term interest bearing debt (DLTT).

- *Revenue* is total sales. The Compustat Fundamentals variable is SALE.

### 1.12.2 Data on Foreign Multinational Firms in the United States

I combine several sources to create consistent measures of the number of foreign multinational companies, their market share and employment across industries in the United States. In particular, I combine the following data sources: 1. the BEA International Surveys on Foreign Direct Investment in the United States(FDIUS), 2. NBER-CES Manufacturing Industry Database, and 3. Census Service Annual Survey (SAS).

The Bureau of Economic Analysis (BEA) every year generates statistics on foreign firms related operations in the United States through its international surveys. In the survey on foreign direct investment in the United States, statistics on the activities of multinational enterprises statistics are provided, where multinational firms are considered those with activities in the U.S. who are affiliates with foreign parents (own at least 50% of the company in the United States. These data contain a wide variety of indicators of their financial structure and operations. To construct the measures of foreign firms' sales and employment I use the data provided summarizing operations across industries (Table A2 of the second part of tables: Majority-Owned U.S. Affiliates). In particular, I use the data on the number of firms, sales and employment across industries. The industry classification used is based on SIC3 codes before 1997 and based on NAICS4 codes after. I standardize the data across years in a consistent way using SIC3 classifications. Details on the process used follow.

This NBER-CES Manufacturing Industry Database is the outcome of a joint effort between the National Bureau of Economic Research (NBER) and U.S. Census Bureau's Center for Economic Studies (CES), that provide statistics on annual industry-level data from 1958-2018 on output, employment, payroll and other input costs, investment, capital stocks, TFP, and various industry-specific price indexes. I use the version provided across 459 four-digit 1987 SIC industries, that are then aggregated at SIC3 industries and merged with the data from FDIUS.

To complement the data on industrial productions with data on Services industries, I use the Service Annual Survey (SAS) from the Census. The Service Annual Survey (SAS) . The survey tables provide information on revenue, payroll, sources of revenue, expenses, exports, among other for service industries. These data are available since 1982. I aggregate the data consistently across 3 digit SIC industries and then merge them with the data from FDIUS. I complement these data with information on employment from the annual County Business Patterns data.

**Consistent 3 digit SIC Codes:**

The use of the data from FDIUS require some manipulations to be operational for research as several statistics on employment or sales are suppressed to protect confidentiality, and (2) industry classifications change over time. I develop a simple method that exploits the set of available adding-up constraints, as in Eckert et al. (2199) to impute missing employment and sales information. Second, using the provided concordances from this paper, I construct annual industry-level (more than 140 3-digit SIC industries in manufacturing and services) data from 1988-2018 on output, employment, payroll of home and foreign owned firms in the United States. Then I compute the foreign firms' sales shares as described in the paper.

### 1.12.3 Measuring IT intensity

At first I describe the task based measure of IT intensity at the occupation level.

#### 1.12.3.1 Occupation-level IT intensity

To understand the IT intensity of tasks at the occupation level (aggregated at the five-digit level that will be matched then with the CPS data), indices from the O*NET skill, task and knowledge measures are used, that incorporate information on the knowledge, activities related to Information Technology and computers. The list below summarizes the description of the tasks, skills and knowledge, that lead to an occupation to be considered more or less IT intensive.

**Variables and detailed questions/descriptions:** The questions and descriptions used to define the intensity with which occupations use Information Technology follows closely Gallipoli and Makridis (2021). I now describe the questions/answers related to *Knowledge* used in each occupation that are used to rank occupations. Then the questions about *Skills* and at the end those related to the *Work Environment.*

The structure will be as follows. First, the general description of the question is given and then I present the specific question used and possible answers that responders will choose and the corresponding ranking.[40]

In terms of *Knowledge,* I rank occupations based on knowledge of:

- **Computers and Electronics**: Knowledge of circuit boards, processors, chips, electronic equipment, and computer hardware and software

  Question: What level of COMPUTERS AND ELECTRONICS is needed to perform your current job?

  L(ow ranking): Operate a VCR to watch a pre-recorded training tape
  H(igh ranking): Create a program to scan computer disks for viruses

- **Engineering and technology**: Knowledge of the practical application of engineering science and technology. This includes applying principles, techniques, procedures, and equipment to the design and production of various goods and services.

  Question: What level of knowledge of ENGINEERING AND TECHNOLOGY is needed to perform your current job?

  L: Install a door lock H: Plan for the impact of weather in designing a bridge

In terms of *Skills,* I rank occupations based on knowledge of:

- **Programming**: Writing computer programs for various purposes

[40] I report the lowest and highest level in terms of ranking. In total there are 6 different levels.

Question: What level of PROGRAMMING is needed to perform your current job?

L: Write a program in BASIC to sort objects in a database H: Write expert system programs to analyze ground radar geological data for probable existence of mineral deposits

- **System Evaluation:** Identifying measures or indicators of system performance and the actions needed to improve or correct performance, relative to the goals of the system

  Question: What level of SYSTEMS EVALUATION is needed to perform your current job?

  L: Determine why a coworker has been overly optimistic about how long it would take to complete a task H: Evaluate the long-term performance problem of a new computer system

- **Quality control analysis:** Conducting tests and inspections of products, services, or processes to evaluate quality or performance

  Question: What level of QUALITY CONTROL ANALYSIS is needed to perform your current job?

  L: Inspect a draft memorandum for clerical errors H: Develop procedures to test a prototype of a new computer system

- **Operations analysis:** Analyzing needs and product requirements to create a design

Question: What level of OPERATIONS ANALYSIS is needed to perform your current job?

L: Select a photocopy machine for an office H: Identify the control system needed for a new process production plant

- **Technology design:** Generating or adapting equipment and technology to serve user needs

  Question: What level of TECHNOLOGY DESIGN is needed to perform your current job?

  L: Adjust exercise equipment for use by a customer H: Create new technology for producing industrial diamonds

- **Management of Material Resources:** Obtaining and seeing to the appropriate use of equipment, facilities, and materials needed to do certain work.

  Question: What level of MANAGEMENT OF MATERIAL RESOURCES is needed to perform your current job?

  L: Rent a meeting room for a management meeting H: Determine and monitor the computer system needs of a large corporation

In terms of *Work Environment,* I rank occupations based on the every day use and update of:

- **Computers**: Using computers and computer systems (including hardware and software) to program, write software, set up functions, enter data, or process information.

Question: What level of WORKING WITH COMPUTERS is needed to perform your current job?

L: Enter employee information into a computer database H: Set up a new computer system for a large multinational company

- **Email**:

  Question: How frequently does your current job require electronic mail?

- **Relevant knowledge**: Keeping up-to-date technically and applying new knowledge to your job

  Question: What level of UPDATING AND USING RELEVANT KNOWLEDGE is needed to perform your current job?

  L: Keep up with price changes in a small retail store H: Learn information related to a complex and rapidly changing technology

- **Data or Information**: Identifying the underlying principles, reasons, or facts of information by breaking down information or data into separate parts.

  Question: What level of ANALYZING DATA OR INFORMATION is needed to perform your current job?

  L: Determine the location of a lost order H: Analyze the cost of medical care services for **all** hospitals(in the country)

- **Processing Information:** Compiling, coding, categorizing, calculating, tabulating, auditing, or verifying information or data.

Question: What level of PROCESSING INFORMATION is needed to perform your current job?

L: Tabulate the costs of parcel deliveries H: Compile data for a complex scientific report

For each of these questions, sub-indices are constructed related to the intensity (average ranking of choices by respondents) of IT across occupations between 2004 and 2016. Then, they are aggregated at the occupation level, to construct an average occupation intensity score, constant across years. Lastly it is standardized (I create z scores of the IT intensity across occupations).

Then, CPS occupation classifications are harmonized between 1990 to 2015 to the five-digit SOC-level. Given the availability of the data and the time invariant score of the IT intensity of an occupation, the scores of occupational IT intensity can be linked to data dated back to 1990.

The primary data for employment and wages come from the the annual Current Population Survey (CPS) between 1991 and 2013 accessed through the Integrated Public Use Microdata (IPUMS) data portal. To mitigate concerns about partial attachment to the labor market, the sample of workers from the CPS is restricted to full-time workers between age 20 and 65, with over $5,000 in annual labor income, at least 20 weeks worked per year, and over $2 real hourly wages. Nominal variables are deflated using the 1990 price index.

# CHAPTER 2

# Information Technology, Multinational firms and Market Concentration in the United States

## 2.1 Introduction

The global economy has been affected by the large increase in the sales of large firms as documented in many studies of market concentration among U.S. firms (for example, Gutierrez and Philippon (2017), Covarrubias et al. (2020), Rossi-Hansberg et al. (2018)). One feature that is missing from studies of competition is often the relationship with globalization and the rise of large multinationals. This is particularly important as measures of concentration need to account for the universe of firms that compete in a specific market. In addition, accounting for operations of all firms, foreign and domestic competing in the U.S. market is crucial to understand the potential that technological improvements like IT may have on competition, since IT is a major driver of the globalization of firm activities. International trade theory, has long understood the need to account for foreign market entry as standard models with firm heterogeneity show how changes in costs of foreign activities affect the sales distribution among both foreign and domestic firms and how market shares reallocate from small unproductive firms to large firms. Technological improvements like IT that have large fixed costs of adoption would imply a similar impact on the reallocation of economic activity to large firms, conditional on large firms paying the fixed costs associated with IT. This paper uses an instrumental variables approach and a simple model of multinational firms with detailed data on the domestic and foreign operations of public firms to understand the implications of IT on foreign competition and the reallocation of economic activity from small domestic firms to large multinationals.

In particular, using data from Compustat accounting for the sales of all (domestic and foreign) public firms in the US market, I uncover some facts that provide a new picture on the common wisdom that IT increased concentration in the United States. I find that, over the past 20 years (from 1997 to 2020) which are the years that public firms are obliged to report their foreign operations in detail and Compustat has collected this information consistently, I uncover the following facts about industries in the United States and globally[1]:

- There is an increase in US market concentration measures among public firms for both Low and High IT intensive industries. The High IT industries have seen a relatively larger increase in concentration measures.
- The IT intensity of an industry is correlated with the share of foreign multinationals in the United States, but not the level of concentration.
- The IT intensity of an industry is correlated with the market shares of top firms in the Global Economy.
- IV regressions show that the relationship is causal from the IT intensity of an

[1] These facts are based on US and global market shares of all public firms and are based on their sales figures in Compustat and Compustat Segments.

industry to Foreign Entry in the United States, and the decline of the market shares of the top US firms.

- The sales growth and operating margin of non multinational firms declined substantially in IT intensive industries that have a large share of foreign affiliates of multinational firms in the United States.

These results are consistent with a theory of multinational firms, which predicts that IT is a form of technology that increases the productivity of establishments operated by foreign multinational firms and as a result IT leads to reallocation of sales from domestic firms to foreign multinationals. Given that IT is not a technology unique to the US or the rest of the world understanding the impact of IT on competition, requires looking at sales of firms of different mode (US Multinationals, Foreign Multinationals, and US domestic firms).

In theory, concentration in the global market or the US economy may be driven by large multinationals becoming larger and expanding across geographies intensifying competition due to IT improving their efficiency of selling to foreign consumers or in contrast IT may be a form to create barriers to entry and thus IT would cause a decline in competition, or entry of foreign multinationals. This paper is a first step to bring disaggregated data of foreign multinationals in the US market to understand whether IT is associated with intensified competition for domestic firms and a larger market share of multinational firms.

In particular, I find that adjusting for operations of foreign establishments in the market concentration measures from Compustat shows a rise in concentration between 1997 and 2020 in the cross section of industries in the US economy.The industries with the highest IT intensity are those that faced larger increases in market concentration globally and have larger market shares of multinational firms, as seen looking at the market shares of their affiliates in the U.S. economy. [2] Lastly, these changes are occurring across all sectors and are robust in the exclusion of the IT producing sectors. Figures 1 and 2 shows the evolution of industrial concentration in the United States, while Figures 3-7 show that IT intensity is correlated with larger foreign market shares, and a slight decline in domestic concentration.[3]

The differences between the findings in this paper and those in the literature (see Bessen (2020a)) could be driven by the fact that I study only large public firms companies but also it may be due to the distinction of domestic and global sales in the data and the distribution of those sales to the US market only. I reconcile these facts with a theory were multinational and domestic firms have differential incentives to adopt IT, since IT is helpful only to mitigate productivity losses due to operations of foreign establishments and derive testable predictions that first rationalize the movements in the data and second summarize in a stylized way the competitive forces faced by domestic firms due to IT adoption and the reallocation of market shares from domestic firms to foreign multinationals.

Then, using firm-level information I test some of the predictions of the model. Consistent, with a theory that predicts that IT increased foreign firms' establishments productivity, I find that IT adoption in an industry is associated with increases in foreign market shares of multinational firms and a negative growth of sales of

[2]The measures of foreign market shares are based both on the foreign sales' share of public firms or the foreign sales share of all firms with foreign affiliates in the United States measured using the official statistics from the BEA Foreign Direct Investment surveys.

[3]These binned scatterplots relate measures of concentration across industries (excluding those industries that software or IT services are the main manufactured product or provided services) to the share of IT labor in the industry workforce. In the empirical application of the paper, I test for the direction of causality using instrumental variables.

domestic non-multinationals firms. In particular, this effect for domestic firms is present only when the share of foreign firms in an industry is large (i.e. in industries that traditionally had more foreign firms operating establishments in the United States).

The findings provide novel evidence in support of the productivity gap between top-performing firms and laggards in an industry. As rising productivity gaps are consistently observed in the US and Europe (De Loecker et al. (2020), an important question arises whether those are associated with increases in productivity of firms' main operations or increases in productivity of firms' foreign operations. As foreign operations require large fixed costs, and are usually more prominent among leaders of an industry, an IT related productivity enhancement would lead to the observed productivity gaps in the consolidated accounts of firms.[4] This means that companies in industries with a large share of foreign multinationals would face an increasing productivity gap and a would potentially lose market share to large multinational firms.

**Literature Review** This paper is related with the broad literature on foreign direct investment. Keller and Yeaple (2013) test how the spatial frictions due to knowledge frictions and distance affect the choice of international operations, between exports and direct foreign sales. In their data, the level of foreing affiliates' sales are is decreasing in knowledge transfer costs across distant markets. Bahar (2020) in a related contribution shows that multinational firms are less likely to horizontally expand if there are larger knowledge frictions.Oldenski (2012) shows that industries

[4]For evidence of the productivity enhancing effects of IT , see Bloom et al. (2012) find similarly US multinationals with a productivity advantage (better managerial practices) gain more from IT.

like services that are based on customer interaction, communication frictions may explain the observed differential of the concentration-proximity tradeoff between manufacturing and services. Bloom et al. (2012) find that US multinationals with a productivity advantage (better managerial practices) gain more from IT.

My paper borrows from this literature about multinational firms to provide novel evidence about the dynamics of concentration in the United States and the driving mechanisms. In hat sense my paper relates to the literature on the rise of superstar firms. Autor et al. (2020) provide evidence for a "winner-take-most" market due to demand driven increased price-sensitivity. Price competition would reallocate market share to high markup/high productivity firms as observed in the data. Haskel and Westlake (2017) relate the rise of superstars to the growing intangible capital investment that could affect the returns of scale faced by firms. Similarly, Crouzet and Eberly (2019) show intangible capital investment is associated with rising concentration; and Bessen et al. (2020) shows that intangibles leads to greater persistence of productivity gaps and declining disruption by entrants. In contrast to this literature, my paper emphasizes a different margin of reallocation that between sales of foreign multinationals and domestic only firms. In a related contemporaneous contribution, Diez et al. (2021) provide direct evidence on the evolution of market shares and productivity of US firms in the US or globally. However, they do not classify foreign firms' sales in Compustat Segments as associated with the United States and thus they can not study the evolution of concentration associated with the multinational firms' margin. In contemporaneous work, Amiti and Heise (2021) study the implication of import competition for concentration and find similarly that adjusting for imports and exports there is no significant rise in concentration. They find that the sales share of the top U.S. firms increased in industries with tougher import competition but when adjusting sales figures to be inclusive of foreign firms' exports to the United States, they find that sales share of large U.S. firms decreased. My results are similar despite the emphasis on foreign affiliates sales and not exports and the different data source.

Lastly, I contribute to the increasing research evidence that document an increased dispersion in productivity between "frontier" firms and "laggard" firms, by providing a theory that relates these productivity gaps with multinational activity and providing direct empirical support. "Frontier" firms in the literature, see Andrews et al. (2015), are those that are more productive, but not large per se. I show that if these more productive firms are able to use IT to increase their productivity in foreign markets while "laggards" with domestic-only operations are affected less from IT, the productivity gap would increase and the growth of sales in IT intensive industries should be lower for domestic only firms. I confirm this theoretical prediction in the data. Hsieh and Rossi-Hansberg (2020) build a similar model to explain the standardization in retail services and the large geographic expansion of productive firms, like The Cheesecake Factory.

The rest of the paper is organized as follows. Section 2 describes the data and the empirical framework. Section 3 describes the stylized facts. Section 4 presents the results from the regression and instrumental variable analysis, Section 5 proposes a theory to explain the observed facts and tests the theoretical implications and Section 6 concludes.

## 2.2 Data

The focus of this paper is on the universe of public companies in the world, both domestic and multinationals. For the US and Canada, I source the data from Compustat North America, while for or the rest of the world, the data come from Compustat Global. In addition, I complement the information from Compustat with information about industry characteristics using aggregate and micro data from the BEA, the U.S. Census Bereau and the Bereau of Labor Statistics as described below.

**Firms' Consolidated Balance Sheet data** I use firm-level sales, and other operating variables provided by Compustat. The nominal quantities for non US firms are converted to US dollars using the exchange rates provided by Compustat. Compustat data contain almost the universe of US and non US public firms as Compustat North America covers all of market capitalization in North America and Compustat Global 96 % of capitalization in Europe and 88 % in Asia. North American data are consistently collected starting in 1965 and global data from 1990. I restrict the sample to start in 1997 since the operating segments data that I use are consistently reported from 1997 and onward as explained in the Appendix.

**Multinational Activity: The Compustat Segment Database** The Compustat Segment Database is used to create consistent sales figures for Foreign vs. Domestic operations and sales to the US market vs the Rest of the World. Two independent ways are used measure domestic and foreign sales in the United States. At the industry-level foreign sales of multinational firms are from the BEA's Data on Foreign Direct Investment in the United States and on the Activities of U.S. Multinational

Enterprises. The industry segments roughly correspond to 3 digit standard industry sector classification that can be matched consistently with the classifications in Compustat. For the US economy, I estimate the share of foreign sales in a given industry as the ratio of sales by 'Majority-owned US Affiliates of Foreign Multinational Enterprises' to total sales, defined as the sum of all shipments from the NBER-CES database. At the firm level I use Compustat Segments to separate domestic from foreign sales for US firms and classify firms as multinationals as in Fillat and Garetto. This gives a firm level measure of foreign sales, FS below. Lastly, I classify sales in Compustat as sales in the US market vs non US sales and as such I can create statistics on the evolution of US only concentration vs global concentration.

**Industry Data** The firm level data are complemented with additional industry level sources: first, I use industry-level national accounts to obtain industry-level deflators and measures of industry-level labor productivity from NBER CES. Industry-level deflators are used to compute firm-level labor productivity in Compustat. in addition, I obtain local establishment size by industry from the business dynamics statistics and employment, payroll and imputed wages figures from the NBER CES Industry accounts. Lastly, I obtain sales for the top 4, top 8 and top 20 firms in each industry and the industry as a whole from the U.S. Economic Census concentration accounts, which are used to compare the concentration measures with those computed from Compustat. The advantage of the Compustat Segment Database over the official concentration numbers lies on the fact that sales in the Census are inclusive the foreign affiliates' sales data for U.S. domestic firms.

**Information Technology by Industry** In this paper, I try to understand which public firms use more intensively processes that depend on IT. Then measures of information technology adoption at the firm level would be required. This would allow me to have a measure of exposure to the differential adoption of Information Technology across industries using firm level variation. Such a measure is not readily available for the large panel of public firms I observe. Following a large literature, that uses the intuition that if firms were using IT they would have a large share of employment related with data processors, software developers and system and database analysts then using publicly available data for each industry, I measure IT intensity as the share of the workforce that is employed in IT specific occupations, except for those occupation that are related to producing IT products. In addition to excluding those occupation, I exclude industries that are primarily involved in production of IT products and services.[5] I also create a measure of IT intensity as described below that I use for robustness where instead of a discrete classification of the IT intensity of an occupation, I measure the IT intensity at the occupation level using the description of tasks.

**Measuring IT Intensity across industries:** To analyse the impact IT had in the riskiness of industries in the United States, measures of information technology adoption at the firm level would be required. This would allow to have a measure of exposure to the differential adoption of information technologies across industries

[5]The industries include SIC 357 Computer And Office Equipment, 737 Computer Programming, Data Processing, and other Computer Services, 873 Research and testing services, 504 Professional & commercial equipment, 573 Radio, television, & computer stores. I exclude these computer producing or selling industries since this paper seeks to understand if firms' use of IT affects their multinational activities and if it intensifies global competition due to productivity enhancing effects in the firms' operations. In these industries, it is hard to distinguish computer occupations related to production activities or internal organization activities.

using firm level variation. Such a measure is not available for a large panel of firms in the U.S. This paper, following an extensive literature in macroeconomics and labor (see for example Gallipoli and Makridis (2021)), provides a measurement strategy to account for the differential use of IT across industries, using the relative share of labor within each industry in occupations that use IT more frequently. The primary source used to measure the intensity that different occupations use IT is the O*NET survey. The O*NET survey is conducted by the U.S. Department of Labor and incorporates information on occupational tasks, skills, and work environment characteristics. Every responder completes a questionaire about the importance and the frequency of certain tasks in their respective occupation. The product of the importance and frequency weights (if available) is calculated to generate an overall IT intensity index for each task, and skills. Then these indices are matched to the Occupational Employment Statistics (OES) national time series[6]. Using the matched dataset, employment-weighted IT intensities for tasks, skills, and knowledge are constructed at the five digit occupation level, as described below.

The second measure of IT labor intensity of an industry in the data is created using the description of each occupation. I classify occupations as IT related and the calculate the related labor share directly from the data. Second, I use the occupation scores described above and aggregate IT score at the industry level. This can be done since occupations in the data are measured at a five-digit level of aggregation, which is matched directly with the index constructed from O*NET. Finally, I aggregate

[6]The OES data provide data for each between 1988-1995 and 1997-2019 for the occupations used across industries and the size of the employment pool for each occupation in each industry. Using these data, I create a balanced panel between 1997-2019 for 3 digit SIC codes. The raw data are available in 3-digit code until 2001 and 4 digit NAICS code since. I use the correspondence table created by Eckert et al. (2199) to create the balanced panel.

occupation IT intensity, at the industry level as follows:

$$IT_{i,t} = \sum_j IT_j \times \frac{emp_{i,j,t}}{\sum_j emp_{i,j,t}}$$

where $\text{emp}_{i,j,t}$ is the employment in industry-location $i$ from the OES database, occupation $j$ and year $t$. Lastly, $IT_{i,t}$ is standardized in each year in order to account for aggregate time trends in the adoption of IT. Thus the cross sectional variation captures the extend at which IT is adopted at the industry level within a year of this measure.

Both the IT share of the workforce and the IT intensity of an industry are correlated with BEA software capital investment measures and software capital across industries.[7] In particular, since in the Bureau of Economic Analysis accounts the software capital share by year is provided for roughly 60 industries that contain multiple SIC3 industries, I aggregate the IT intensity/share data based on labore to match the BEA/BLS industries and correlate the share of IT workers in the industry workforce with the share of software capital in total capital. The correlation coefficient is large, significant and equal to 0.57.

**Measures of Industrial Concentration and Foreign Competition:**

The concentration data are for 1997-2019 and come from the restated sales data in Compustat. In particular, as described in the Appendix I use the Compustat Segments data to create domestic and foreign sales figures for all public firms, along with US and non US market specific sales for all public firms. The industry definitions I use in Compustat, are defined at the 3 digit SIC level, and do not necessarily

[7]Tambe and Hitt (2012) similarly show that labor-based IT measures corresponds to non labor based measures of IT at the firm or industry level.

correspond to segments needed to study competition (Shapiro 2018), as they are in a high level of aggregation. However, a large number of papers in empirical finance has measured industry concentration based on these industry classifications. My paper is not dealing with the definition of a SIC3 digit industry as a market but builds on the existing literature to show that even at these aggregated industries level, classification of company total sales as US sales leads to different conclusion compared to using restated industry sales data from segments data. This contribution is similar to the contribution by a number of recent papers that show that rising concentration at the national level appears to be accompanied by increased competition at the local level (Rossi-Hansberg et al. (2018)) and thus the aggregation of geographic markets may affect the conclusion of studies using concentration indices.

In addition, despite a large literature and public discussion of High Tech firms and their implications for competition and welfare, this paper excludes these industries since the focus is on IT, as a productivity enhancing technology and not about industries with special characteristics, like network effects. The economic census data on concentration that have been used in the literature provide a more comprehensive picture of concentration across industries but do not separate shipments between domestic and foreign markets and would not help me classify firms' sales as U.S. only and create measures of concentration based on US only sales, independent of the location of incorporation of a firm. That is why I choose to work with Compustat data. In the appendix, I use data from the census to show how the indices in the two datasets are correlated. It is clear that restating sales to account for U.S. sales only increases the correlation with the data in the Census.

I measure foreign competition, by the multinational foreign affiliates' sales share, both at the US and non US level. This measure is defined as:

$$\text{FR}_{mt} = \sum_{f \in F(m)} \frac{x_{fmt}}{X_{mt}}$$

where $F(m)$ denotes the set of foreign firms in market $m$ (US-industry, Rest of the World-industry, Global) and $X_{mt}$ total sales in market-industry $m$. The US local sales measures the presence of large foreign multinational firms in the US market. I aggregate the measures of foreign sales shares (these data are readily available from the FDI statistics in BEA) at approximately the 3-digit classification that can be matched with the balance sheet and equity data in Compustat and CRSP respectively. By construction, the FCI ranges from 0 to 1, where a value of 1 indicates maximum level of foreign presence, i.e. when only foreign large multinational firms operate in a specific market-year. Lastly, I also use data from Compustat to create the same measures and provide information on the relationship of these measures with official statistics in the Appendix. In addition, I then use the sales data in Compustat, to create measures of global and national (US and Rest of the World concentration) measures, in particular I construct the share of the top 4(10 or 20 ) firms in a market independent of the country of domicile. This measure is defined as:

$$\text{CR}^n_{mt} = \sum_{f \in S(m;n)} \frac{x_{fmt}}{X_{mt}}$$

The alternative measure which is the Herfindahl-Hirschman Index (HHI), defined as the sum of squares of the whole distribution of market shares within an industry. Bessen (2020a) finds increasing market concentration associated with IT for all of these measures based on US census data. What is important as discussed is that in these measures the definition of the market over which sales figures are used. If for example $S^{US}$ is the set of firms located in the U.S. (U.S. firms only) and by $S^{*}$ is the set of firms located in the rest of the world selling also to the U.S. market through foreign affiliates, Bessen (2020a) and studies based on Census data uses market shares only for domestic firms, as follows: $share_{fmt} = \frac{\mathrm{x\ fmt}}{X_{fmt}}$ where shipments $x_{fmt}$ denotes a U.S. firm's total sales, both domestic sales and foreign (through exports), and $X_{mt}$ is based on total shipments data also in year excluding sales of firms in the US through foreign affiliates. However, since large public firms operate in global markets through foreign affiliates (or exports) market concentration measures need to be based on sales in the U.S market. This is what I do in this paper, as follows: I subtract U.S. firms' foreign sales from the total sales figure in Compustat Segments and include foreign firms' sales in the US from the Compustat Segments data. Therefore, market shares of firms that sell in the US market are defined solely based on sales in the United States and the numerator is total sales in the US market (this numerator includes both sales from exports or sales of foreign affiliates in Compustat independent on the mode of sales). Importantly, both the market shares of US and foreign firms selling to the U.S. are constructed in the same way, and this can be done due to the classification of segments as U.S. only segments[8] Figure Figure 2.1 shows how the measure of US market concentration, constructed with market shares based on sales of both domestic and foreign firms, have changed through the years 1997 to

[8]This strategy includes measurement error in the definition of the market shares as some segments can not be classified as US only in the data and are treated as entirely non-US, or US depending on the measure used. For example, firms may report segments as "United States, Asia and other". Tables 2.1 tp 2.4 provide correlations among the concentration measures in Compustat and correlation of the HHI indices used in the paper and in the Census. As is evident, using sales data from all public firms in the United States increases the correlation with Census based data substantially both in the early years(1997) and later (2012).

2020 conditional on the IT intensity of an industry. Classifying industries as Low IT or High IT if they belong in the bottom or top third of the IT employment share shows that independent of the IT share of an industry, industries concentration has increased but relatively more for High IT industries. This upward trend is consistent with a large empirical literature (see, for example, Bessen (2020a)) who shows the evolution of concentration using total sales data for all firms with establishments located in the U.S.. In Figure 2.3 to Figure 2.4 in the Appendix, I plot binned scatter plots of the relationship between foreign market shares and concentration and similarly in Figure 2.5 to Figure 2.7, the IT employment share and concentration in US industries. US industries that have a large foreign firms' share of sales are overall less concentrated independently of the measure used (sales based on US only or global sales). Industries with a relatively higher share of IT worker do not appear to be more concentrated in the Compustat data, unless one is willing to treat the global economy as one market and calculates concentration measures for all public firms using total sales data. Regarding the IT intensity of the US economy, on average, in non IT industries, IT workers account for 3.4 % percent of total employment in a 3 digit industry in the mid year 2006.

## 2.3 Stylized Facts

In this section, a number of new stylized facts about the evolution of market shares of public firms in the U.S. are described and how these measures relate to IT and entry of multinationals across industries in the United States. The measures of concentration defined earlier provide a similar picture so most of the discussion will use as baseline statistics for the top 4 firms market concentration in each market

(US, Rest of the World and Global, that is the United States and the Rest of the World combined). I estimate the following equation:

$$\text{CR}\,{}^{4}_{kt} = \alpha + X_{kt}\beta + \gamma IT_{kt} + \mu_{k't} + \varepsilon_{kt}$$

where $CR^4{}_{ik}$ is the share of top 4 US firms in year $t$ and industry $k$, $X_{kt}$ is a vector of industry factors across years including, for example, the relative wage, the average establishment size, and the number of establishments in a local market as a measure of overall entry costs, $IT_{kt}$ measures the industry IT intensity, while $\mu_{k't}$ captures sector and time fixed effects[9], $\varepsilon_{kt}$ is the error term. The errors are clustered by industry sector.[10] Fact 1. The IT intensity of an industry is correlated with the share of foreign multinationals in the United States, but not the level of concentration. In Tables **??** and 7, I summarize how a one percentage point increase in the share of IT occupations in an industry is related with a 0.7 percentage point increase in the foreign sales share of an industry, an increase in the top firms' market shares globally but a small and insignificant decline of firms' market shares in the United States economy. Tables 8 and 9 using the total sales of an industry as a weight in the regression analysis.

As discussed, this finding is consistent with a large literature that thinks of IT as a technology that enhances the operations of firms across geographies. In that case, large multinational firms would adopt IT and increase their productivity, increasing their market shares across countries. The regression analysis above although informative of the industrial structure of Low and High IT intensive industries does not support

[9]where a sector $k'$ is defined as a 2 digit sector

[10]Robustness of the findings to other measures will be provided in the Online Appendix.

necessarily a causal link for the mechanism described above. In particular, it could be the case that large multinational firms are large and productive and are able to pay the large costs of operating multiple IT departments for operations unrelated with their foreign sales and production. In that case, correlations described above would show up in the data, but no meaningful mechanism on the impact of IT is necessarily affecting the industries that have larger shares of IT workers. In the next sections, I use an instrumental variables approach based on Bessen (2020a) and provide theoretical and empirical predictions that support the mechanism detailed above.

## 2.4 Identification

For identification, I use an instrument for the industry measure of IT intensity. In particular, I use the share of jobs in each industry that are sedentary. Bessen (2020a) motivates the use of industry sedentariness in 1977 as an instrument for IT intensity of an occupation based on the fact that computers are could be more easily used in sedentary occupations. However, there is no direct link between an industries share of multinational firms or the share of large firms, especially measured after 1997, and how sedentary occupations in an industry were in the past. He then provide some support for the exclusion restriction. I follow Bessen (2020a) and aggregate the industry sendentariness measure at the industry level mapping occupation with industries in the 2000 Census 5% public use sample data and the time invariant measure at the industry level. Using these instrumental variable **??** provides support that actually a large share of IT increases the foreign market share (based on data on operation of foreign multinationals in the United States from FDIUS) by almost

0.6 percentage point, while it leads to a reduction in the market share of the top 4 domestic firms. The first stage regressions are reported in **??**.

Given that my data are at the firm level, I then use firm level information to corroborate this findings. In particular, 2.13 and 2.14 show that among US public multinational firms, the level of the IT intensity of an industry is associated with a large foreign sales' share (the share of sales of firms that are not domestic) and an increase in the IT share of an industry by 1 percent affects the foreign sales' share of a firm by 0.3 percent in the intensive margin. Robustness using the IT intensity of an industry or sales is reported in tables 2.14 and the same specification in changes in 2.15. In the next paragraph, I study the effect on the extensive margin.

**Entry Results** In this paragraph, I present the empirical analysis investigating the effect of IT on multinational entry. I estimate the following equation:

$$\text{entry}_{kt} = \alpha + X_{kt}\beta + \gamma IT_{kt} + \mu_{k't} + \varepsilon_{kt}$$

where $\text{entry}_{ik}$ is the number of multinational firms in the US in year $t$ and industry $k, X_{kt}$ is a vector of industry factors across years including, for example, the relative wage, the average establishment size, and the number of establishments in a local market as a measure of overall entry costs, $IT_{kt}$ measures the industry IT intensity, while $\mu_{k't}$ are sector-time fixed effects[11], $\varepsilon_{kt}$ is the error term. The errors are clustered by industry sector as in the OLS regressions above. As is common in the international trade literature, Poisson estimations (see Silva and Tenreyro (2006)) are used in the analysis. Tables 2.16 to 2.19 report the results. I find that multinational activity

[11] where a sector $k'$ is defined as a 2 digit sector

is associated positively with the IT share of an industry ( Table 2.16), while using the instrument variable a significant and large effect of IT on multinational entry is found in levels (Table 2.17). In contrast, regressing the change in the number of multinational firms on lagged values of industry IT intensity shows that despite the existence of a small positive association, the effect is not significant and the share of IT employees in the past does not necessarily predict an increase in the number of multinational firms ( Table 2.18 and Table 2.19). Overall, IT intensive industries seem to have a large number of foreign firms, however IT is not associated with large swings in the number of multinational firms across industries.

## 2.5 Theory and Empirical evidence

In this section, I build a stylized model on how IT and multinational production may be related, motivated by the empirical facts above, and derive testable prediction using the balance sheet data of public firms, in the United States. The theory is a two-country general equilibrium model of production with firm and industry heterogeneity, as in the theories of multinational production like Helpman et al. (2004). The theory abstracts from the decision of a firm to export[12] since the model is stylized to provide testable prediction related to IT and the reallocation of market shares to multinational firms. The model economy consists of two countries. The firms have headquarters in one of the two countries. Firms differ in their idiosyncratic productivity, which is known when firms make decisions. This means that the two countries have a pool of establishments operating in the local economy with different

[12]The model abstracts from trade in differentiated goods, and thus all local consumption across sectors is being produced by either firms headquartered in the local market or branches-establishments of firms from a different region.

productivity. Firms can operate establishments across both countries and supply their goods in the local economy through their establishments. In each country, there is a representative consumer. The consumer enjoys the consumption of goods supplied by establishments locally.

Not all firms are multinational firms, due to fixed costs of operating establishments in distant markets. Productivity of these establishments is also impacted by distance. If a firm wants to operate in a country, not where its headquarters is located, it has to transfer technology in the foreign location, which implies that firm productivity differs across establishments of the same firm. These efficiency costs may be reduced if a firm adopts IT in each period by paying a fixed cost and thus the firm trades off the efficiency gains of IT with a fixed cost of employing IT.

These efficiency costs link this model with theories of multinational production as in Cravino and Levchenko (2017) and Alviarez et al. (2020). Predictions related to revenues and operating margins of firms of different productivity conditional on the level of IT adoption of an industry are derived. In particular, I derive conditions under which firms within industries are more exposed to foreign competition

The basic description of the model is provided in this Section, then predictions about the relation of IT fixed costs and IT intensity across industries are derived, along with predictions on the effect of IT adoption on profits, foreign competition and reallocation of market shares.

### 2.5.1 Demand Side

The aggregate consumption bundle in each country is given by $C$. The consumption bundle is an aggregate of individual consumption of goods produced in each of the

$J + 1$ sectors. Sector 0 provides a single homogeneous good, as in Chaney (2008). The other $J$ sectors are made of a continuum of differentiated goods. If quantity $c_0$ of the homogeneous good is consumed, along with $c_J(\omega)$ units of each variety $\omega$ in sector $J$, the consumption aggregate is given by:

$$C = c_0^{1-a_0} \left[ \sum_J \left( \int_{\Omega_J} c_J(\omega)^{\frac{\sigma_J - 1}{\sigma_J}} d\omega \right)^{\frac{\sigma_J}{\sigma_J - 1} \frac{\theta - 1}{\theta}} \right]^{\frac{\theta}{\theta - 1} a_0}$$

where $0 < a_0 < 1$ represents the expenditure share on the differentiated goods sector, $\theta > 1$ is the elasticity of substitution across sectors, $\sigma_J$ is the elasticity of substitution across varieties within a sector $J$ (which is assumed to be higher than $\theta$) and $\Omega_J$ is the set of establishments producing in the domestic economy in sector $J$, which is determined in equilibrium from the fixed costs of multinational production. Households get revenues from their inelastic labor supply in quantity $L$ and from ownership of a mutual fund that redistributes profits of both "home" and "foreign" firms. Their budget constraint is then given by:

$$p_0 c_0 + \sum_J \int_{\Omega_J} p_J(\omega) c_J(\omega) d\omega \leq wL + \Pi$$

where $p_J(\omega)$ is the price of variety $\omega$ in industry $J, w$ is the wage, and $\Pi$ is the profit redistributed to domestic consumers through ownership of the equity shares.

### 2.5.2 Supply Side

The homogeneous good 0 is freely traded and is used as the numeraire in each region. It is produced under constant returns to scale with one unit of labor producing 1 units of good and its price is set equal to 1.[13] Each firm in the differentiated sectors $J \in \mathcal{J}$ produces a variety $\omega$. The quantity produced is denoted $q_J(\omega)$. Production of goods requires labor inputs. Labor is the only factor of production in the model, and its use by a firm producing variety $\omega$ is $l_J(\omega)$. Firms are heterogeneous in productivity and produce each variety with an efficiency parameter denoted by $\varphi$. This productivity is the firm's idiosyncratic efficiency at the headquarters' country. Idiosyncratic productivity at HQ is fixed overtime but is randomly assigned across firms. As in most of empirical applications based on Helpman et al. (2004), the distribution of idiosyncratic productivity in each industry is Pareto with tail parameter $\gamma_J > \sigma_J - 1$. The probability of a firm's productivity being below a given level $\varphi$ in industry $J$ is $Pr\{\tilde{\varphi} < \varphi\} = G_J(\varphi)$. I will assume that this productivity distribution is Pareto with parameter $\gamma_J$. This will allow me to derive analytical predictions. In future work, I plan to derive predictions for more general distributions. The lower bound of idiosyncratic productivity for sector $J$ is without loss of generality $\underline{\varphi}_J$. There are different levels of productivity across countries, due to the differences in the mean of idiosyncratic productivity. Most theoretical predictions are derived with respect to "domestic" firms, that correspond to firms based in the US economy.

#### 2.5.2.1 Firm establishments

Firms may operate establishments on both their headquarters country and the "foreign" country. Operations of an establishment located in a foreign country requires that the firm pays an operating fixed cost $f_J$ measured in "domestic" labor efficiency

[13] This assumption is made so that the two regions have the same level of wages, and entry of multinational does not affect through labor costs domestic firms. This assumption is extended in the Appendix to account for entry effects on domestic firms.

units paid every period. Given fixed costs of entry, this determines a firm-specific threshold productivity level below which firms do not operate establishments, other than in their home country. I provide now details related to the adoption of IT and the efficiency costs of operating an establishment in a different country. In particular, the efficiency losses in equilibrium will be given by $\exp(-\kappa \mathbb{I}_a(\varphi < \underline{\varphi}_{ITJ}))$ where $\mathbb{I}_a(\varphi < \underline{\varphi}_{ITJ})$ determines if firm productivity is above of below the cutoff of IT adoption by a firm. In particular, the efficiency costs are zero, if a firm adopts IT and $\kappa$ otherwise. This means, the firm each period can increase its "foreign" productivity, but this requires a fixed cost $f_{ITJ}$ that differs across sectors. When deciding whether or not to adopt IT, firms trade off benefits from lower efficiency costs against higher operating costs. Operating costs are associated with the costs of creating, for example, IT services offices or hiring software engineers due to in house software development that provide support to the main function of the firm. [14]

#### 2.5.2.2 Firm Revenues and Profits

Establishments set prices under monopolistic competition in each industry. Given a constant elasticity of substitution, prices are a constant markup over marginal cost. An establishment of a firm with productivity $\varphi$ sets the following price if it operates in firms' headquarters:

$$p_J(\varphi) = \frac{\sigma_J}{\sigma_J - 1}/\varphi$$

[14] Alternatively, these costs can be thought of any type of intangible fixed investment that increases the ability of firm to expand geographically.

and the following price when it does not operate in firms' headquarters:

$$p_{NJ}(\varphi) = \frac{\sigma_J}{\sigma_J - 1} / \Big( \varphi \exp(-\kappa \mathbb{I}_a(\varphi < \underline{\varphi}_{ITJ}) \Big)$$

The productivity of establishments in the two different countries differ by assumption. The efficiency cost $\exp(\kappa \mathbb{I}_a(\varphi < \underline{\varphi}_{ITJ}))$ cost represents costs of technology transfer or more generally any efficiency losses due to managing an establishment in a different country. Efficiency costs depend on the IT decision, given by the indicator function $\mathbb{I}_a(\varphi < \underline{\varphi}_{ITJ})$. In what follows, I will be using the following expression for prices set by domestic multinational firms in the "foreign" country:

$$p_{NJ}(\varphi) = K_J(\varphi) p_J(\varphi),$$

where

$$K_J(\varphi) \equiv \exp(\kappa \mathbb{I}_a(\varphi < \underline{\varphi}_{ITJ}))$$

Firms earn total revenues $R_J(\varphi)$ from their sales of establishments in the "home" country, and if they operate in the "foreign" country they have $R_{NJ}(\varphi)$ in sales. Sales in the "home" region do not require a fixed cost of investment. Thus, sales functions are defined as:

$$R_J(\varphi) = \left( \frac{p_J(\varphi)}{P_J} \right)^{1-\sigma_J} P_J C_J$$

where $P_J$ is industry's $J$ price index and $C_J$ is the industry composite good, aggregated from the set of differentiated goods. Revenues of firms in the foreign market are given by

$$R_{NJ}(\varphi) = \left(\frac{K_J(\varphi)p_J(\varphi)}{P_J^*}\right)^{1-\sigma_J} P_J^* C_J^*$$

Profits from the second establishment are calculated after operating costs, which include the cost of operating IT, if the firm chooses to do so. Hence, the level of profits of a second establishment are given by:

$$\pi_{NJ}(\varphi) = \frac{1}{\sigma_J}\left(\frac{K_J(\varphi)p_J(\varphi)}{P_J^*}\right)^{1-\sigma_J} P_J^* C_J^* - f_J - hf_{ITJ}\mathbb{I}_a(\varphi \geq \underline{\varphi}_{ITJ}).$$

The fixed costs of IT $hf_{ITJ}$ represent two different mechanism, one associated with an invariant characteristic of industries that makes IT easier to adopt[15] and a common across industries quality index $h$ that will be the parameter that I will use to derive comparative statics, representing different long run equilibrium (i.e. equilibria with different quality of IT labor thus different fixed costs of adoption). From the expression above, one can see that profits from operating a second establishment are increasing in idiosyncratic productivity, and hence there exists a productivity cutoff in each industry under which a firm decides to create a second establishment.

**Decision to operate second establishment and adopt IT** The cutoff for foreign market entry is given by

$$\underline{\varphi}_{NJ} = \min_{\varphi}\{\varphi \mid \varphi \text{ implies that firm is operating a second establishment. }\}$$

[15]This is the model measure that resembles mostly sedentariness.

Similarly, for firms that choose to use IT, I denote

$$\underline{\varphi}_{ITJ} = \min_{\varphi}\{\varphi \mid \varphi \text{ is adopting IT}\}.$$

The derivation of cutoffs for IT adoption and for multinational production is included in the Appendix. Then average firm productivity is given by:

$$\bar{\varphi}_{ITJ} := \left[\int_{\underline{\varphi_{ITJ}}}^{\infty} \varphi^{\sigma_J - 1} \mathrm{d}G_J(\varphi)\right]^{\frac{1}{\sigma_J - 1}}$$

The fraction of firms operating multiple plants is denoted by $\zeta_{NJ}$ and the fraction of firms adopting IT is $\zeta_{ITJ}$. Similarly, these variables satisfy:

$$\zeta_{ITJ} := \left[\int_{\underline{\varphi_{ITJ}}}^{\infty} \mathrm{d}G_J(\varphi)\right]^{\frac{1}{\sigma_J - 1}}$$

#### 2.5.2.3 Industry aggregation

If total industry profits for "home" firms in a sector $J$ are defined as the sum of the profits of firms in the "home" and the "foreign" market:

$$\Pi_J := N_J \left[\int_{\underline{\varphi}_J}^{\infty} \pi_J(\varphi_J)\, \mathrm{d}G_J(\varphi) + \int_{\underline{\varphi}_{NJ}}^{\infty} \pi_{NJ}(\varphi_J)\, \mathrm{d}G_J(\varphi)\right]$$

Using the expressions for the profit functions and the cutoffs, aggregate profits can be written as:

$$\Pi_J := N_J \left[\pi_J(\bar{\varphi}_J) + \zeta_{NJ}\pi_{NJ}(\bar{\varphi}_{NJ}) + \zeta_{NJ}\Gamma_J^{-\gamma_J}\Delta\pi_{NJ}(\Gamma_J\bar{\varphi}_{NJ})\right]$$

The same aggregation property simplifies the expression for the sectoral price index

$$P_J = \left(N_J \cdot p_J\left(\bar{\varphi}_J\right)^{1-\sigma_J} + \zeta^*_{NJ} N^*_J \cdot p^*_{NJ}\left(\bar{\varphi}^*_{NJ}\right)^{1-\sigma_J} + \zeta^*_{NJ} \Gamma^{*-\gamma_J}_J N^*_J \Delta p^*_{NJ}\left(\Gamma^*_J \bar{\varphi}^*_{NJ}\right)^{1-\sigma_J}\right)^{\frac{1}{1-\sigma_J}}$$

where the following function is used, determining the difference in the price of a firm with a productivity $\varphi$, in the case it adopts information technologies or not:

$$\Delta p^*_{NJ}(\varphi) = (1 - \exp(\kappa^*)) p^*_{NJ}(\varphi)$$

As a result in equilibrium:

$$P_J = \left(N_J \cdot p_J\left(\bar{\varphi}_J\right)^{1-\sigma_J} + \zeta^*_{NJ} N^*_J \cdot p^*_{NJ}\left(\bar{\varphi}^*_{NJ}\right)^{1-\sigma_J} H^*_J\right)^{\frac{1}{1-\sigma_J}}$$

where $H^*_J \equiv H\Bigg(\exp(\kappa)^*, \Gamma^*_J, \gamma_J, \sigma_J, h\Bigg)$ which is a variable determining the impact of a shock on IT quality $h$ on the price index of an industry $J$ through the sales share of large foreign firms in the "home" market. Observe that the quality index is common across countries as it is assumed that increases in productivity of IT are common across countries. The fixed costs of adoption can still differ across industries and countries.

#### 2.5.2.4 Equilibrium

In equilibrium, the aggregate budget constraint of the representative household is given in terms of the aggregate price index $P$, composite consumption $C$, labor income $L$ and total profits from each location and sector $J$, $\Pi = \sum_J \Pi_J$:

$$PC \leq L + \Pi$$

The mass of firms $N_J$ in each sector is assumed to be fixed. There is no free entry or exit of firms. However, the set of producers in a given market, $\Omega_J$, may vary across industries and countries due to endogenous choice of operating an establishment. An equilibrium in this economy is a collection of prices $(p_J, p_{M,J}, P_J, P_T, P)$, output $q_J(\varphi)$, consumption $c_J(\varphi)$, and labor demand $l_J(\varphi)$ such that (i) each firm maximizes profit given consumer demand and operating costs, (ii) consumers maximize their utility given prices, and (iii) markets for goods and for labor clear. In sum, there are $2 \cdot (\mathcal{J} + 1)$ endogenous variables in the model: the aggregate consumption level in each location, $(C, C^{\star})$, and the industry-level cutoffs, $(\varphi_{NJ}, \varphi^{\star}_{NJ})$. Knowing these quantities is sufficient to solve for the equilibrium.

#### 2.5.2.5 Revenues, Operating Margins, and Concentration

In this section, the link between the IT intensity of a sector, and firms revenues, the margins and the top firms' share is derived. In particular, the differential response of firms to these shocks across the size distribution and across industries with different degrees of foreign firm share is emphasized. The proofs of the predictions discussed here can be found in the Appendix where more details on the theory and several additional predictions are included.

**Lemma 9.** *IT intensity, measured by the share of IT labor within a sector, is decreasing in IT adoption costs $f_{ITJ}$.*

As expect as the fixed cost of IT increases, there is a reduction in IT intensity in each industry. Similarly, a decline in the fixed cost investment parameter $h$ leads to increases in the IT share of all industries

**Foreign firms' multinational operations** I first define competition from foreign firms as

$$\mathcal{I}_J = \frac{\zeta_J^* N_J^* \cdot p_{NJ}^* \left(\bar{\varphi}_{NJ}^*\right)^{1-\sigma_J} H_J}{P_J^{1-\sigma_J}}$$

This represents the marginal impact of large foreign multinational firms operating an establishment in a region away from the firms' HQ on the local price index for a given industry. Given the definition of $P_J$, this measure is bounded: $\mathcal{I}_J \in [0, 1]$.

**Lemma 10.** *The level of $\mathcal{I}_J$ is decreasing with fixed costs $f_{ITJ}^*$. This means that this level is increasing in IT intensity.*

The lemma above, is a result of the fact that in low IT fixed costs ($f_{ITJ}^*$) costs, large multinational firms set a lower price. As a result the impact of global production in the price index is lower in these industries with higher average efficiency costs and the displacement of small "domestic" firms higher.

**Effect on revenues** An elasticity of a variable $x$ is denoted by $\mathcal{E}(x)$ and are with respect to a shock on IT labor productivity in all markets $h$, which is defined as $\mathcal{E}(x) = \frac{d \log x}{d \log h}$. The discussion treats such a shock as a decline in $h$ which is closer to what happened in the recent years in the United States. The elasticity derived here are approximate and do not account for general equilibrium effects through the effects on aggregate demand. After defining the index level of multinational firms $\mathcal{I}_J$. The effect of a shock to IT labor productivity affects both demand for individual varieties and total industry expenditures. The entry of foreign multinational firms lowers the industry price index, thus increases the expenditures at the industry level. Since by assumption, the within industry substitution elasticity is higher within industries than across, the productivity shock in the rest of the economy reduces demand for locally produced goods. In addition, the aggregate productivity shocks affect aggregate demand, through the effect on wealth of consumers in the local economy. In particular, this channel determines the effect on domestic firm revenues. Now, I have the following results for the elasticity of domestic revenues to a shock in IT labor productivity.

**Lemma 11.** *The elasticity of revenues generated in the home market for a home firm with productivity $\phi$ to a shock in $h$ is:*

$$\mathcal{E}\left(R_J(\varphi)\right) = -\left(\sigma_J - \theta\right) \cdot \left(-\mathcal{E}^*\left(P_J\right)\right) + \frac{1 - a_0 - \theta}{a_0} \cdot \left(-\mathcal{E}(P) + \mathcal{E}(C)\right)$$

Ignoring for now the second term, related to aggregate variables, the profits and cash flows are affected by the shock through industry prices as follows:

$$\mathcal{E}\left(R_J(\varphi)\right) = -\left(\sigma_J - \theta\right) \cdot \mathcal{I}_J \cdot \left[\left(\frac{\gamma_J}{\sigma_J - 1} - 1\right)\left(1 - 1/H_J^*\right)\right]$$

This term summarizes the threat firms face from increasing competition which depends on the following variables: (a) the foreign firms index $\mathcal{I}_J$ that represents how much firms in the rest of the world affect local firms. It is larger when IT costs are smaller and thus a large number of multinational firms operate in the United States. Lastly, it affects the extensive margin of IT adoption, summarized by $\left(1 - 1/H_J^*\right)$.

In contrast, total revenues of "home" multinational firms operating establishments in both "home" and foreign countries may benefit from such a shock, since more firms can now adopt IT (after a negative shock). Here I summarize this effect. Revenues of multinational firms from foreign operations change according to

$$\mathcal{E}\left(R_{NJ}\right)=\left(\frac{\Delta R_{NJ}^{IT}}{R_{NJ}}\right)\left(-\frac{\gamma_J-\sigma_J+1}{\sigma_J-1}\right)$$

and is negative (positive for a decline $h$ and depends on the revenue share of IT adopting firms) and $\frac{\Delta R_{NJ}^{IT}}{R_{NJ}}$ is the increase of sales of multinational firms due to IT use over the total sales in an industry by multinational firms. Details are provided in the Appendix.

Across industries, as firms have higher level of IT intensity initially [16], the share of multinational firms will be larger and as a result exposure of domestic firms to sales reallocation risk due to global competition, can be understood better by studying the reaction of sales of firms with different type. Looking at the reaction of sales in the model, and in particular looking at the reaction of firms that can not pay the fixed costs and become multinational firms is informative about the effect of IT across industries.

**Proposition 3.** *Consider two industries $J_1$ and $J_2$ in the home economy, affected by a shock to IT labor productivity. If industries differ only in the initial fixed cost of IT, with industry 2 having a lower fixed cost of adoption*[17]*, then multinational firms share is greater in industry $J_2$ than $J_1$, or $\mathcal{I}_2 > \mathcal{I}_1$. (ii) The elasticity of revenues for domestic only firms is more negative in industry $J_2$. (iii) The difference in the*

[16] which is the case if industries have lower fixed costs of operating IT.

[17] For example, due to the sedentary intensity of occupations employed in these industries

*elasticity of revenues between large multinational and domestic only firms to this shock to IT labor productivity is greater in industry* $J_2$.

### 2.5.3 Testing the empirical predictions

**The Heterogeneous Effects of IT across firms** I first test the implications of the model for sales of firms in the Unites States since the growth of sales of different type of firms (MNE and domestic), are informative according to the model for the risk of displacement due to IT. Later I test how these findings relate to the discussion on firms' operating margins, see Bessen (2020a).

Consistent with the predictions above, I find that the positive sales effects of greater IT use is only happening for multinational firms or firms that operate in industries with low foreign share. In contrast,

I show in Table 2.20 that the growth of sales of US domestic only firms is related negatively by increases in foreign competition, as measured by the change in the foreign affiliates' share, and the effect is higher when looking only in IT intensive industries. The result is not significant when considering the universe of firms (column 2). Similar results are presented in Table 2.22 using the lagged value of foreign market share instead of the change in foreign market share.

Table 2.21 also reports that the growth of sales of US domestic firms is increasing the share of an industry for industries with low foreign Share intensity (column 1) but it is insignificant for companies in industries with a high level of foreign competition.

Table 2.23 instruments the lagged value of foreign market share with the sendetary intensity of an industry and compares the results with Table 2.22. As can be seen in column 2 the coefficient remains negative and statistically significant providing support that the results are not driven measurement error or reverse causality.

**Change in Operating margins** Sales per se might reflect a choice of firms to downscale and operate in more profitable markets in which case operating margins may increase for smaller domestic firms which is not consistent with the theory described above. In contrast my theory predicts that large firms pay a fixed cost to adopt IT and increase their operating margin in the long run as their operations abroad become less costly. The operating margins in the model increase for IT adopters as in all models that consider entry choices with firm heterogeneity, as fixed costs do not depend on productivity. These quasi rents of IT should show up as an increase in operating margins for large multinationals in industries with IT intensity. Table 2.24, following Bessen (2020a) provides an analysis of the growth in operating margins. The sample consists of publicly listed US firms that reported in 2000 and 2014, excluding firms in regulated sectors and the finance sector. The dependent variable is the change in operating margin between 2000 and 2014, where operating margin is defined as operating income after depreciation but before taxes and research and development expenses all divided by revenues. I exclude R & D from income because it is not related per se with multinational production in the model. I then treat the expenses in research and development as explanatory variables in the regression. That is, operating profits may reflect the returns on investments in IT but also potential returns to intangible and tangible capital. Then, I define the operating margin for firm $i$ at time $t$ as

$$M_{it} = \alpha \times \mathrm{IT}_{it} + \delta \times t + \beta_1 \frac{\boldsymbol{K_i^1}}{R_{it}} + \ldots + \varepsilon_{ii}$$

where $\boldsymbol{K_i^1}$ is a vector summarizing stocks of capital assets (intangible and tangible). $\alpha$ represents the effect of IT; and $\delta$ represents exogenous growth rate. Since there are also significant firm fixed effects over the long study period, I prefer to estimate as in Bessen (2020a) the equation in first differences:

$$\Delta M_i = \alpha \times \Delta \mathrm{IT}_i + \delta + \beta_1 \Delta \boldsymbol{K_i^1} + \ldots + \Delta \varepsilon_i$$

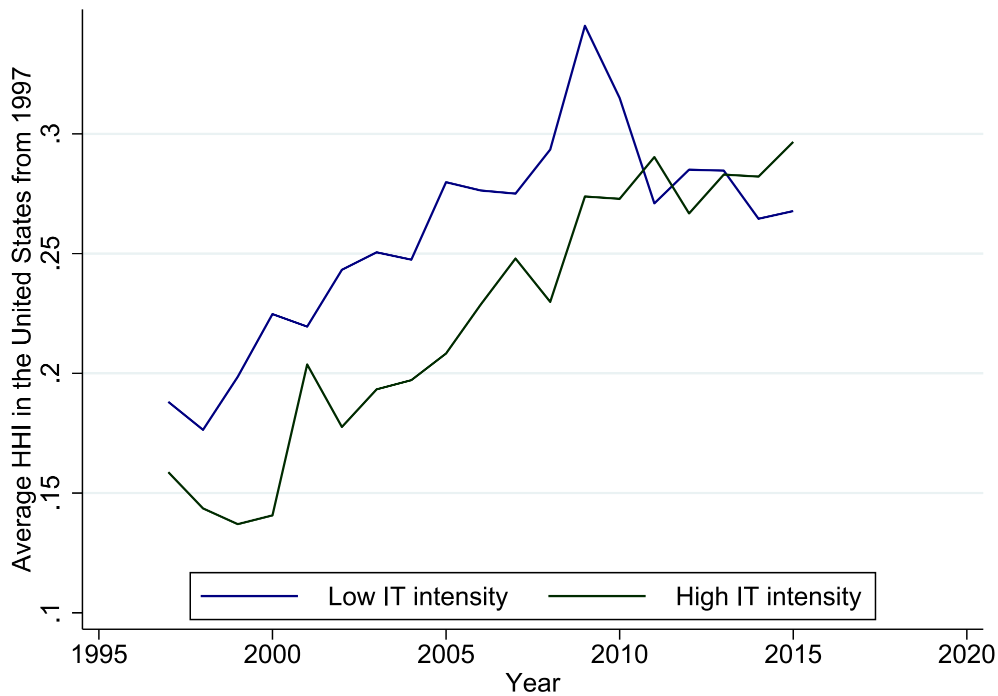
Table 2.24 shows that the growth of operating margins are driven by the operating margins of multinational firms, when defining the sample of multinational firms (as those with a large foreign share in year 2000, where in columns 1 and 2 the cutoff is set at 5 percent, while in column 3 and 4 at 10 percent.) The cutoff is not set at 0 since then given that I am looking at firms with continual presence between 2000 and 2014 most of those firms (approximately 95 percent report positive foreign sales.)

## 2.6 Conclusion

In this paper I examine the relationship between information and communication technology, multinational activity and displacement risk for firms in United States. I use detailed data from Compustat on all public firms to create consistent measures of foreign sales of firms in the United States and abroad and present a description of how IT affects the level of overall concentration in the United States and foreign entry and competition. My results indicate a positive relation between foreign competition and IT adoption rates across US industries, that potentially explains the negative effects of IT on market shares of US domestic firms. The results challenge the common wisdom about IT and dominant firms in the United States economy and shed light on the observed productivity gaps between leaders and laggards. In particular, the mechanism supported from the data is one where large multinational firms gain from IT and displace domestic firms' market shares leading to a reallocation of sales to incumbent multinationals that become more productive. Shedding light to these forces using official data is an important research objective for our understanding of competition in the global economy and changes in firms' technology. This paper using data on the universe of public firms is a first step to answer this question.

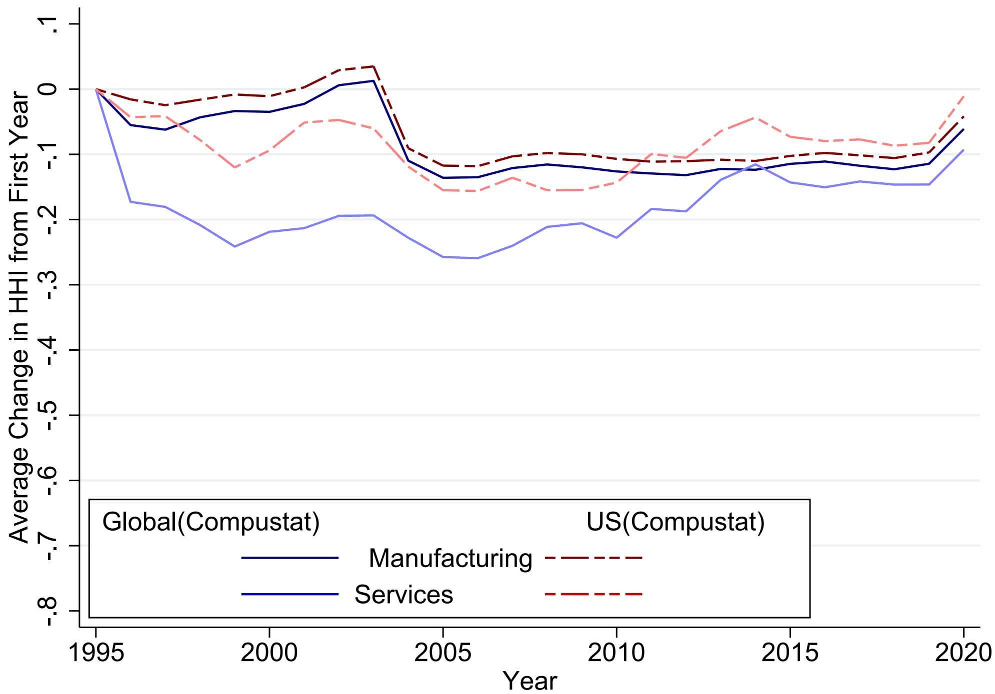
## 2.7 Tables and Figures

Figure 2.1: Evolution of Concentration in the United States, Panel 1



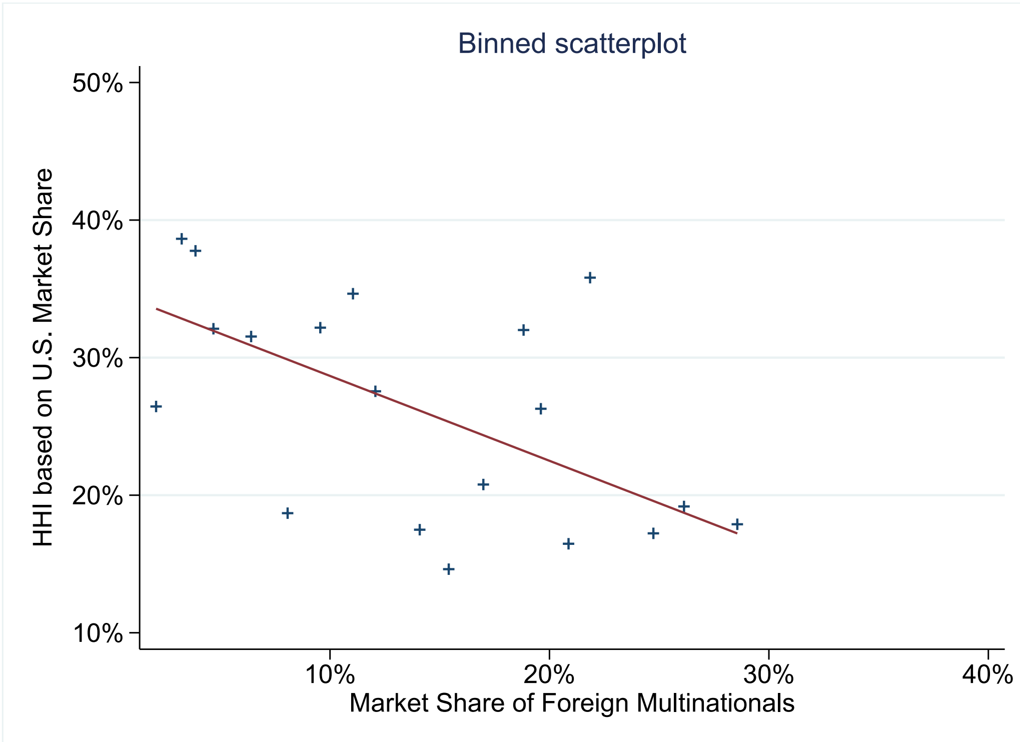

*Notes*: This figure shows the dynamics of HHI indices in the United States for High IT intensive and Low IT intensive sectors using data on the sales of all public firms in the United States.

Figure 2.2: Evolution of Concentration in the United States, Panel 2



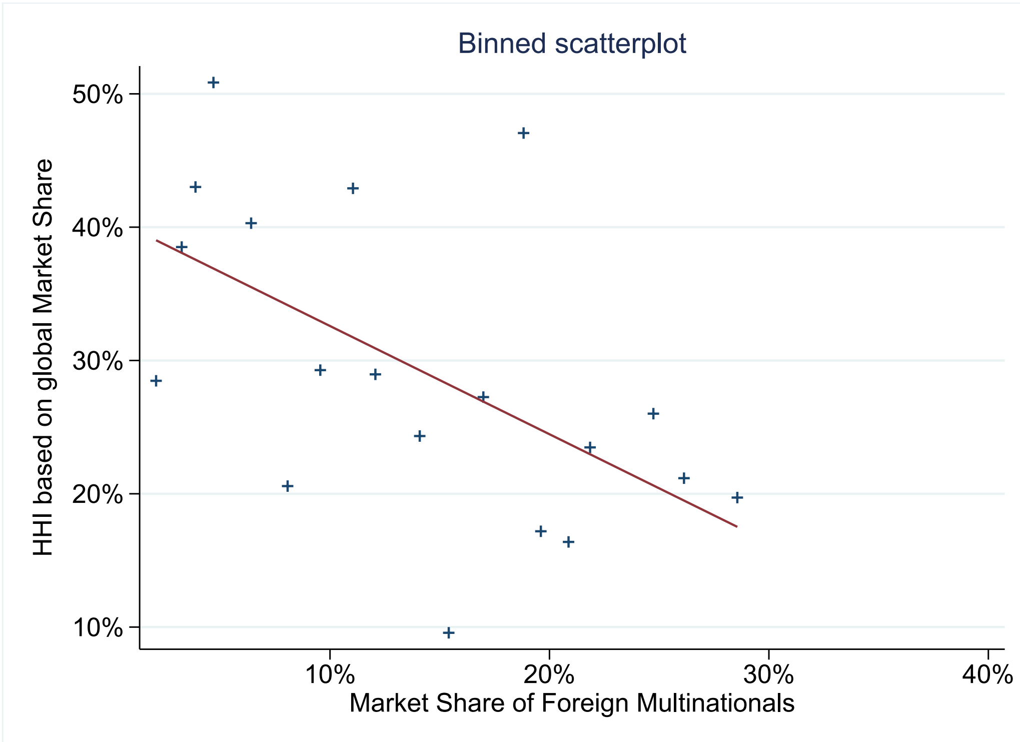

*Notes*: This figure shows the dynamics of changes in HHI indices across manufacturing and services industries, using data on sales of public firms globally and nationally.

Figure 2.3: Evolution of Concentration in the United States, Panel 3



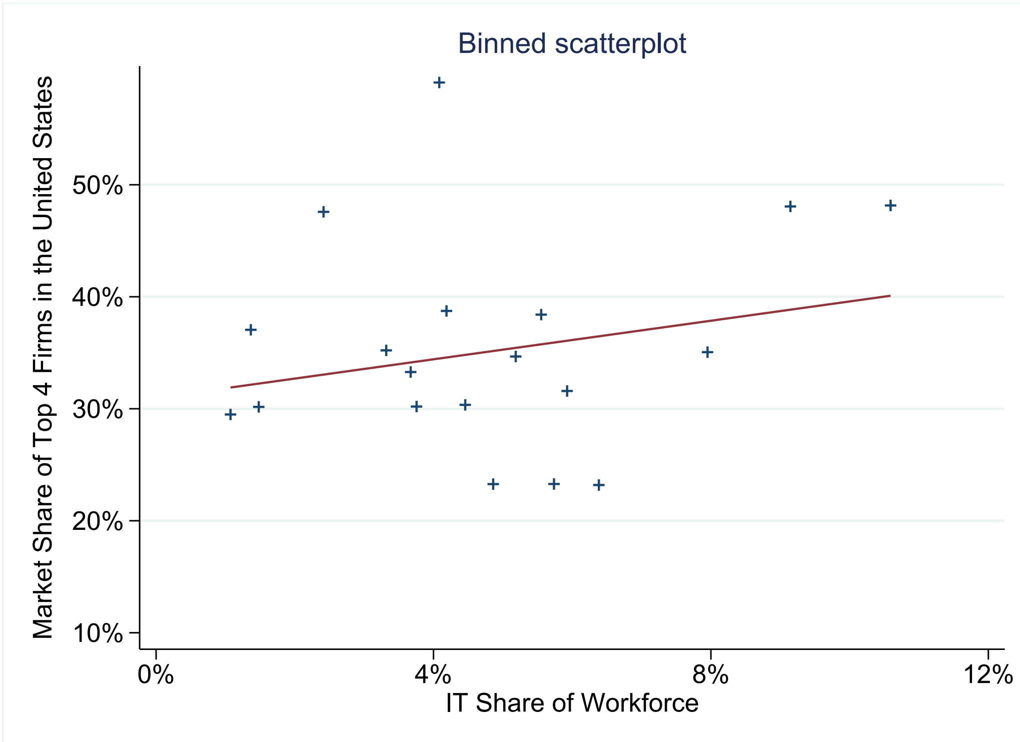

*Notes*: This figure shows a binned scatterplot of the relationship of HHI calculated using sales data of all firms in the United States and the market share of multinational firms

Figure 2.4: Evolution of Concentration in the United States, Panel 4



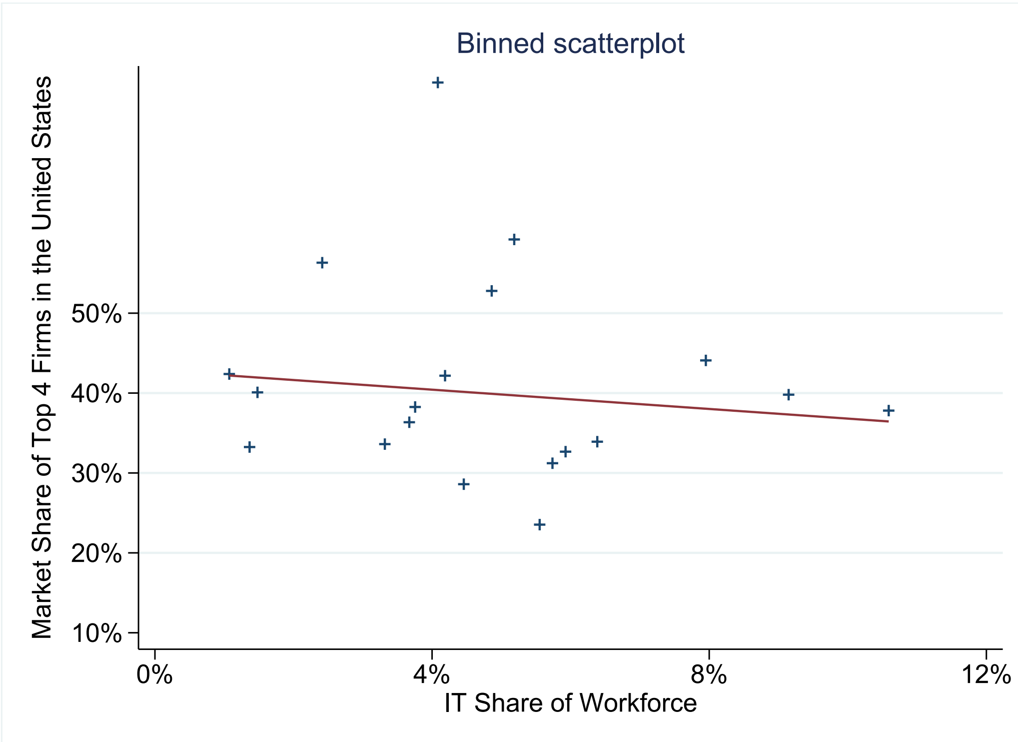

*Notes*: This figure shows a binned scatterplot of the relationship of HHI calculated using sales data of all firms traded globally and the market share of multinational firms

Figure 2.5: Evolution of Concentration in the United States, Panel 5



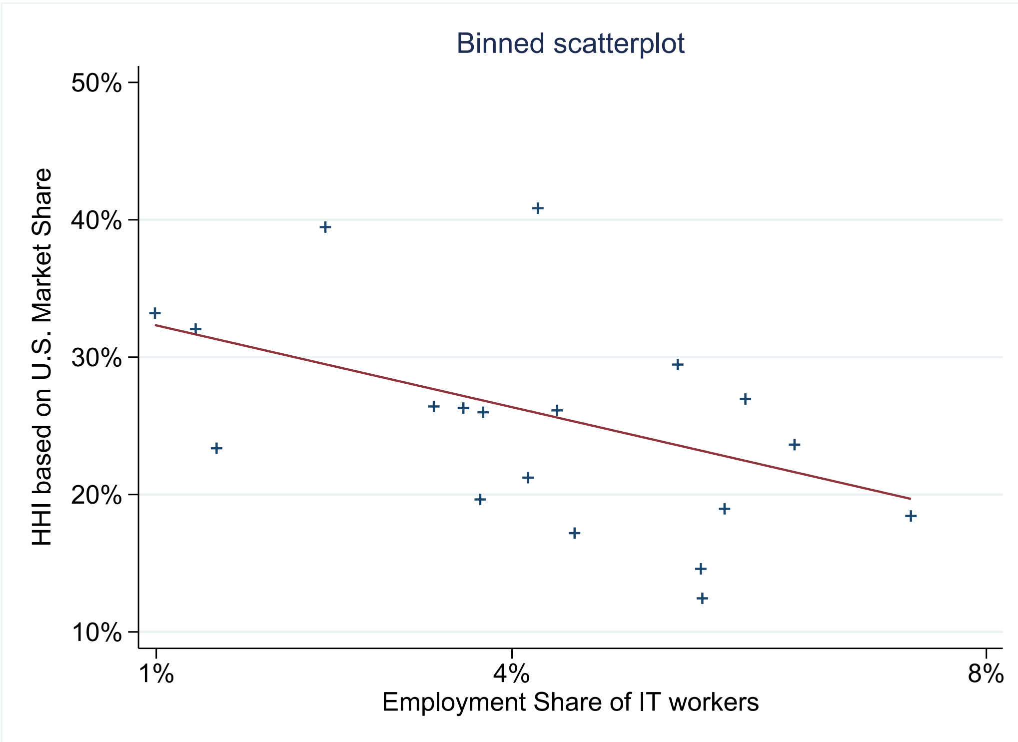

*Notes*: This figure shows a binned scatter plot of the relationship of top market shares using global sales data of all firms traded and located in the United States and the Information Technology employment share.

Figure 2.6: Evolution of Concentration in the United States, Panel 6




*Notes*: This figure shows a binned scatter plot of the relationship of top market shares using local sales data of all firms traded and located in the United States and the Information Technology employment share.

Figure 2.7: Evolution of Concentration in the United States, Panel 7




*Notes*: This figure shows a binned scatter plot of the relationship of HHI using local sales data of all firms traded and located in the United States and the Information Technology employment share.

| | CR4US | CR4Global | CR8Global | CR8US | CR20Global | CR20US | GlobalHHI | USHHI |
|---|---|---|---|---|---|---|---|---|
| CR4US | 1 | | | | | | | |
| CR4Global | 0.319*** | 1 | | | | | | |
| CR8Global | 0.319*** | 0.995*** | 1 | | | | | |
| CR8US | 0.995*** | 0.320*** | 0.643*** | 1 | | | | |
| CR20Global | 0.319*** | 0.995*** | 1.000*** | 0.644*** | 1 | | | |
| CR20US | 0.994*** | 0.320*** | 0.644*** | 1.000*** | 0.645*** | 1 | | |
| GlobalHHI | 0.400*** | 0.817*** | 0.816*** | 0.402*** | 0.816*** | 0.402*** | 1 | |
| USHHI | 0.895*** | 0.365*** | 0.366*** | 0.887*** | 0.365*** | 0.887*** | 0.409*** | 1 |

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

Table 2.1: Correlations of Concentration Indices based on Global and US only sales

| | USHHIa | USHHI | HHI |
|---|---|---|---|
| USHHIa | 1 | | |
| USHHI | 0.299*** | 1 | |
| HHI | 0.109*** | 0.162*** | 1 |

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

Table 2.2: Correlations of Concentration Indices based on Compustat (Unadjusted and Adjusted for US sales) and Indices in the Census data

| | USHHIa | USHHI | HHI |
|---|---|---|---|
| USHHIa | 1 | | |
| USHHI | 0.334*** | 1 | |
| HHI | 0.0829*** | 0.248*** | 1 |

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

Table 2.3: Correlations of Concentration Indices based on Compustat (Unadjusted and Adjusted for US sales) and Indices in the Census data in 2012

| | USHHIa | USHHI | HHI |
|---|---|---|---|
| USHHIa | 1 | | |
| USHHI | 0.136*** | 1 | |
| HHI | 0.127*** | 0.161*** | 1 |

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

Table 2.4: Correlations of Concentration Indices based on Compustat (Unadjusted and Adjusted for US sales) and Indices in the Census data in 1997

| Occupation Code | Occupation Name |
|---|---|
| 56000 | Office machine operators, data processors |
| 25100 | Computer scientists and related |
| 22127 | Computer engineers |
| 57199 | Other communications operators |
| 15024-5 | Communications managers |
| 85705 | Data processing equipment repairers |
| 15-0000 | Computer Occupations |
| 43-4000 | Information and record clerks |
| 11-3020 | Computer and information systems managers |
| 17-2060 | Computer hardware engineers |
| 43-2000 | Communications equipment operators |
| 43-9020 | Data entry and information processing workers |
| 43-9010 | Computer operators |
| 43-9070 | Office machine operators, except computer |
| 49-2010 | Computer, automated teller, and office machine repairers |

Table 2.5: IT related occupations used to construct the share of IT workers.

| | (1) Foreign Share | | (2) Global HHI | | (3) US HHI | | (4) Global HHI | | (5) US HHI | | (6) Foreign Share | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ITshare | 0.71** | (0.13) | 0.84** | (0.20) | -0.99** | (0.21) | 0.91** | (0.26) | -0.26 | (0.21) | 0.38** | (0.14) |
| Year FE | Y | | Y | | Y | | Y | | Y | | Y | |
| Industry (SIC2) FE | Y | | Y | | Y | | Y | | Y | | Y | |
| Industry Controls | Y | | Y | | Y | | Y | | Y | | Y | |
| $N$ | 1298 | | 1522 | | 1522 | | 979 | | 979 | | 964 | |
| $R^2$ | 0.444 | | 0.260 | | 0.221 | | 0.282 | | 0.285 | | 0.488 | |

Standard errors in parentheses
* $p < .05$, ** $p < .01$

Table 2.6: IT, Concentration and Foreign Competition (Summary)

| | (1) CR20 US | | (2) CR20 Global | | (3) CR8 US | | (4) CR8 Global | | (5) CR4 Global | | (6) CR4 US | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ITshare | -0.30 | (0.21) | 0.91** | (0.26) | -0.30 | (0.21) | 0.90** | (0.26) | 0.91** | (0.27) | -0.30 | (0.21) |
| Year FE | Y | | Y | | Y | | Y | | Y | | Y | |
| Industry (SIC2) FE | Y | | Y | | Y | | Y | | Y | | Y | |
| Industry Controls | Y | | Y | | Y | | Y | | Y | | Y | |
| $N$ | 981 | | 981 | | 981 | | 981 | | 979 | | 979 | |
| $R^2$ | 0.274 | | 0.282 | | 0.276 | | 0.284 | | 0.285 | | 0.280 | |

Standard errors in parentheses
* $p < .05$, ** $p < .01$

Table 2.7: IT and Top Shares (Unweighted and Sales Weighted)

| | (1) Global HHI | | (2) US HHI | | (3) Global HHI | | (4) US HHI | |
|---|---|---|---|---|---|---|---|---|
| ITshare | 0.84** | (0.20) | -0.99** | (0.21) | 0.91** | (0.26) | -0.26 | (0.21) |
| Year FE | Y | | Y | | Y | | Y | |
| Industry (SIC2) FE | Y | | Y | | Y | | Y | |
| Industry Controls | Y | | Y | | Y | | Y | |
| $N$ | 1522 | | 1522 | | 979 | | 979 | |
| $R^2$ | 0.260 | | 0.221 | | 0.282 | | 0.285 | |

Standard errors in parentheses
* $p < .05$, ** $p < .01$

Table 2.8: IT and Concentration (Unweighted and Sales Weighted)

| | (1) Foreign Share(FDIUS) | | (2) Foreign Share(Compustat) | | (3) Foreign Share(FDIUS) | | (4) Foreign Share(Compustat) | |
|---|---|---|---|---|---|---|---|---|
| IT Share | 0.71** | (0.13) | 0.05 | (0.03) | 0.38** | (0.14) | 0.46** | (0.04) |
| Year FE | Y | | Y | | Y | | Y | |
| Industry (SIC2) FE | Y | | Y | | Y | | Y | |
| Industry Controls | Y | | Y | | Y | | Y | |
| $N$ | 1298 | | 1522 | | 964 | | 979 | |
| $R^2$ | 0.444 | | 0.154 | | 0.488 | | 0.226 | |

Standard errors in parentheses
* $p < .05$, ** $p < .01$

Table 2.9: IT and Foreign Competition (Unweighted and Sales Weighted)

| | (1) Global CR4 | (2) US CR4 | (3) Global HHI | (4) US HHI | (5) Foreign Share | (6) Foreign Share(Compustat) |
|---|---|---|---|---|---|---|
| IV | 0.15+ (0.09) | -0.49** (0.08) | 0.14+ (0.09) | -0.48** (0.08) | 0.57** (0.07) | 0.01 (0.01) |
| Year FE | Y | Y | Y | Y | Y | Y |
| Industry (SIC2) FE | Y | Y | Y | Y | Y | Y |
| Industry Controls | Y | Y | Y | Y | Y | Y |
| $N$ | 1678 | 1678 | 1677 | 1677 | 1742 | 1677 |
| $R^2$ | 0.103 | 0.136 | 0.103 | 0.137 | 0.224 | 0.100 |

Standard errors in parentheses
+ $p < .1$, * $p < .05$, ** $p < .01$

Table 2.10: IT, Concentration and Foreign Competition (IV regressions)

| | (1) IT Intensity | (2) IT Share |
|---|---|---|
| IV | 0.77** (0.04) | 12.55** (1.26) |
| Year FE | Y | Y |
| Industry (SIC2) FE | Y | Y |
| Industry Controls | Y | Y |
| $N$ | 1632 | 1522 |
| $R^2$ | 0.634 | 0.559 |

Standard errors in parentheses
+ $p < .1$, * $p < .05$, ** $p < .01$

Table 2.11: First Stage

| | Foreign Share | Foreign Share |
|---|---|---|
| IT Share | 1.16** (0.03) | 1.17** (0.02) |
| Year FE | Y | Y |
| Industry (SIC2) FE | Y | Y |
| Industry Controls | Y | Y |
| Firm Controls | Y | Y |
| $N$ | 5158 | 5158 |
| $R^2$ | 0.758 | 0.859 |

Standard errors in parentheses
* $p < .05$, ** $p < .01$

Table 2.12: Relationship between foreign sales of US MNEs and the share of IT workforce

| | Foreign Share | Foreign Share |
|---|---|---|
| IT Intensity | 37.66** (0.53) | 31.15** (0.35) |
| Year FE | Y | Y |
| Industry (SIC2) FE | Y | Y |
| Industry Controls | Y | Y |
| Firm Controls | Y | Y |
| $N$ | 5158 | 5158 |
| $R^2$ | 0.847 | 0.916 |

Standard errors in parentheses
* $p < .05$, ** $p < .01$

Table 2.13: Relationship between foreign sales of US MNEs and the IT intensity of an industry

| | (1) Foreign Share | (2) Foreign Share | (3) Foreign Share |
|---|---|---|---|
| IV | 64.18** (1.51) | 59.82** (1.30) | 52.10** (1.33) |
| Year FE | Y | Y | Y |
| Industry (SIC2) FE | Y | Y | Y |
| Industry Controls | Y | Y | Y |
| Firm Controls | Y | Y | |
| $N$ | 5158 | 5158 | 5157 |
| $R^2$ | 0.776 | 0.847 | 0.777 |

Standard errors in parentheses
* $p < .05$, ** $p < .01$

Table 2.14: Relationship between foreign sales of US MNEs and IT (IV regressions)

| | (1) OLS | (2) IV |
|---|---|---|
| IT Intensity | 0.09* (0.04) | 0.26** (0.07) |
| Year FE | Y | Y |
| Industry (SIC2) FE | Y | Y |
| Industry Controls | Y | Y |
| Firm Controls | Y | Y |
| $N$ | 11316 | 11316 |
| $R^2$ | 0.184 | 0.116 |

Standard errors in parentheses
+ $p < .1$, * $p < .05$, ** $p < .01$

Table 2.15: Relationship between foreign sales of US MNEs and IT in changes (OLS and IV regressions)

| | (1) Number of multinational firms | (2) Number of multinational firms |
|---|---|---|
| IT intensity | 0.86** (0.12) | |
| IT Share | | 0.99** (0.28) |
| Year FE | Y | Y |
| Industry (SIC2) FE | Y | Y |
| Industry Controls | Y | Y |
| $N$ | 1436 | 1522 |
| $R^2$ | 0.198 | 0.190 |

Standard errors in parentheses
+ $p < .1$, * $p < .05$, ** $p < .01$

Table 2.16: Relationship between the number of US MNEs and IT (OLS)

| | (1) Number of multinational firms | (2) Number of multinational firms |
|---|---|---|
| IT Intensity | 1.56** (0.22) | |
| IT Share | | 8.87** (2.12) |
| Year FE | Y | Y |
| Industry (SIC2) FE | Y | Y |
| Industry Controls | Y | Y |
| $N$ | 1436 | 1522 |
| $R^2$ | 0.209 | 0.170 |

Standard errors in parentheses
+ $p < .1$, * $p < .05$, ** $p < .01$

Table 2.17: Relationship between the number of US MNEs and IT (IV)

| | (1) $\Delta N.MNs$ | (2) $\Delta N.MNs$ |
|---|---|---|
| L. IT Intensity | 0.80** (0.26) | |
| L. IT Share | | 0.05 (0.29) |
| Year FE | Y | Y |
| Industry (SIC2) FE | Y | Y |
| Industry Controls | Y | Y |
| $N$ | 1434 | 1351 |
| $R^2$ | 0.135 | 0.074 |

Standard errors in parentheses
+ $p < .1$, * $p < .05$, ** $p < .01$

Table 2.18: Relationship between the entry of US MNEs and IT (OLS)

| | (1) | (2) |
|---|---|---|
| | $\Delta N.MNEs$ | $\Delta N.MNEs$ |
| L.IT intensity (IV) | 0.42 (4.15) | |
| L.IT share (IV) | | 17.54 (37.68) |
| Year FE | Y | Y |
| Industry (SIC2) FE | Y | Y |
| Industry Controls | Y | Y |
| $N$ | 1434 | 1351 |
| $R^2$ | 0.205 | 0.132 |

Standard errors in parentheses
+ $p < .1$, * $p < .05$, ** $p < .01$

Table 2.19: Relationship between the entry of US MNEs and IT (IV)

| | $\Delta gRevenue_{US}$ | $\Delta gRevenue_{US}$ | $\Delta gRevenue_{US}(Domestic)$ |
|---|---|---|---|
| $\Delta F.Share$ | 0.02 (0.04) | 0.16+ (0.09) | 0.20 (0.18) |
| $\Delta F.Share(HighITindustries)$ | | -0.18+ (0.10) | -0.40* (0.19) |
| Year FE | Y | Y | Y |
| Industry (SIC2) FE | Y | Y | Y |
| Industry Controls | Y | Y | Y |
| Firm Controls | Y | Y | Y |
| $N$ | 36915 | 36915 | 13797 |
| $R^2$ | 0.231 | 0.259 | 0.153 |

Standard errors in parentheses
+ $p < .1$, * $p < .05$, ** $p < .01$

Table 2.20: The differential effect of Foreign Market Share on the sales of US firms (OLS)

| | $\Delta gRevenue_{US}(LowFS)$ | $\Delta gRevenue_{US}(HighFS)$ |
|---|---|---|
| IT Share | 6.67** (2.03) | 0.94 (2.35) |
| Year FE | Y | Y |
| Industry (SIC2) FE | Y | Y |
| Industry Controls | Y | Y |
| Firm Controls | Y | Y |
| $N$ | 23117 | 13797 |
| $R^2$ | 0.388 | 0.125 |

Standard errors in parentheses
+ $p < .1$, * $p < .05$, ** $p < .01$

Table 2.21: The differential effect of IT on the sales of US firms conditional on foreign market shares(OLS)

| | (1) | (2) |
|---|---|---|
| | $\Delta gRevenue_{US}(LowIT)$ | $\Delta gRevenue_{US}(HighIT)$ |
| Foreign Share | -0.25 (0.18) | -0.25* (0.12) |
| Year FE | Y | Y |
| Industry (SIC2) FE | Y | Y |
| Industry Controls | Y | Y |
| Firm Controls | Y | Y |
| $N$ | 1394 | 2154 |
| $R^2$ | 0.315 | 0.266 |

Standard errors in parentheses
+ $p < .1$, * $p < .05$, ** $p < .01$

Table 2.22: The differential effect of IT on the sales of US firms (OLS)

| | (1) | (2) |
|---|---|---|
| | $\Delta gRevenue_{US}(LowIT)$ | $\Delta gRevenue_{US}(HighIT)$ |
| Foreign Share(IV) | -0.10 (0.08) | -0.23** (0.08) |
| Year FE | Y | Y |
| Industry (SIC2) FE | Y | Y |
| Industry Controls | Y | Y |
| Firm Controls | Y | Y |
| $N$ | 2180 | 2593 |
| $R^2$ | 0.383 | 0.231 |

Standard errors in parentheses

+ $p < .1$, * $p < .05$, ** $p < .01$

Table 2.23: The differential effect of IT on the sales of US firms by IT intensity (IV)

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | $\Delta Op.M(MNE)$ | $\Delta Op.M(Domestic)$ | $\Delta Op.M(MNE)$ | $\Delta Op.M(Domestic)$ |
| Change in IT%(IV) | 8.54* (3.38) | -2.18 (5.91) | 13.57** (5.17) | -29.50 (98.13) |
| Year FE | Y | Y | Y | Y |
| Industry (SIC2) FE | Y | Y | Y | Y |
| Industry Controls | Y | Y | Y | Y |
| Firm Controls | Y | Y | Y | Y |
| $N$ | 453 | 289 | 305 | 437 |
| $R^2$ | 0.172 | 0.057 | 0.638 | 0.234 |

Standard errors in parentheses

* $p < .05$, ** $p < .01$

Table 2.24: Operating Margin (Long Differences)

## 2.8 Theory Appendix

In this section, I derive formally the competitive equilibrium of the model with $J$ industries and 2 countries.

### 2.8.1 Consumption Choices

Given the nested demand, I derive the optimal allocations and decisions in three steps. First, I derive demand for the bundle $C_D$ of differentiated good sectors and the homogeneous good sector, $c_0$. The upper tier optimization program for consumers is

$$\max_{C_D, c_0} c_0^{1-a_0} \cdot C_D^{a_0}, \qquad \text{s.t.} \qquad P_D C_D + p_0 c_0 \leq Y$$

where $C_D$ is the consumption index from consumption in the $\mathcal{J}$ industries, $P_D$ the relevant price index, $p_0$ the price of the homogeneous good, and $Y$ the total income of consumers. From the first order conditions I derive the aggregate price index $P$ and demand for each type of goods:

$$P = \left(\frac{P_D}{a_0}\right)^{a_0} \left(\frac{p_0}{1-a_0}\right)^{1-a_0}$$
$$c_0 = (1-a_0)\frac{PC}{p_0}$$
$$C_D = a_0 \frac{PC}{P_D}$$

Given the allocation above, the consumer optimizes over the allocation across the $\mathcal{J}$ industries. Given the constant elasticity of substitution $\theta$, the optimization problem yields the usual expression for consumption under CES preferences:

$$\max_{\{C_J\}} \left( \sum_J C_J^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \quad \text{s.t} \quad \sum_J P_J C_J \leq P_D C_D$$

where $\{P_J\}$ represents the price level for each sector $J$. The optimal allocations are given by

$$C_J = \left( \frac{P_J}{P_D} \right)^{-\theta} \cdot C_D$$

and total expenditures in sector $J$ are

$$P_J C_J = \left( \frac{P_J}{P_D} \right)^{1-\theta} a_0 \cdot PC$$

This means that the price index for the differentiated goods is

$$P_D = \left[ \sum_J P_J^{1-\theta} \right]^{\frac{1}{1-\theta}}$$

Finally, within each sector, the variety-level demand is given by $c_J(\omega)$, where $c_J(\omega)$ optimizes the following problem given the aggregated sectoral level consumption and prices in sector $J$ :

$$\max_{c_J(\omega)} \left[ \int_{\Omega_J} c_J(\omega)^{\frac{\sigma_J-1}{\sigma_J}} d\omega \right]^{\frac{\sigma_J}{\sigma_J-1}} \quad \text{s.t.} \quad \int_{\Omega_J} p_J(\omega) c_J(\omega) d\omega \leq P_J C_J$$

From first-order conditions, individual variety expenditures and the price index across all varieties $\Omega$, with a price $p(\omega)$ of each variety, satisfies:

$$p(\omega)c_J(\omega) = p(\omega)\left(\frac{p(\omega)}{P_J}\right)^{-\sigma_J} \cdot C_J$$

$$P_J = \left[\int_\Omega p(\omega)^{1-\sigma_J} d\omega\right]^{\frac{1}{1-\sigma_J}}$$

In the following sections I describe the determination of the number of varieties $\Omega$ and prices $p(\omega)$ that determine the dynamics of the sales shares of firms and their correlation with aggregate consumption processes.

### 2.8.2 Supply Side

***Sector 0*** Sector 0 produces a homogeneous good with linear technology in labor and unit productivity. The homogeneous good 0 is freely traded and is used as the numeraire in each country. It is produced under constant returns to scale with one unit of labor producing $w$ units of good and its price is set equal to 1. Then each country has a different wage $w$ and $w^*$.

***Differentiated Sectors*** Firms in the other sectors operate under monopolistic competition and thus their prices are equal to the markup times the marginal cost. Given CES demand in each industry, where the constant elasticity is given by $\sigma_J$, the markup is given by $\sigma_J/(\sigma_J - 1)$. An establishment of a firm with efficiency parameter $\varphi$ sets the following price if it operates in firms' headquarters, given the discussion on firm productivity, that follows:

$$p_J(\varphi) = \frac{\sigma_J}{\sigma_J - 1} w/(\varphi)$$

and the following price when it does not operate in firms' headquarters:

$$p_{NJ}(\varphi) = \frac{\sigma_J}{\sigma_J - 1} w^* / \Big(\varphi \exp(-\kappa \mathbb{I}(\varphi < \underline{\varphi}_{ITJ})\Big)$$

The productivity of establishments in the two different locations are the same by assumption except for the efficiency costs. In particular, the establishment productivity is equal to the productivity of the firm at the headquarter's location $\varphi$ times an efficiency cost term $\exp(-\kappa \mathbb{I}_a(\varphi < \underline{\varphi}_{ITJ}))$. The efficiency cost represents costs of technology transfer or more generally any efficiency losses due to managing an establishment in a distant environment. Efficiency costs depend on the IT adoption decision $\mathbb{I}(\varphi \geq \underline{\varphi}_{ITJ})$ of the firm. In what follows, I will be using the following expression for prices:

$$p_{NJ}(\varphi) = K(\varphi) \frac{w^*}{w} p_J(\varphi),$$

where

$$K(\varphi) \equiv \exp(\kappa \mathbb{I}(\varphi \geq \underline{\varphi}_{ITJ}))$$

These efficiency losses affect productivity and thus prices. Firm profits depend on chosen prices and quantities produced, and the number of establishments operated by the firms, along with the IT adoption decision. The local HQ - establishment profits are given by

$$\begin{aligned}\pi_J(\varphi) &= \frac{1}{\sigma_J} \cdot \left(\frac{p_J(\varphi)}{P_J}\right)^{1-\sigma_J} \cdot P_J C_J \\ &= \frac{p_J(\varphi)}{\sigma_J} \cdot \left(\frac{p_J(\varphi)}{P_J}\right)^{-\sigma_J} \cdot \left(\frac{P_J}{P_D}\right)^{1-\theta} \cdot a_0 \cdot PC\end{aligned}$$

The level of profits (or losses) of a second location are given by:

$$\pi_{NJ}(\varphi) = \frac{1}{\sigma_J} \cdot \left(\frac{p_{NJ}(\varphi)}{P_J^*}\right)^{1-\sigma_J} \cdot P_J^* C_J^* - f_J - \frac{f_{ITJ}\mathbb{I}(\varphi \geq \underline{\varphi}_{ITJ})}{1/h}.$$

Profits are increasing in idiosyncratic productivity, and hence there exists a productivity cutoff in each industry under which a firm decides to create a second establishment. Similarly, there is a cutoff related to the decision to adopt IT. The assumption for the fixed costs are such that the cuttof for IT adoption is always larger than that of operating a second establishment.

#### 2.8.2.1 Decision to operate second establishment and adopt IT

In this section, I describe the cutoffs that determine the decisions of the firms. I define the following cutoff level for firms that operate a second establishment as

$$\underline{\varphi}_{NJ} = \min_{\varphi}\{\varphi \mid \varphi \text{ implies that firm is operating a second establishment}\}.$$

Similarly, for firms that choose to use IT, I have:

$$\underline{\varphi}_{ITJ} = \min_{\varphi}\{\varphi \mid \varphi \text{ is adopting IT}\}.$$

I impose the relevant restrictions such that there is always a positive mass of firms, operating a second establishment but do not adopt IT. Now let's derive the cutoffs. The cutoff productivity for IT adoption is given by the lower bound of $\varphi$ such that:

$$\frac{1}{\sigma_J} \cdot \left( \frac{\frac{w^*}{w}(p_J(\varphi)}{P_J^*} \right)^{1-\sigma_J} \cdot P_J^* C_J^* - f_J - \frac{f_{ITJ}}{1/h} >$$
$$\frac{1}{\sigma_J} \cdot \left( \frac{\exp(\kappa)\frac{w^*}{w}(p_J(\varphi)}{P_J^*} \right)^{1-\sigma_J} \cdot P_J^* C_J^* - f_J$$

which is true if:

$$B_J^{*-1} \left[ (\varphi)^{-1+\sigma_J} - K^{1-\sigma_J} (\varphi)^{-1+\sigma_J} \right] - \frac{f_{ITJ}}{1/h} \geq 0$$

where $K = \exp(\kappa)$ and $B_J^*$ is the following helpful expression summarising the aggregate state of the economy:

$$B_J^* = \sigma_J \left( \frac{\sigma_J}{\sigma_J - 1} \frac{w^*}{w} \right)^{\sigma_J - 1} \cdot (P_J^*)^{-\sigma_J} (C_J^*)^{-1}$$

Then, the cutoff is such that:

$$(\underline{\varphi}_{ITJ})^{\sigma_J - 1} = h \frac{B_J^* f_{ITJ}}{1 - K^{1-\sigma_J}}$$

Similarly, the cutoff productivity for being a multinational firm is given by

$$\left(\underline{\varphi}_{NJ}\right)^{\sigma_J - 1} = B_J^* f_J (K)^{\sigma_J - 1}$$

A very useful property of this model is that the relative ratio of the cutoffs will be constant. In particular, the two cutoffs satisfy:

$$\underline{\varphi}_{ITJ}/\underline{\varphi}_{NJ} = \left(\frac{1}{K^{\sigma_J-1}-1}\right)^{1/(\sigma_J-1)} (hf_{ITJ}/f_J)^{1/(\sigma_J-1)} \equiv \Gamma_J$$

so the two cutoffs move proportionally with the aggregate productivity, $A$, which is an important property used to derive the results below. This property in particular implies that given that by assumption the parameters are assumed to be fixed, then the relationship between the cutoffs is constant over time and the only fluctuations in IT adoption and establishment entry are due to aggregate productivity shocks. For what follows, the following equation will be useful

$$hf_{ITJ} = f_J \Gamma_J^{\sigma_J-1}(K^{\sigma_J-1}-1)$$

To derive an expression for the local sectoral price index I need to determine the mass of multianational firms operating in industry $J$, that their HQs are not in the "home" economy, $N^*_{NJ}$. These variables then summarize the supply side of the economy and given the aggregate productivity shocks $A$ and $A^*$ are essentially static. Lastly, total industry profits for "home" firms in a sector $J$ are defined as:

$$\Pi_J := \left[\int_{\Omega_J}^{\infty} \pi_J(\varphi_J)\,\mathrm{d}G_J(\varphi) + \int_{\Omega^*_{NJ}}^{\infty} \pi_{NJ}(\varphi_J)\,\mathrm{d}G_J(\varphi)\right]$$

The set of "home" products $\Omega^\star_{NJ}$ sold in the foreign country is determined by the cutoff in the previous section.

#### 2.8.2.2 Equilibrium.

An equilibrium is a set of prices and allocations

$$(p_J, p_{NJ}, P_J, P_{Tt}, P_t), q_J(\varphi), c_J(\varphi), l_J(\varphi)$$

such that: (a) given prices, allocations maximize the households program; (b) given prices allocations maximize firms profits; (c) labor markets and good markets clear.

To characterize the equilibrium, I derive the aggregate production function, price indices and revenue distributions. First, I calculate the equilibrium profit of the differentiated varieties producers in each industry. Home demands and profits are given in equations as in the main body of the paper.

#### 2.8.2.3 Industry Aggregation

As in Melitz (2003) and Ghironi and Melitz (2005) for the solution of the equilibrium, it is enough to keep track only the mass and the average productivity for firms that choose to operate the same number of establishments, and that have the same technologies, i.e. they have adopted IT or not. This means for the aggregation, the theoretical predictions and for the numerical implementation of the model, I need to keep track of:

1. The fraction of firms in industry $J$ that engage in production $\zeta_J$, the mass of firms that operate in two locations $\zeta_{NJ}$ and the mass of firms that have adopted IT $\zeta_{ITJ}$.

2. Derive average productivity levels for these different groups: 1) $\bar{\varphi}_J$, for all firms;

2) $\bar{\varphi}_{NJ}$, for firms that operate in two locations and 3) $\bar{\varphi}_{ITJ}$, for firms that adopt IT . Similarly I need to keep track the same cutoffs for the other region

3. Industry-wide profits and price indices can be calculated using probability masses and average productivity levels.

As I show below, the aggregation of industry variables is simplified even further since the relative cuttofs $\bar{\varphi}_{ITJ}$ and $\bar{\varphi}_{NJ}$ are given by a constant, as well as the ratio of the mass of firms $\zeta_{NJ}$ and $\zeta_{ITJ}$ due to the Pareto assumption.

### 2.8.3 Aggregation

#### 2.8.3.1 Multinational firms and IT adoption

Given the productivity cutoff for entering the foreign country $\varphi_{NJ}$, the fraction of ME firms, denoted $\zeta_{NJ}$, is given by

$$\zeta_{NJ} := Pr\left\{\tilde{\varphi} > \underline{\varphi}_{NJ}\right\} = \left(\frac{\underline{\varphi}_{NJ}}{\underline{\varphi}_{J}}\right)^{-\gamma_J}$$

Given the cutoffs described above, the fraction of firms that choose to adopt IT then satisfies:

$$\zeta_{ITJ} = Pr\left\{\tilde{\varphi} > \underline{\varphi}_{ITJ}\right\}$$

Due to the Pareto distribution assumption, the average productivity of firms with productivity higher than a cutoff value $\underline{\varphi}_{ITJ}$ would be equal to:

$$\overline{\varphi}_{ITJ} = \left[\frac{\int_{\varphi_{ITJ}}^{\infty} \varphi^{\sigma_J - 1} dG_J(\varphi)}{1 - G\left(\underline{\varphi}_{ITJ}\right)}\right]^{\frac{1}{\sigma_J - 1}} = \nu_J \underline{\varphi}_{ITJ}$$

where $\nu_J$ is defined as $\nu_J := (\gamma_J / (\gamma_J - (\sigma_J - 1)))^{1/(\sigma_J - 1)}$ and so it depends only on the elasticity of substitution and the tail parameter of the distribution, which leads to the formulas described in the paper. The average productivity of firms with productivity higher than cutoff value $\underline{\varphi}_{NJ}$ also satisfies:

$$\bar{\varphi}_{NJ} = \nu_J \underline{\varphi}_{NJ}$$

where $\nu_J$ is defined as $\nu_J := (\gamma_J / (\gamma_J - (\sigma_J - 1)))^{1/(\sigma_J - 1)}$ and so it depends only on the elasticity of substitution and the tail parameter of the distribution. Then, the local price indices for sector $J$ are given by:

$$P_J = \left( N_J \int_{\underline{\varphi}_J} p_J(\varphi)^{1-\sigma_J} d\varphi + (\zeta^*_{NJ} N^*_J) \int_{\underline{\varphi}^*_{NJ}} p^*_{NJ}(\varphi)^{1-\sigma_J} d\varphi \right)^{\frac{1}{1-\sigma_J}}$$

where the price of goods from an establishment of a firm not located in the same county satisfies the following expression:

$$p^*_{NJ}(\varphi) = \begin{cases} K^* \frac{w}{w^*} p^*_J(\varphi) & \text{if } \underline{\varphi}_{NJ} < \varphi \leq \underline{\varphi}_{ITJ} \\ \frac{w}{w^*} p^*_J(\varphi) & \text{if } \varphi > \underline{\varphi}_{ITJ} \end{cases}$$

Note that the price index of different industries reflects the decline in the price level from the IT adoption and thus the increase in competition, in industries of which the fixed cost of adoption is lower. Now the price index in industry $J$ reflects the effect of an increase in competition from the IT intensive firms leading to lower industry level prices.

#### 2.8.3.2 Aggregation

As in Melitz (2003), instead of keeping track of the distribution of production and prices, it is sufficient to analyze average producers, first for the whole domestic market $\bar{\varphi}_J$ and second for the subset of multinational firms $\bar{\varphi}_{NJ}$ . The following quantities are sufficient to define the equilibrium:

$$\bar{\varphi}_J := \left[\int_{\underline{\varphi}_J}^{\infty} \varphi^{\sigma_J - 1} \mathrm{d}G_J(\varphi)\right]^{\frac{1}{\sigma_J - 1}} = \nu_J \cdot \underline{\varphi}_J$$

$$\bar{\varphi}_{NJ} := \left[\int_{\varphi_{NJ}}^{\infty} \varphi^{\sigma_J - 1} \mathrm{d}G_J(\varphi)\right]^{\frac{1}{\sigma_J - 1}} = \nu_J \cdot \underline{\varphi}_{NJ}$$

$$\bar{\varphi}_{ITJ} := \left[\int_{\varphi_{ITJ}}^{\infty} \varphi^{\sigma_J - 1} \mathrm{d}G_J(\varphi)\right]^{\frac{1}{\sigma_J - 1}} = \nu_J \cdot \underline{\varphi}_{ITJ}$$

where $\nu_J$, the average of firm productivity under a Pareto distribution, is given by $\nu_J = \left(\frac{\gamma_J}{\gamma_J - (\sigma_J - 1)}\right)^{\frac{1}{\sigma_J - 1}}$.

Average profits for domestic establishments in the "home" country in industry $J$ are $\pi_J(\bar{\varphi}_J)$ and for the establishments in the foreign country are given by $\pi_{NJ}(\bar{\varphi}_{NJ}) + \Delta\pi_{NJ}(\bar{\varphi}_{ITJ})$ where $\Delta\pi_{NJ}(\bar{\varphi}_{ITJ})$ are the additional realized profits if a firms adopts IT and is defined explicitly below[18]:

$$\Delta\pi_{NJ}(\bar{\varphi}_{ITJ}) = B_J\left[(\bar{\varphi}_{ITJ})^{-1+\sigma_J} - K^{1-\sigma_J}(\bar{\varphi}_{ITJ})^{-1+\sigma_J}\right] - \frac{f_{ITJ}}{1/h}$$

[18]This expression summarizes the additional profits of IT adopters, compared to a case where this option is not available.

and similarly for the prices, since we have:

$$p^*_{NJ}(\varphi) = \begin{cases} K^* \frac{w}{w^*} p^*_J(\varphi) & \text{if } \underline{\varphi}_{NJ} < \varphi \leq \underline{\varphi}_{ITJ} \\ \frac{w}{w^*} p^*_J(\varphi) & \text{if } \varphi > \underline{\varphi}_{ITJ} \end{cases}$$

and the realized reduction in the price in the case of IT adoption for a firm with productivity $\varphi$, we have $\Delta p^*_{NJ}(\varphi) = (1 - K^*) \frac{w}{w^*} p^*_J(\varphi)$. In addition, given the definition of mean levels, across different groups I have:

$$\bar{\varphi}_{ITJ}/\bar{\varphi}_{NJ} = \left( \frac{1}{K^{\sigma_J - 1} - 1} \right) (h f_{ITJ}/f_J)^{1/(\sigma_J - 1)} = \Gamma_J$$

and for what follows I derive

$$\Gamma_J = \bar{\Gamma}_J h^{1/(\sigma_J - 1)}$$

The relative share of IT adopters also satisfies:

$$\zeta_{ITJ}/\zeta_{NJ} = \Gamma_J^{-\gamma_J}$$

.

Using the expressions for the profit functions and the cutoffs, aggregate profits can be written as:

$$\Pi_J := N_J \left[ \pi_J \left( \bar{\varphi}_J \right) + \zeta_{NJ} \pi_{NJ} \left( \bar{\varphi}_{NJ} \right) + \zeta_{NJ} \Gamma_J^{-\gamma_J} \Delta \pi_{NJ} \left( \Gamma_J \bar{\varphi}_{NJ} \right) \right]$$

where I have substituted the expressions for $\bar{\varphi}_{ITJ}$ and $\zeta_{ITJ}$ which makes it immediate to see that the IT cutoffs are not important for aggregation only through the sufficient statistic $\Gamma_J$. This implies that I need to keep track only the cutoff for the operation of a second establishment $\bar{\varphi}_{NJ} = \upsilon_J \underline{\varphi}_{NJ}$ and for comparative statics with respect to $h$ I only need to consider how the sufficient statistic $\Gamma_J$ changes. The same aggregation property simplifies the expression for the sectoral price index $P_J$ :

$$P_J = \left(N_J \cdot p_J\left(\bar{\varphi}_J\right)^{1-\sigma_J} + \zeta_{NJ}^* N_J^* \cdot p_{NJ}^*\left(\bar{\varphi}_{NJ}^*\right)^{1-\sigma_J} + \zeta_{NJ}^* \Gamma_J^{*-\gamma_J} N_J^* \Delta p_{NJ}^*\left(\Gamma_J^* \bar{\varphi}_{NJ}^*\right)^{1-\sigma_J}\right)^{\frac{1}{1-\sigma_J}}$$

where $p_{NJ}^*\left(\bar{\varphi}_{NJ}^*\right) = K^* \frac{w}{w^*} p_J^*(\bar{\varphi}_{NJ}^*)$ and $\Delta p_{NJ}^*\left(\bar{\varphi}_{NJ}^*\right) = (K^* - 1)\frac{w}{w^*} p_J^*(\bar{\varphi}_{NJ}^*)$.

So simplifying even further

$$P_J = \left(N_J \cdot p_J\left(\bar{\varphi}_J\right)^{1-\sigma_J} + \zeta_{NJ}^* N_J^* \cdot p_{NJ}^*\left(\bar{\varphi}_{NJ}^*\right)^{1-\sigma_J}\left[1 + (K^{*\sigma_J - 1} - 1)\Gamma_J^{*-\gamma_J + \sigma_J - 1}\right]\right)^{\frac{1}{1-\sigma_J}}$$

or using the following definition:

$$H\Bigg(h, K^*, \Gamma_J^*, \gamma_J, \sigma_J\Bigg) \equiv \left[1 + (K^{*\sigma_J - 1} - 1) h^{\frac{-\gamma_J}{\sigma_J - 1} + 1} \Gamma_J^{*-\gamma_J + \sigma_J - 1}\right] :$$

$$P_J = \left(N_J \cdot p_J\left(\bar{\varphi}_J\right)^{1-\sigma_J} + \zeta_{NJ}^* N_J^* \cdot p_{NJ}^*\left(\bar{\varphi}_{NJ}^*\right)^{1-\sigma_J} H\Bigg(h, K^*, \Gamma_J^*, \gamma_J, \sigma_J\Bigg)\right)^{\frac{1}{1-\sigma_J}}$$

where I use explicitly the dependence on h, since this is the variable that I would do comparative statics with respect to. In addition it is important to note that $h$ is the same parameter for both domestic and foreign markets.

### 2.8.4 IT intensity

**Lemma 12.** *Proof of Lemma 1*

In particular, I have that IT labor hours in the "home" market are equal to the product of the number of producers, the amount required to operate IT and the endogenous percentage of firms that choose to operate IT:

$$L_J^{IT} = N_J \times f_{ITJ} \times \zeta_{ITJ} \times h = N_J f_{ITJ} h \Gamma_J^{-\gamma_J} \zeta_{NJ} =$$

$$= N_J h f_{ITJ} \left( \frac{1}{K^{\sigma_J - 1} - 1} \right)^{-\gamma_J/(\sigma_J - 1)} (h f_{ITJ}/f_J)^{-\gamma_J/(\sigma_J-1)} \zeta_{NJ}$$

$$L_J^{IT} = N_J \zeta_{NJ} \left( f_J (K^{\sigma_J - 1} - 1) \right)^{\gamma_J/(\sigma_J-1)} (h f_{ITJ})^{1-\gamma_J/(\sigma_J-1)}$$

Given the fixed number of firms $N_J$, and the fact that $\zeta_{NJ}$ is independent of $h f_{ITJ}$, the proof of Lemma 1 is immediate.

The level of IT fixed costs reduces the number of IT workers and thus the IT intensity of the industry. In addition, the level of the fixed costs and the efficiency losses $K = \exp(\kappa)$ interact to determine the overall level of IT intensity of an industry.

In addition, this key equation shows that the more heterogeneity there is in an industry, then the larger the IT intensity, conditional on the fixed cost of IT. Also the level of heterogeneity, determines how a shock to the cost of IT adoption affects the reaction of IT intensity, through the level of the elasticity. In addition, it is important to observe that the level of the IT intensity of each industry, corresponds to the labor based measures of IT intensity as the ones used for the empirical exercise based on the IT employment of industries in the U.S.

### 2.8.5 Multinational firm's share

First let us define the multinational firm's effect on the price index (competition) as:

$$\mathcal{I}_J = \frac{\zeta_{NJ}^{*} N_J^{*} \cdot p_{NJ}^{*} \left(\bar{\varphi}_{NJ}^{*}\right)^{1-\sigma_J} H_J^{*}}{P_J^{1-\sigma_J}}$$

It is useful to remember also that

$$p_{NJ}^{*}(\bar{\varphi}_{NJ}^{*}) = K^{*} \frac{w}{w^{*}} p_J^{*}(\bar{\varphi}_{NJ}^{*})$$

This represents the marginal impact of multinational firms on the price index for a given industry. Given our definition of $P_J$, this variable is bounded: $\mathcal{I}_J \in [0,1]$.

**Lemma 13.** *The level of $\mathcal{I}_J$ is a decreasing function of the cost of adoption $f_{ITJ}^{*}$.*

The proof of this proposition is immediate since it is a simple matter of observing that $f_{ITJ}^{*}$ appears only in the expression for $H_J^{*}$ and that $H_J^{*}$ is decreasing in $f_{ITJ}^{*}$.

### 2.8.6 Elasticities

All elasticities $\mathcal{E}(X) \equiv \frac{\partial log X}{\partial log h}$ are with respect to a quality of IT shock $h$. Elasticities related to total and sector price indices:

$$\mathcal{E}(P) = a_0 \mathcal{E}\left(P_D\right)$$

$$\mathcal{E}\left(P_D\right) = \sum_J \left(\frac{P_D}{P_J}\right)^{\theta-1} \mathcal{E}\left(P_J\right)$$

Elasticities related to total, sector and industry consumption:

$$
\begin{aligned}
\mathcal{E}(C) &= -\mathcal{E}(P) + \frac{\Pi}{wL+\Pi}\mathcal{E}(\Pi) \\
\mathcal{E}\left(C_D\right) &= \mathcal{E}(C) - (1-a_0)\,\mathcal{E}\left(P_D\right) = \mathcal{E}(C) - \left(\frac{1}{a_0} - 1\right)\mathcal{E}(P) \\
\mathcal{E}\left(C_J\right) &= -\theta\mathcal{E}\left(P_J\right) + \theta\mathcal{E}\left(P_D\right) + \mathcal{E}\left(C_D\right) = ...
\end{aligned}
$$

$$
-\theta\mathcal{E}\left(P_J\right) + \mathcal{E}(C) + \left[\theta - (1-a_0)\right]\mathcal{E}\left(P_D\right)
$$

**Productivity cutoff-** The only relevant productivity cutoff after aggregation is that of foreign entry. Under the parametric assumptions in this paper, the cutoff does not depend on $h$ and so

$$
\mathcal{E}\left(\varphi^*_{NJ}\right) = 0
$$

### 2.8.7 Model implications

Let's recall the definition of the following variable:

$$
\mathcal{I}_J = \frac{\zeta^*_{NJ} N^*_J \cdot p^*_{NJ}\left(\bar{\varphi}^*_{NJ}\right)^{1-\sigma_J} H^*_J}{P_J^{1-\sigma_J}}
$$

and

$$
p^*_{NJ}(\bar{\varphi}^*_{NJ}) = K^* \frac{w}{w^*} p^*_J(\bar{\varphi}^*_{NJ})
$$

where the only effect of $h$ is through $H^*_J$.

**Lemma 14.** *The elasticity of firms' local cash flows to $h$ is*

$$\mathcal{E}\left(\pi_{LJ}(\varphi)\right)=\mathcal{E}\left(\Pi_{LJ}\right) \quad = \underbrace{-\left(\sigma_J-\theta\right)\left(-\mathcal{E}\left(P_J\right)\right)}_{\text{competition effect}} + \underbrace{\mathcal{E}\left(C\right)+\frac{1-a_0-\theta}{a_0}\left(-\mathcal{E}(P)\right)}_{\text{expenditure effect}}$$

*where*

$$\mathcal{E}\left(P_J\right)=-\frac{1}{1-\sigma_J}\frac{\zeta_{NJ}^{*}N_J^{*}\cdot p_{NJ}^{*}\left(\bar{\varphi}_{NJ}^{*}\right)^{1-\sigma_J}H_J^{*}}{P_J^{1-\sigma_J}}\cdot\left[\frac{-\gamma_J+\sigma_J-1}{\sigma_J-1}\cdot\left(1-1/H_J^{*}\right)\right]$$

*where $\mathcal{I}_J$ determines the level of competition from multinational firms in industry $J$ defined above. The elasticity is bigger in absolute value if the level of IT fixed costs are lower, that is the elasticity is bigger, the bigger is the level of $\mathcal{I}_J$ and $H_J^*$. In addition, due to the linear relationship of sales and profits the same elasticity applies to sales.*

Remember that profits of firms that operate establishments locally are given by

$$\Pi_{LJ}=N_J\int\pi_J(\varphi)d\varphi=N_J\pi_J(\bar{\varphi}_J)=\frac{1}{\sigma_J}\cdot\left(\frac{p_J(\bar{\varphi}_J)}{P_J}\right)^{1-\sigma_J}\cdot\left(\frac{P_J}{P_D}\right)^{1-\theta}\cdot a_0\cdot PC$$

A shock to $h$ leads to an increase in foreign competition from multinational firms through the effect on the price index. The elasticity of local profits is [19]

$$\mathcal{E}\left(\Pi_{LJ}\right)=\mathcal{E}\left(\pi_J(\bar{\varphi}_J)\right)=-\left(\sigma_J-1\right)\cdot\left(-\mathcal{E}\left(P_J\right)\right)+\quad\mathcal{E}(PC)$$

In addition it is useful to observe that irrespective of the firm size the elasticity of

[19] There are second-order effects of redistribution through the industry shares. I verify that they are small in the calibration and ignore them in the the derivation that follows.

local profits is equalized across the size distribution and thus

$$\mathcal{E}\left(\pi_{LJ}(\varphi)\right) = \mathcal{E}\left(\Pi_{LJ}\right) \quad = \underbrace{-\left(\sigma_J - \theta\right)\left(-\mathcal{E}\left(P_J\right)\right)}_{\text{competition effect}} + \underbrace{\mathcal{E}\left(C\right) + \frac{1 - a_0 - \theta}{a_0}\left(-\mathcal{E}(P)\right)}_{\text{expenditure effect}}$$

This means that both large and small domestic firms lose domestic market share.

*Competition effect.* In particular, observe that the competition effect differs across industries. The elasticity for the price index in industry $J$ is:

$$\mathcal{E}\left(P_J\right) = -\frac{1}{1-\sigma_J}\frac{\zeta_{NJ}^* N_J^* \cdot p_{NJ}^*\left(\bar{\varphi}_{NJ}^*\right)^{1-\sigma_J} H_J^*}{P_J^{1-\sigma_J}} \cdot \left[\mathcal{E}\left(H_J^*\right)\right]$$

where I use the following equality (from the definition of $H_J^*$)

$$\mathcal{E}\left(H_J^*\right) = \frac{-\gamma_J + \sigma_J - 1}{\sigma_J - 1} \cdot \left(1 - 1/H_J^*\right)$$

QED.

**Lemma 15.** *The elasticity of domestic firms' foreign sales to domestic IT quality shocks $h$ is negative and bigger in absolute value for more IT intensive industries.*

**Proof** Profits for multinational firms are as follows in the foreign market:

$$\pi_{NJ}(\varphi) = \frac{1}{\sigma_J} \cdot \left(\frac{p_{NJ}(\varphi)}{P_J^*}\right)^{1-\sigma_J} \cdot P_J^* C_J^* - f_J - \frac{f_{ITJ}\mathbb{I}(\varphi \geq \underline{\varphi}_{ITJ})}{1/h}.$$

I also define the revenue function as

$$R_{NJ}(\varphi) = \pi_{NJ}(\varphi) + f_J/A + \frac{f_{ITJ}\mathbb{I}\left(\varphi \geq \varphi_{ITJ}\right)}{1/h}$$

Given that for aggregate foreign profits and revenues I showed that $h$ appears only in

$$\Delta\pi_{NJ}\left(\bar{\varphi}_{ITJ}\right)=B_J\left[\left(\bar{\varphi}_{ITJ}\right)^{-1+\sigma_J}-K^{1-\sigma_J}\left(\bar{\varphi}_{ITJ}\right)^{-1+\sigma_J}\right]-\frac{f_{ITJ}}{1/h}$$

and due to the Pareto distribution and the zero profit condition:

$$\Delta R_{NJ}\left(\bar{\varphi}_{ITJ}\right)=hf_{ITJ}\frac{\gamma_J-\sigma_J+1}{\sigma_J-1}$$

Then following the same steps as in Chaney, it is easy to show that the elasticity of foreign revenues are equal to $-\frac{\gamma_J-\sigma_J+1}{\sigma_J-1}$ times the additional sales share generated by multinational firms adopting IT. Then the conclusion follows.

### 2.8.8 Proof of Proposition 1

Let us first recall Proposition 1 : Consider two industries in the same country and a shock to IT quality $h$. If fixed costs of IT adoption are lower in industry $J_1$ then: (a) The elasticity of revenues for non multinationals is more negative in $J_1$ (b) The difference in the elasticity of revenues comparing the two industries is larger (in absolute value) for non multinational firms than for multinational firms.

Proof of (a). To recall the result that the level of MNEs $\mathcal{I}_J$ is decreasing with the cost of adoption $f_{ITJ}$, all else equal. Moreover, a shock in $h$ has bigger impact on domestic sales if the share of large non local firms is higher. It then follows that the elasticity of domestic profits is also larger (in absolute value) in industries with a lower cost of operating IT $f_{ITJ}$.

Proof of (b). Observe first that $\mathcal{E}\left(R_{LJ_1}\right)<\mathcal{E}\left(R_{LJ_2}\right)<0$. Moreover, we have that

$\mathcal{E}(R_{NJ_1}) > \mathcal{E}(R_{NJ_2})$. It follows that:

$$\mathcal{E}(R_{LJ_2}) - \mathcal{E}(R_{NJ_2}) > \mathcal{E}(R_{LJ_1}) - \mathcal{E}(R_{NJ_1})$$

In addition, the difference between the elasticity of the profit of a firm below the cutoff $\varphi_{NJ}$ and one above is:

$$\mathcal{E}(R_L) - \mathcal{E}(R_L + R_N)_{\text{above the cutoff}} = \alpha_N \left(\mathcal{E}(R_L) - \mathcal{E}(R_N)\right)$$

where $\alpha_N$ the share of profits of large firms from sales outside of the local location, which it is immediate to show that, all else equal, $\alpha_{NJ_2} < \alpha_{NJ_1}$, as the share of sales outside of the local economy, is smaller for firms in industries with high costs of doing IT. Using this inequality we conclude:

$$\mathcal{E}(R_{NJ_1}) - \mathcal{E}(R_{NJ_2}) < \mathcal{E}(R_{LJ_1} + R_{NJ_1})_{\text{above cutoff}} - \mathcal{E}(R_{LJ_2} + R_{NJ_2})_{\text{above cutoff}}$$

This is the prediction I take directly to the data.

**Model Predictions on concentration** The next section briefly describes how IT can intensify foreign competition and may affect market concentration in the standard model of multinational firms.

**IT and industry concentration in the model** In the model, a continuum of firms indexed by productivity $\varphi$ produces differentiated consumption goods in each industry $J$. In the discussion that follows, I drop $J$ for exposition purposes. The firms can sell to two countries, "US" and "ROW", subject to a fixed cost of creating a foreign establishment $f_J > 0$ and can adopt IT subject to a fixed cost of adoption $hf_{ITJ}$. There are also efficiency losses from production abroad equal to $\kappa < 1$. Then, firm's revenues are

$$r_{US}(\varphi) = r_{US}(\varphi) + \mathbb{I}_{MNE} r'_{US}(\varphi) \times \exp(\kappa' \mathbb{I}_{NIT})$$

where $r_{US}(\varphi)$ are revenues of US firms in the domestic market, $r'_{US}(\varphi)$ are revenues from multinational activities in the rest of the world for US firms,$\mathbb{I}_{NIT} = 1 - \mathbb{I}_{IT}$ and $\mathbb{I}_{ROW}, \mathbb{I}_{IT}$ are indicators that equal to one if a firm is a multinational/IT adopter and $\kappa' = \kappa(1 - \sigma)$. Similarly, in the foreign market:

$$r_{ROW}(\varphi) = r_{ROW}(\varphi) + \mathbb{I}_{MNE} r'_{ROW}(\varphi) \times \exp(\kappa' \mathbb{I}_{IT}).$$

Firms sell to a representative household with CES demand with elasticity $\sigma$. In equilibrium, revenues will be given by

$$r_{US}(\varphi) = \left(\frac{\sigma - 1}{\sigma} \varphi P_{US}\right)^{\sigma - 1} R_{US}$$

and

$$r'_{US}(\varphi) = \left(\frac{\sigma - 1}{\sigma} \varphi P_{US}\right)^{\sigma - 1} R_{US} \times \exp(\kappa' \mathbb{I}_{NIT})$$

where $R_{US}$ are aggregate revenues and $P_{US}$ the industry price index in the United States. Thus, IT adopting firms have larger sales, which would lead to a larger market share for foreign multinationals.

I describe the implications of the model for the effect of IT on the US domestic market concentration defined by

$$C_{\bar{\varphi}} = \frac{\int_{\bar{\varphi}}^{\infty} r(\varphi)\mu(\varphi)d\varphi}{R}$$

where $\mu(\varphi)$ is the mass of firms with productivity $\varphi$ and $\int_{\bar{\varphi}}^{\infty} \mu(\varphi)d\varphi = X$. Here, $X$ is some exogenously chosen constant. This measure is a model analogue to the market share of the top $X$ firms. Consider a reduction in the fixed cost $h$ As shown, a smaller $h$ causes sales figures of multinational firms to rise, leading to an increase in the market share of multinational firms in the United States . Revenues in the domestic market, $r_{US}(\varphi)$, due to increased competition even for firms above multinational cutoffs fall.The more productive US multinationals also adopt IT and increase their revenues only in the rest of the world, while smaller domestic firms are displaced. Since all domestic firms lose due to the increase in the number of varieties produced more efficiently, domestic firms' share of the overall market falls.

The model thus predicts that all domestic firms, including the top $X$ firms will have lower market shares accounting for the market shares from foreign operations in the United States. For the effect on top shares of firms in the United States independently of their headquarters' country, there are two alternatives regarding the reallocation of market shares from domestic to foreign firms: 1. market share is reallocated from domestic small to large foreign firms and market concentration rises or 2. market share is reallocated from domestic large to smaller foreign multinationals and market concentration declines. The data seem to provide empirical support for the second case.

## 2.9 Measurement and Data Construction

This Appendix contains additional information on the sample and data construction. In this section, I describe in detail the construction of the final dataset, starting from the firm- level dataset of stock returns, balance sheet data and multinational firms' employment and sales. Then, I describe the measurement of IT intensity at the occupation level and the aggregation of the index at the industry level. I conclude providing summary statistics for all of those data.

### 2.9.1 Firm level Data

I use balance shhet data from Compustat and Compustat Global. Firm-level accounting variables are winsorized at the 1% level in every sample year to reduce the influence of possible outliers. Moreover, I rely on historical segment data of firms reporting foreign income from COMPUSTAT to classify firms multinational activities as in Fillat and Garetto (2015) as described below. I define and construct the following variables for every firm:

- *Cost of goods sold* involves all direct costs involved with producing a good. This includes the cost of materials and other intermediate inputs, as well as the labor directly used to produce a good. It is observed on the income statement. The Compustat variable is COGS.

- *Selling, general and administrative expenses* are all direct and indirect selling, general and administrative expenses. They include overhead costs and costs such as advertisement or packaging and distribution. It is observed on the income statement. The Compustat variable is XSGA.

- *Operating expenses* are the sum of cost of goods sold and selling, general, and administrative expenses. The Compustat variable is XOPR.
- *Operating Margin* is the ratio of operating profit = revenues - operating expenses over revenues.
- *Total Sales* is total sales of firms as reported in Compustat (SALE).
- *Assets* is the logarithm of a firm's total book assets (AT).
- *PP&E* is net property, plant and investment (PPENT) scaled by total book assets (AT).
- *Market Leverage* is the firm's financial leverage and defined as the proportion of total debt of the market value of the firm. The market value of the firm is the market value of common equity defined as in Fama and French. Total debt is the book value of short-term (DLC) and long-term interest bearing debt (DLTT).
- *Administrative Capital* is a firm's organizational capital and defined as in Peters and Taylor (2017).
- *Revenue* is total sales. The Compustat Fundamentals variable is SALE.

### 2.9.2 Compustat Segments data

Since 1997 (Statement No. 131), The Financial Accounting Standards Board (FASB) has increased the accounting obligations of public firms regarding the way in which they report information about different operations (across sectors and geographies: segments) in their statements. Any âcomponents of an enterprise about which separate financial information is available that is evaluated regularly by the chief operating decision maker in deciding how to allocate resources and in assessing performanceâ are defined as different segments and per the (FAS) No. 131 firms have to provide information about the sales (and often other operating variables) derived among other from different regions in which the firms have operations. Despite the fact that firms are obliged to inform the public regarding their operational segments, the accounting obligations do not specify a standardized way with which the provision of information from firms should be done. As a result the information in the segments data is disclosed in the way the firm decides. This means that in contrast to official data, that contain information of foreign operation of firms across countries in a consistent way for all firms, the information in Compustat disclosed by firms may differ as firms provide data for different segments that are not the same when one looks across firms. These data are disaggregated in several different ways: either by product, geography, legal entity, or by customer, lastly and importantly for the purposes of this paper, similarly to disclosure of foreign operation in the Census data, FAS defines a minimum threshold that makes disclosure of information mandatory. In particular, the revenues generated in each of the reported segments should at least be equal to 10% of the total revenue of the firm, or when not satisfied the same standard is implemented for operating profits and firms' total assets. A potential problem with this is that in case of multinational supply chains a firm could provide information about a specific customer operating across different markets instead of providing information about the different geographic segments that the firms is associated with. This problem would lead to some measurement error in the classification of firms as multinational and the definition of sales provided in Compustat as sales in the United versus the Rest of the World defined now.

Compustat provides information regarding the geographic segments at which each public firm operates and is obliged to disclose information. A problem occurs if one is interested in the distribution of sales of firms in a specific geographic country, for example the United States, because information provided by firms is may or may not be disaggregated by individual foreign countries and thus in Compustat Segments are not always classified based on individual countries but often are summarised across regions. Compustat identifies for each firm if a geographic segment is associated with the domestic or the foreign market based on the country of incorporation of a firm. Thus, for US public firms information on their domestic sales in the United States is readily available. In contrast, for non US firms sales in the United States are not disclosed in a consistent way. For that purpose, I follow a certain procedure to create a consistent classification of geographic segments as segments associated with the U.S. market only or if segments are associated with non US countries. I detail the data construction below:

In particular, first as described in Fillat and Garetto (2015a), there are two options on data selection: 1) include those firms that are included in the Compustat Segments data and drop all other which would lead to very large errors in the measurement of concentration in the United States but less measurement error on the classification of firms as Multinationals, or 2) include all firms in Compustat and Compustat Global and impute as domestic sales, the sale figure in their balance sheet data when no data are available in Compustat Segments. The data used in this paper correspond to the second case. I use the same procedure as in Fillat and Garetto (2015a) to prepare a cleaned version of the data and in addition I create a consistent classification of the geographic segments in Compustat as associated with sales to US consumers (or US firms) or sales associated with non US consumers, based on a segments name. This process is described below.

Since there are three types of geographic segments: (1) total, (2) domestic, and (3) non-domestic. A firm is classified as non multinational in a given year if there is a missing or zero value for foreign sales (segments with Segment Geographic Type of 3 ) for a given year. This means that a firm is classified as multinational in a specific year when the operating segments have a maximum value of a Geographic Segment Type equal to 3 for a given year and the foreign sales associated with these segments are non-missing or non- zero. In addition, due to the classification of segments as domestic (Type 2) vs foreign (Type 3) I can classify the names of domestic segments based on the country of operation of each firm in Compustat and as a results all sales of US firms in Compustat associated with domestic segments are classified as US sales. This implementation of segment data relies entirely on the classification type but since for US public firms, nondomestic segments may classify the market of operation as associated with the United States, I assume that the Compustat classification is erroneous and re-classify the segment as domestic for US firms. Then for foreign firms, I classify segments as associated with the US, if the name of the segments identifies the US (or Canada) as the only or the main operation segment. If a segment is associated with the US but also third countries I classify this segment as âotherâ. For the results of this paper, I consider then sales in the United States to be only those reported entirely about the United States and I do not impute the share of sales that correspond to the US market from operations classified as âotherâ. Lastly, all other or foreign operations that can be clearly identified and are not related to the US are classified as non US operations. The data then are aggregated by firm-year (sector is unique for each firm in almost all disclosed data in Compustat).

### 2.9.3 Data on Foreign Multinational Firms in the United States

I combine several sources to create consistent measures of the number of foreign multinational companies, their market share and employment across industries in the United States. In particular, I combine the following data sources: 1. the BEA International Surveys on Foreign Direct Investment in the United States(FDIUS), 2. NBER-CES Manufacturing Industry Database, and 3. Census Service Annual Survey (SAS). The details are given in Chapter 1.

### 2.9.4 Measuring IT intensity

At first I describe the task based measure of IT intensity at the occupation level.

#### 2.9.4.1 Occupation-level IT intensity

To understand the IT intensity of tasks at the occupation level (aggregated at the five-digit level that will be matched then with the CPS data), indices from the O*NET skill, task and knowledge measures are used, that incorporate information on the knowledge, activities related to information technology and computers. The list below summarizes the description of the tasks, skills and knowledge, that lead to an occupation to be considered more or less IT intensive. The details of the construction are included in Chapter 1.

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