PhD THESIS DECLARATION

I, the undersigned

FAMILY NAME	QUINTANA GONZÁLEZ
NAME	JAVIER
Student ID no.	1824234

Thesis title:

Essays in International Economics, Regional Divergence, and Productivity.

PhD in	Economics and Finance
Cycle	30th
Student's Advisor	Tom Schmitz
Calendar year of thesis defence	2020

DECLARE

under my responsibility:

1) that, according to Italian Republic Presidential Decree no. 445, 28th December 2000, mendacious declarations, falsifying records and the use of false records are punishable under the Italian penal code and related special laws. Should any of the above prove true, all benefits included in this declaration and those of the temporary "embargo" are automatically forfeited from the beginning;

2) that the University has the obligation, according to art. 6, par. 11, Ministerial Decree no. 224, 30th April 1999, to keep a copy of the thesis on deposit at the "Bilioteche Nazionali Centrali" (Italian National Libraries) in Rome and Florence, where consultation will be permitted, unless there is a temporary "embargo" protecting the rights of external bodies and the industrial/commercial exploitation of the thesis;

3) that the Bocconi Library will file the thesis in its "Archivio Istituzionale ad Accesso Aperto" (Institutional Registry) which permits online consultation of the complete text (except in cases of temporary "embargo");

4) that, in order to file the thesis at the Bocconi Library, the University requires that the thesis be submitted online by the student in unalterable format to Società NORMADEC (acting on behalf of the University), and that NORMADEC will indicate in each footnote the following information:

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

- PhD thesis Essays in International Economics, Regional Divergence, and Productivity;
- by Quintana González, Javier ;
- defended at Università Commerciale "Luigi Bocconi" – Milano in the year 2020;
- the thesis is protected by the regulations governing copyright (Italian law no. 633, 22nd April 1941 and subsequent modifications). The exception is the right of Università Commerciale "Luigi Bocconi" to reproduce the same, quoting the source, for research and teaching purposes;

- **only when a separate "Embargo" Request has been undersigned**: the thesis is subject to "embargo" for (indicate duration of the "embargo") ..... months;

5) that the copy of the thesis submitted online to Normadec is identical to the copies handed in/sent to the members of the Thesis Board and to any other paper or digital copy deposited at the University offices, and, as a consequence, the University is absolved from any responsibility regarding errors, inaccuracy or omissions in the contents of the thesis;

6) that the contents and organization of the thesis is an original work carried out by the undersigned and does not in any way compromise the rights of third parties (Italian law, no. 633, 22nd April 1941 and subsequent integrations and modifications), including those regarding security of personal details; therefore the University is in any case absolved from any responsibility whatsoever, civil, administrative or penal, and shall be exempt from any requests or claims from third parties;

7) **choose 7a or 7b**:

7a) that the thesis is not subject to "embargo", i.e. that it is not the result of work included in the regulations governing industrial property; it was not written as part of a project financed by public or private bodies with restrictions on the diffusion of the results; is not subject to patent or protection registrations.

Or

7b) that the PhD thesis is subject to "embargo" as per the separate undersigned "PhD Thesis Temporary ″Embargo″ Request".



Date 10/12/2020

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Abstract

This thesis is composed of three Chapters. The first two address topics on international trade and regional divergence. The third one addresses the measure of productivity series.

Chapter 1 analyzes the contribution of import competition to the divergence among US metropolitan areas over recent decades. I document that the sharp rise of imports of Chinese manufacturing goods had a significant effect on the spatial skill polarization and the divergence of wages and skill premium among American cities. The effects of the China shock on the spatial skill polarization and returns to skills were systematically different depending on the skill intensity of local services. Among highly educated cities, a higher exposure to import competition increases the college-educated workforce and the wages for skilled workers. I show that the contribution of the trade shock operates through the reallocation of workers across sectors and cities. High human capital regions exposed to the China shock undergo a faster transition from manufacturing to skill-intensive service industries.

Chapter 2 provides a theoretical model of skill-biased sector change consistent with the findings in Chapter 1. Resources previously employed in manufacturing, such as labor or office space, turn idle after the negative trade shock hits the sector and they are reallocated to other industries in which returns stay higher.

Chapter 3 is co-authored with Diego Comín (Darmouth University), Tom Schmitz (Bocconi University), and Antonella Trigari (Bocconi University). This chapter proposes a new way to estimate series of Total Factor Productivity (TFP). Our measure of TFP growth takes into account changes in factor utilization. We show that the use of changes in hours per worker as a proxy for unobserved changes in factor utilization is problematic for a range of European countries. We propose using an alternative proxy, based on surveys of firm capacity utilization. We show that this yields new insights on TFP growth in the Great Recession, especially in Southern Europe.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Contents

1 Import Competition, Regional Divergence, and the Rise of the Skilled City **1**

1.1 Introduction 1

1.2 Data and Sample 10

1.2.1 Commuting Zone Level Analysis 10

1.2.2 Industry-Commuting Zone Level Analysis 11

1.3 Import competition and Regional Divergence 12

1.3.1 Econometric Specification 13

1.4 Stylized Facts on Skill Sorting and Skill Premium 19

1.4.1 Contribution of Import Penetration to Regional Divergence 22

1.4.2 Import Competition and Demographic Changes 24

1.4.3 Import Competition and College Wage Premium 29

1.5 Labor Reallocation across Sectors 32

1.5.1 Labor Market Exposure to the China shock 33

1.5.2 Labor Reallocation and Sectoral Transfromation 35

1.6 Conclusions 38

Appendix 40

1.A Data and Sample Appendix 42

1.B Model of Labor Reallocation 46

1.B.1 Labor Market-mediated exposure to the China shock 53

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

1.B.2 Skill Intensity and Labor Reallocation 54

2 Import Competition, Regional Divergence: : A model of skill-biased sector change 57

2.1 Introduction 57

2.2 Related Literature 59

2.3 Theoretical Model 61

2.4 Impact of Trade 65

2.4.1 Trade shock without geographical mobility 66

2.4.2 Trade shock with geographical mobility 67

Appendix 70

2.A Derivation of equilibrium office space allocation 70

2.B Derivation of equilibrium unskilled labor 70

2.C Derivation of skilled wages 71

3 A New Measure of Utilization-Adjusted Total Factor Productivity Growth 73

3.1 Introduction 73

3.2 Growth accounting with fluctuations in factor utilization 78

3.2.1 Assumptions 78

3.2.2 Fundamental growth accounting results 82

3.2.3 Unobserved short-run fluctuations 84

3.3 Hours per worker and factor utilization 86

3.3.1 Fluctuations in hours per worker over the business cycle 86

3.3.2 Comparing hours per worker and capacity utilization surveys 87

3.3.3 Worker heterogeneity and biases in the BFK methodology 90

3.3.4 An alternative utilization proxy 93

3.4 Data and results 96

3.4.1 Growth accounting data 96

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

3.4.2 Data for instrumental variables and capacity utilization surveys . . 98
3.4.3 Estimation results 101
3.4.4 Properties of the adjusted TFP series 104
3.5 Conclusions 108
Appendix 112
3.A Data Appendix 112
3.A.1 Growth accounting data 112
3.A.2 Survey data on Capacity Utilization 116
3.A.3 Instruments 120
3.B Robustness checks 123
3.B.1 Non-manufacturing sectors capacity utilization level 123
3.B.2 No backcasted values for missing observations 124
3.B.3 Not detrended survey data on capacity utilization 124
3.B.4 Different sector composition 125

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Chapter 1

Import Competition, Regional Divergence, and the Rise of the Skilled City

1.1 Introduction

Over recent decades, cities in the United States have grown apart from each other. While some metropolitan areas thrived, others have experienced a secular decline. In particular, cities with a higher density of college-educated workers have displayed a superior performance over a whole range of urban and economic growth measures. Two of the most salient features of the Great Divergence are the spatial skill polarization and the divergence of the college wage premium across local labor markets (Moretti (2012)). Most educated cities have increased their skill advantage over the last decades. Bachelor's degree holders are more likely to move to cities with a high density of college-educated population today than they used to be. At the same time, real wages for workers with a college degree have stopped converging across local labor markets, as opposed to real wages for workers without college education. College-educated workers in skill-abundant cities have expe-

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

rienced a more rapid wage growth than their peers in less educated areas. The sorting of educated and high-earning workers into few cities have deepened inequalities within and between locations. The relevance of this spatial inequalities goes beyond economic or labor outcomes: a large literature has drawn attention to how spatial polarization has first-order social, political, and cultural implications.

Contemporaneously, the United States experienced an unprecedented increase in imports of manufacturing goods following China's access to the world market economy. An extensive literature documents that the increase of Chinese imports had a significantly negative impact on manufacturing employment (Autor et al. (2013) (hereafter ADH), Pierce and Schott (2016)). Geographically, the drop in manufacturing employment was more severe in labor markets specialized in industries most exposed to Chinese competition. The consequences of the China shock were not limited to manufacturing-related outcomes. A vast literature documents that local labor markets with a larger employment share in exposed industries had different outcomes in a wide range of topics.[1] However, according to this analysis, the China shock did not have any significant effect on the spatial skill polarization or the divergence of skill premium. Areas with a larger share of employment in industries competing with Chinese manufacturers did not experience on average different changes in terms of population or returns to skills than areas with lower exposure to import competition. I document that this finding masks systematic differences in the effects of the China shock according to the skill intensity in the local non-manufacturing sector.

In this paper, I show that the rise of import competition played a relevant role on the divergence among US metropolitan areas over the period between 1990 and 2007. Conditional to a similar level of exposure to the China shock, the effects on the size of local

[1] An incredibly rich literature reports the consequences of the China shock on a wide variety of outcomes. On innovation (Dorn et al. (2016), Bloom et al. (2016)), political outcomes (Autor et al. (2016), Colantone and Stanig (2018)), provision of public goods (Feler and Senses (2017)), health (Colantone et al. (2015),Adda and Fawaz (2019)), pollution (Rohlf (2018)) or marriage market (Dorn et al. (2017)). My contribution, instead, focuses on standard dependent variables -wages and workforce size- but heterogeneous effects of the China shock

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

college-educated population and college wage premium differ according to the skill intensity of local service industries. Among cities with high human capital, a higher exposure to the China shock fosters an inflow of college-educated workers to the region and an increase of real wages for skilled workers. On the other hand, when import competition affects skill-scarce locations, the consequences are a drop in college-educated workforce and real wages for skilled workers.

I show that the reallocation of labor from exposed manufacturing industries to the service sector explains these systematic differences. Competition in local labor markets is a key propagation channel of the trade shock from directly exposed industries to the rest of the economy. Service sectors benefit from local manufacturing industries being exposed to the China shock as long as the latters contract their labor demand. When the local non-manufacturing sector is populated by skill-intensive industries, these grow by having access to a larger pool of local resources, they benefit from agglomeration externalities, and they shift up the demand for skilled workers in the region. Thus, when the China shock meets a high skill-intensity region, the final outcome is a stronger reallocation of labor from manufacturing to skill-intensive services and a positive shift in the demand of skilled workers.

Namely, metropolitan areas such as San Jose, Raleigh or Austin (with large and highly exposed manufacturing sectors, and a large share of college-educated workforce by 1990) will perform better than cities in the Rust Belt such as Reading, Harrisburg or Dayton (with similarly large and exposed manufacturing sectors but with a low density of college-educated workers). In the former regions, the China shock reallocates resources from manufacturing industries to skill-intensive and fast-growing service industries. I show that due to the China shock, these skilled-and-exposed metropolitan areas will also display a superior performance than areas like Washington or New York (with a similar density of college-educated workers but negligible exposure to manufacturing import competition). On the other hand, those regions in the Rust Belt perform worse than other

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

areas with a similarly low share of college-educated population but lower exposure to import competition such as Las Vegas or Jacksonville. In these cases, the low skill-intensive local service sectors will not compensate the loses in the manufacturing industries.[2]

Empirically, I develop my analysis in two steps. First, following the spirit of ADH I analyze the impact of the change in import penetration on skill sorting and skill premium in urban commuting zones between 1990 and 2007.[3] The main dependent variables are decade changes in working-age population and changes in real wages by educational level. I extend ADH baseline regressions including the interaction between the China shock and the initial share of college-educated workforce in the non-manufacturing sector. This will be my variable of interest, capturing the heterogeneity of effects of the trade shock according to the skill intensity of local services. The main threat to the identification of the heterogeneous effects will be the potential correlation of skill intensity in local services with other local characteristics. By construction, the interaction of those covariates and the change in import penetration will also correlate with my variable of interest. I address the issue by including a large set of controls interacting the China shock with local manufacturing characteristics, demographic variables, and the export potential of the local labor markets. These controls account for confounding sources of heterogeneity as well as unobserved differences in exposure to trade competition.

The contribution of the China shock to regional divergence is significant and economically sizable. I find that the heterogeneous effects of import competition explains above than one third and one fourth of the variation of the spatial skill polarization and the divergence of skill premium, respectively. Comparing cities with the median level of exposure to import competition, a commuting zone at the 75th percentile of skill-intensity will have a 13.1% faster growth of college-educated workforce and a 4.5% faster growth of real

[2]Figure 1..4 shows the ranking of change in import penetration between 2000-2007, horizontal axis, and the ranking in share of workforce with college education in 1990, vertical axis.

[3]Throughout the paper I use interchangeably the terms city, metropolitan area, and local labor market as equivalent terms for urban commuting zones. Section 1.2 provides the definition of this geographical unit (Tolbert and Sizer (1996))

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

wages of college-educated workers per decade than one at the 25th percentile of skill-intensity. Moreover, comparing cities at the 75th percentile of skill-intensity, a city at the 75th percentile of exposure to the China shock will have a 12.6% faster growth of college-educated workforce and a 3.3% faster growth of real wages of college-educated workers per decade than one at the 25th percentile of exposure to import competition. Conversely, among cities at the 25th percentile of skill intensity, a city at the 75th percentile of exposure to the China shock will have a 5.6% relative drop of college-educated workforce and a 2.9% relative drop of real wages of college-educated workers per decade than one at the 25th percentile of exposure to import competition.

Second, I carry out the analysis of labor reallocation as the mechanism for trade-induced regional divergence. I propose a simple model of labor reallocation to rationalize the findings in the first part of the analysis. In the model, workers are imperfectly mobile across sectors and across locations. Following the China shock, service industries have access to a larger pool of labor following the contraction in manufacturing employment. They increase their employment proportionally to the local exposure to the China shock and their occupational similarity with shrinking manufacturing industries. Skill-intensive service industries benefit from agglomeration externalities according to their skill intensity. The degree of exposure of a region to the Chinese import competition and the density of skill-intensive industries in the local service sector determine the effects of the China shock in terms of wages and workforce size.

In this framework, I introduce a novel measure of 'labor market exposure' to the China shock. This model-derived variable exploits the geographical distribution of directly exposed industries, the uneven geographical co-location of different manufacturing and non-manufacturing industries, and occupational similarities between sectors. It captures the changes in the local labor supply that an industry-commuting zone pair faces following the contraction of employment demand of directly exposed manufacturing industries.

Armed with my measure of 'labor market exposure' to the China shock I quantify the

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

cross sector labor reallocation and I analyze whether local service industries benefit from the negative shock to the rest of local industries. Empirically, I regress growth rates of industry-commuting zone employment on my measure of 'labor market' exposure to the China shock. This measure varies at the industry-commuting zone level, so it allows the inclusion of city-time and industry-time fixed effects. Thus, the analysis gets rid of potential city- or industry-specific trends, such as technological progress or aggregate demand effects. This setting compares the growth rate of employment of the same industry across locations with distinct levels of exposure to the China shock. Finally, I can test whether the reallocation of labor favors the most skill-intensive industries.

This mechanism rationalizes the contribution of import competition to the spatial skill polarization and the divergence of skill premium. Skill-intensive non manufacturing industries leverage out the flow of workers leaving the local manufacturing sector. Skilled services in highly exposed locations have access to a larger pool of resources, they benefit from agglomeration externalities, become more productive than their counterparts in other cities, and they attract skilled workers from other regions. Empirically, I find that cities with higher skill density undergo a faster transition from manufacturing to service industries. Conditional to the same level of exposure to the China shock, the contraction in manufacturing employment is larger in most educated local labor markets. In skilled-and-exposed regions, the growth of knowledge-intensive industries compensate the losses of manufacturing employment.

Related Literature

This paper relates to a number of literature strands. First, it contributes to the abundant literature about the effects on US local labor markets of the sharp rise of Chinese manufacturing exports. I document the role of the China shock in the divergence among US commuting zones in terms of spatial skill polarization and dispersion of skill premium. Autor et al. (2013) exploit initial differences in industry specialization to account

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

for exposure to Chinese import competition. Local labor markets with a larger share of employment in exposed industries experienced a sharper contraction of manufacturing employment. Nonetheless, their analysis does not find any significant effect of the China shock on population counts, density of college-educated workers, or skill premium. I show that the average zero effect masks systematic differences in the effect of import competition on the mentioned variables. First, the novel heterogeneity analysis in my paper establishes that import competition has positive effects among the most skill-abundant labor markets and that the negative impact is concentrated in skill-scarce labor markets. This implies that the non-significant effects estimated in ADH are the average of highly heterogeneous consequences of the China shock.

Similar to my paper, Bloom et al. (2019) analyze the interaction between the contraction of manufacturing employment and the expansion of service industries. Using firm-level data, they document the reorganization of labor from manufacturing to offshore-related activities. They find that this process occurs predominantly in high human capital areas and multinational firms. My paper reports consistent findings on the cross sector reorganization of labor and I document the implications in terms on population changes and wage inequalities at local level. I exploit similarities in occupational requirements to identify labor reallocation between industries. Additionally, I discuss the econometric challenges on the identification of heterogeneous effects due to the correlation of human capital density and other local characteristics.

Other recent papers provide a structural estimation of the effects of trade competition on local labor markets. Caliendo et al. (2019) estimate reallocation elasticities across sectors and locations. However, they do not consider the skill intensity of sectors or individuals, so they cannot address skill sorting or skill premium divergence. Burstein et al. (2019) analyze the contribution of technical change and trade to differences between occupations, although they do not have a geographical component in their work.

My work also contributes to the literature on inter-sectoral linkages and the transmis-

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

sion of shocks. My paper highlights the competition on local labor markets as propagation mechanism of industry-specific shocks. This channel complements other common approaches in the literature focusing on input-output relationships or general equilibrium price and demand effects. Acemoglu et al. (2016) analyzes the transmission of the China shock from directly exposed industries to upstream suppliers and downstream client industries exploiting national-wide input-output relationships. Adao et al. (2019) consider the reallocation of homogeneous labor from manufacturing to an homogeneous non-manufacturing sector following changes in aggregate demand. My analysis quantifies the propagation of the shock to industry-commuting zone pairs that differ in skills as well as intensity in shock exposure. Also, I exploit the similarity in occupational requirements to identify the transmission of the shock.

My paper also relates to the long standing literature on skill premia, and more precisely to the geographical component of wage differentials. I show that skill-abundant regions will benefit from the negative shock to the local manufacturing sector, as they will undergo a positive and skill-oriented sectoral transformation. The sectoral change shifts the relative labor demand in skill-abundant cities in favor of college-educated workers. This approach complements the usual focus on skill-biased technological change as the main driver of skill premium. Autor and Dorn (2013) find that the effect of computerization is larger in those regions where jobs are more intensive in routine tasks. Giannone (2017) quantifies the large contribution of SBTC and agglomeration economies to the end of wage convergence. Beaudry et al. (2006) examine the faster PC adoption in skill-abundant metropolitan areas and the subsequent increase in skill premium. Eckert et al. (2019) document the contribution of falling communication cost to the rise of skill services in large cities. These approaches rely on changes that have industry-specific effects, but without geographical variation within industries. My analysis complements this strand of the literature. Using my 'labor market' measure of exposure to the China shock, I can compare the growth of the same industry across different locations. This setting allows me to control for industry-

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

specific exposure to automation, technical change, or falling communication costs. I show that in the comparison of industry-commuting zone pairs, skill-intensive industries located in highly exposed regions experience a faster employment growth.

My work also relates to the literature concerning the sorting of college-educated workers. I show that skill-abundant regions with a high exposure to the China shock increase their skill advantage because of trade competition. Hornbeck and Moretti (2018) solves a similar spatial equilibrium where college-educated workers migrate following TFP changes in manufacturing. In my paper I show that migration flows arise only from the interaction of the shock on manufacturing and the characteristics of the service sector. Skilled-and-exposed regions increase simultaneously the supply and real wages of college-educated workers in non-manufacturing industries. I find that population changes are entirely driven by college-educated workforce, while the number of workers without a college degree does not respond to the exposure to the China shock. This finding is consistent with the literature reporting that propensity to migrate increases with education (Wozniak (2010), Malamud and Wozniak (2012), Notowidigdo (2019)). Similar to Monras (2018), I find that positive immigration flows to regions experiencing a positive transformation are more important than outmigration flows from declining areas.

The structure of the paper is as follows. Section 1.2 presents the data and sample of the analysis. Section 1.3 discusses the econometrical approach. Section 1.4 documents the contribution of import competition to spatial skill polarization and divergence of skill premium. Section 1.5 introduces the measure of 'labor market' exposure and quantifies the labor reallocation across sectors. Section 1.6 provides concluding remarks. More details on the data and the model are in Section 1.A and Section 1.B respectively.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

1.2 Data and Sample

This section describes the sample and data sources employed in the empirical analysis of the paper. There are two main empirical settings in the paper. In the first one, the level of analysis is the local labor market. In the second one, the units of analysis are pairs of industries and local labor markets.

The geographical unit in both parts is the commuting zone (CZ), as defined by Tolbert and Sizer (1996).These commuting zones are clusters of US counties that replicate local labor markets. I restrict my sample to the 321 urban commuting zones overlapping with Metropolitan Statistical Areas in contiguous continental US.[4]

1.2.1 Commuting Zone Level Analysis

The first econometric setting analyzes changes in outcomes of commuting zones. Following the previous literature (Autor et al. (2013), Acemoglu et al. (2016)), the sample consists of two ten-year equivalent differences in the outcomes of interest. For each commuting zone, I include two differences for the periods 1990-2000 and 2000-2007.

The primary source for data at the commuting zone level are the Census Integrated Public Use Micro Samples (Census IPUMS) for the years 1970, 1980, 1990 and 2000, and the American Community Survey (ACS) for the period 2006-2008 (Ruggles et al. (2016)). From this sources, I get data on the level of education, age, gender, wages, type of worker and employer, number of weeks and hours of work, industry and occupation, place of work and birth, and rental prices. Using this data, I construct the main dependent variables of the analysis, the skill intensity of local industries, and additional controls.[5] I compute changes in the workforce size by educational level and changes in real wages[6] and college

[4]Excluding Alaska, Hawaii, and Puerto Rico

[5]These demographic controls include population, female labor participation, share of foreign-born, and share of young population. The manufacturing sector controls include average wage, share of college-educated workers in the sector and the share of employment in management occupations

[6]Section 1.A details the construction of commuting zone-specific changes in real wages.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

wage premium. I restrict the sample to individuals between 25 and 60 y.o., and I compute wages excluding self-employed workers, public employees, individuals with missing wages or weeks, or who worked less than 26 weeks in the previous year. I supplement the data with additional controls at the commuting zone from Autor et al. (2013) as control variables.[7]

Finally, I use the measure of import penetration from Acemoglu et al. (2016). Section 1.3.1 discusses in detail the construction of the variable, the instrumental counterpart, and potential mismeasurement issues.

1.2.2 Industry-Commuting Zone Level Analysis

The second setting examines changes in the employment of pairs of industries and commuting zones. The sample consists, as well, in two stacked quasi-decade changes in log employment for the periods 1990-2000 and 2000-2007. Data on employment in industry-commuting zone pairs comes from the 1990, 2000 and 2007 samples of the County Business Patterns (CBP) from the US Census.[8][9] The degree of industrial aggregation is the 4-digit SIC level.

The main dependent variable in this setting is my novel measure of 'labor market exposure' to the China shock that I introduce in Section 1.5.1. The construction of this data requires data on the intensity with which each industry employs an occupation. I use the Occupational Employment Statistics (OES) from the Bureau of Labor Statistics. This dataset provides the level of employment of 711 occupations (7-digit Standard Occupational Classification) for 368 SIC industries (135 manufacturing and 233 non-manufacturing industries).

I group the SOC occupational titles in the data into 60 occupational clusters. I cluster

[7] This variables includes characteristics of local labor markets as offshorability and routine intensity of occupations.

[8] `https://www.census.gov/programs-surveys/cbp.html`

[9] In many cases, information at the most disaggregated level is not fully disclosed and it is only reported on brackets. I use the algorithm in Autor et al. (2013) to impute employment by county and 4-digit SIC.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

occupations using the data from the Careers Changers Matrix from O*Net database[10] (Farr and Shatkin (2004)). This dataset exploits similarities in the required experience and skills for a given job. It provides the list of occupations to which *workers from one occupation may transfer with minimal additional preparation.*

1.3 Import competition and Regional Divergence

In this section, I document several facts about the causal relationship between the rise of import competition and regional divergence. First, I analyze the contribution of the China shock to changes in college intensity among regions. I find that skill-intensive regions facing a higher import competition increase the density of college-educated workers. This change comes from immigration flows of college-educated workers; while I do not find significant evidence of crowding out of workers without a college degree. On the other hand, skill-scarce regions decrease their skill-density through a relative drop in the number of college-educated workers when they are exposed to import competition.

Second, the contribution of import competition to the divergence of skill premia follows a similar pattern. Among regions with a skill-intensive non-manufacturing sector, a higher level of import penetration increases the relative returns to skills. On the other hand, import competition reduces de wage gap between college and non-college workers in less educated areas. In this section, I show that this contribution operates through the change of real wages of college-educated workers in non-manufacturing industries. The effect of the China shock is not significant in terms of real wages in the manufacturing sector or for service workers without college education.

[10] `https://www.onetcenter.org/dictionary/20.3/excel/career_changers_matrix.html`

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

1.3.1 Econometric Specification

The following section discusses the identification strategy that I follow to analyze the causal effect of the rise of Chinese manufacturing imports on changes in college-education ratios and skill returns in US local labor markets. The econometric specification follows closely the spirit of ADH regressing changes in commuting zones' outcomes on the exposure to the China shock based on initial industrial specialization. The sample of the analysis are two stacked ten-year equivalent differences between 1990-2000 and 2000-2007. The geographical units are 321 urban commuting zones that include all the local labor markets overlapping with metropolitan areas.

My analysis extends the one in ADH by allowing the China shock to have systematically heterogeneous effects. In particular, the variable of interest in my analysis is the interaction between the level of exposure to the China shock and the skill intensity of local services at the time of the arrival of the shock.

Equation (1.1) displays the baseline specification for the regressions at the commuting zone level in the paper. It identifies the effect of the change in import penetration conditional on a given level of skill intensity of local services. $\Delta Y_{c,t}$ are ten year-equivalent changes in the outcomes of interest. $\Delta \text{IP}_{c,t}$ is the change in import penetration faced by a commuting zone in the period between t and $t+1$, following the definition in Acemoglu et al. (2016) that I describe in the next section. $\text{Skill}_{c,t-1}$ is the share of workers with a college degree in the non-manufacturing sector of the commuting zone at the beginning of the period. Finally, $\Gamma_{c,t-1}$ are additional characteristics of the commuting zone at the beginning of the period included as controls.

$$\Delta Y_{c,t} = \beta_{\text{I}} \cdot \Delta \text{IP}_{c,t} + \beta_{\text{IS}} \cdot \Delta \text{IP}_{c,t} \cdot \text{Skill}_{c,t-1} + \beta_{\Gamma} \cdot \Gamma_{c,t-1} + \beta_{\text{I}\Gamma} \cdot \Delta \text{IP}_{c,t} \cdot \Gamma_{c,t-1} + \epsilon_{c,t} \quad (1.1)$$

In this setting, the effect of the China shock is the combination of an intercept, β_{I}, and a

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

slope, β_{IS}, that moves along the values of skill intensity in local non-manufacturing sectors. A significant estimate $\widehat{\beta}_{\text{IS}}$ would imply that the effects of rising import penetration are statistically different for commuting zones with diverse levels of services' skill intensity. In other words, even conditional on a similar level of exposure to import competition, the predicted effects of trade competition would be different according to regions' density of skilled workers.

There are several threats to the validity of this approach. First, the potential endogeneity of trade flows and skill intensity. Second, unobserved differences in effective exposure to import competition. Finally, the existence of confounding sources of heterogeneous effects of the China shock.

Endogeneity and Instrumental Strategy

Import exposure

I define import penetration following Acemoglu et al. (2016) (hereafter AADHP). It consists of a shift-share procedure, apportioning the growth in Chinese imports in every manufacturing industry j according to the share of employment in the industry in the commuting zone, c, at the beginning of the period.

$$\Delta \text{IP}_{c,t} = \sum_{j} \frac{L_{c,j,t-1}}{L_{c,t-1}} \cdot \frac{\Delta M^{UC}_{j,t}}{Y_{j,91} + M_{j,91} - E_{j,91}} \tag{1.2}$$

where $\Delta M^{UC}_{j,t}$ denotes the change in US imports from China in sector j between $t-1$ and t. This value is normalized by the domestic absorption at the beginning of the period. $L_{c,j,t-1}$ represents the start-of-the-period employment in sector j in local market, and $L_{c,t-1}$ represents the total local employment. Thus, geographical variation in $\Delta \text{IP}_{c,t}$ comes entirely from differences in local industry structure at the beginning of the period. The measure of commuting zone import exposure is likely to suffer from an endogeneity problem. To isolate the supply-driven component (e.g. productivity growth of Chinese

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

producers and fall of tariffs and trading costs) from US local demand or productivity shocks, the instrumental variable applies the Bartik formula to the contemporaneous changes in import from China to eight other developed economies normalized by local domestic absorption.

$$\Delta \text{IP}_{c,t}^{IV} = \sum_{j} \frac{L_{c,j,88}}{L_{c,88}} \cdot \frac{\Delta M_{j,t}^{OC}}{Y_{j,88} + M_{j,88} - E_{j,88}} \tag{1.3}$$

Identification relies on the assumption that high-income countries face similar supply-driven Chinese import competition, while demand shocks are uncorrelated between these eight countries and the United States.

Skill intensity

Following Acemoglu and Autor (2011) I use educational attainment as a proxy for skills. Skill intensity in local services is proxied by the share of workforce in the sector -between age 25-60 yo.-[11] with at least a bachelor's degree.

College density could be endogenous to the expectation in relative wage changes, industrial composition, or other unobserved trends. To address that issue, I instrument skill intensity with the share of non-manufacturing workforce with a college degree in 1970, introducing a two-decade lag.[12]

Manufacturing industries heterogeneity

The definition of import exposure in AADHP implicitly assumes homogeneity within each manufacturing industry. In other words, every worker within an industry contributes to the same extent to the degree of import exposure of their area, regardless of the nature

[11] The age restriction to workers older than 25 y.o. alleviates measurement concerns regarding individuals combining studies and part-time jobs.

[12] Including a two-decade lag also helps to mitigate the potential bias introduced by the contemporaneous process of skilled-bias technological change that started in the 1980s by using a predetermined instrumental variable. This strategy exploits the long-term persistence of the level of college education, and it relates to the approach of Valero and Van Reenen (2016), that analyzes the long-term implication of the number of established colleges an area.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

of the tasks they carry out in their jobs. The weighting factor for the imputation of the growth of imports in industry j to each commuting zone c is the share of employment that industry j has in the commuting zone, independently of the type of workers or occupations that the industry employs in the location.

This assumption is not innocuous if the variation within industries is correlated with other local characteristics such as the skill intensity in the local sector. As an example, let's take a manufacturing company that locates its headquarters in a given commuting zone and its production plant in a different one. Given the nature of their jobs, production workers in the latter location will be more severely affected by the rise of import competition as their jobs will likely be suppressed. On the other hand, executive and managing employees in the former site could potentially benefit from offshoring part of the production process (Grossman and Rossi-Hansberg (2008)). Still, according to the measure of import competition in AADHP, both commuting zones should experience the same changes following the China shock as long as they employ a similar number of workers in the industry.

If the composition of local manufacturing industries is correlated with local services' skill intensity, the estimated effect for the interactive term $\Delta \text{IP}_{c,t} \cdot \text{Skill}_{c,t-1}$ would be biased. If manufacturing industries in skill-intensive regions are particularly protected from trade due to their composition, the estimator would be biasing down the effect of the interaction. I deal with the issue including a set of interactive controls of characteristics of local manufacturing industries. These controls are the interaction of $\Delta \text{IP}_{c,t}$ with characteristics of the local manufacturing sector in a commuting zone at the beginning of the sample, $\Gamma_{c,t-1}$. These characteristics of local manufacturing are the share of college-educated workers, the share of management, routine-intensive or offshorable occupations in the sector, and average wage as a proxy of productivity. The inclusion of these controls, both in levels as well as interacted with $\Delta \text{IP}_{c,t}$, controls for local characteristics as well as unobserved differences in exposure to import penetration.

As long as the interactive controls include the endogenous trade component ($\Delta \text{IP}_{c,t}$),

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

I instrument these terms with the interaction of the instrumental variable for import penetration ($\Delta IP^{Ot}_{c,t+1}$) and the value of the covariate at the beginning of the sample ($\Gamma_{c,t-1}$).

Bartik Instrument and Pre-trends of Dependent Variables

A growing literature (Borusyak et al. (2018), Goldsmith-Pinkham et al. (2018), Adao et al. (2019)) has raised concerns on the identification of Bartik-style instruments. These concerns are related with the potential endogeneity of local industrial composition. Even if the factors driving the change in imports of each industry are exogenous to US local conditions (China's internal reforms and tariff reductions), the initial industrial structure and the share of employment in exposed industries might be correlated with the outcome variables. Larger shares of employment in certain industrial sectors might be the consequence of endogenous unobserved characteristics. In that case, the allocation of the exogenous trade shock according to these potentially endogenous Bartik weights would bias the results.

To address that issue, I implement two of the proposed solutions in the aforementioned papers. First, I include the pre-trend of the dependent variables in the decade between 1980 and 1990.[13] Second, I include the share of employment in directly exposed industries interacted with a time trend.[14] These two elements control for existing pretends as well as unobserved characteristics of regions with high exposure to the China shock.[15]

[13]The inclusion of the pre-tend of the outcome variable addresses also other concerns like the existence of pre-dated evolution of local labor markets due to skill-biased technical change.

[14]Following Acemoglu et al. (2016), I define the directly exposed sector to encompass all manufacturing industries for which predicted import exposure rose by at least 2 percentage points between 1991 and 2011

[15]As a robustness check, I compute robust standard errors instead of standard errors clustered at state-level. Additionally, also as a robustness check, I include the interaction of a time trend with the share of employment in the five manufacturing industries with highest Rotemberg weights as defined in Goldsmith-Pinkham et al. (2018)

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Confounding Sources of Heterogeneity

Another potential threat to the identification strategy is the existence of other sources of heterogeneity correlated with skill intensity. Given that the regressor of interest in my analysis is an interaction of $\Delta \text{IP}_{c,t}$, I need to control by other potential interactions of covariates correlated with $\text{Skill}_{c,t-1}$. Take as an example the case of larger commuting zones. This areas are typically more educated that smaller commuting zones. If larger cities are better at responding to adverse shocks (Bakker (2018)), my variable interest could be capturing this heterogeneity source rather than properly the skill intensity of local services. Following the discussion in the previous section, I include as controls the interaction of $\Delta \text{IP}_{c,t}$ with a wide battery of local characteristics.

The first set of controls deals with local demographic characteristics. I include as controls the log population, the share of foreign-born population, female employment participation, and the share of young workforce.[16] These variables are highly correlated with the share of college-educated workforce. More educated cities are typically larger, younger, have a larger share of foreign-born population, and women participate more in the labor market. The inclusion of these controls, again in levels and interacted with the trade shock variable, isolates the potential agglomeration effects or a better ability of large cities to absorb negative economic shocks. Given any effect of rising import competition on local labor conditions, the elasticity of labor supply (both in the intensive and the extensive margin) might be different for diverse urban sizes, for areas with a diverse share of foreign-born, female labor participation, or with a younger population. Thus, these controls might be particularly relevant in regressions with population changes or migration flows as dependent variables.

Finally, I include the variable of exposure to exports from Feenstra et al. (2017). The access of China to the world market economy meant a massive supply shock, but it was also a positive shift in the demand for producers in the rest of the world. Those

[16] Table 1..8 shows the correlations between local services' skill intensity and the groups of covariates

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

regions that were more exposed to Chinese import competition could also benefit from a larger exposure to the growth of exports. The inclusion of this control rules out the potential effects of within-sector specialization. That would be the case if a sector losing employment in one part of the production chain because of import competition, at the same time, gained jobs in another part of the chain due to exporting. This potential specialization along the value chain could not be neutral for college or non college-educated workers.

1.4 Stylized Facts on Skill Sorting and Skill Premium

Table 1.1 shows the estimation of Equation (1.1) for changes in the share of college-educated workforce and the change in college wage premium. For each panel, column 1 replicates the baseline analysis in ADH, regressing the dependent variables on the measure of import penetration, without the inclusion of any interactive term. Columns 2-4 estimate the models with the heterogeneous effects of $\Delta \text{IP}_{i,t}$ including sequentially the sets of interactive controls discussed in the previous section.

Column 1 reflects the fact that the average contribution of the China shock to skill sorting and the divergence of skill premium is not significantly different from zero. Commuting zones with a larger share of employment in industries exposed to Chinese competition did not perform differently on average than commuting zones with little employment in those industries. This finding could mislead to state that import competition did not contribute to spatial skill polarization or the divergence of skill premium. Columns 2-4 show that this is not the case.

The non-significant average effects masks systematic differences in the effect of import competition on commuting zones with diverse non-manufacturing skill intensity. The estimation of models with heterogeneous effects of import competition delivers a clear pattern of divergence. The contribution of import competition becomes the combination

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

of a negative and significant intercept ($\hat{\beta}_{\text{I}}$) and a positive and significant slope ($\hat{\beta}_{\text{IS}}$) on the interaction of import competition and local services' skill intensity. Considering the effect of the China shock among regions with unskilled service industries, it is negative because the positive effect does not compensate the initial negative intercept. On the other hand, among regions with skill-intensive non-manufacturing sectors, the effect of import competition becomes positive.

The absolute value of the ratio $\hat{\beta}_{\text{I}}/\hat{\beta}_{\text{IS}}$ denotes the level of services' skill intensity above which the effect of the China shock becomes positive in terms of college-education density or skill premia.[17] In all the specifications in which the estimated effects of the China shock are significantly heterogeneous,[18] this value falls close to 1/3, approximately the population-weighted median of the share of college-educated workers in non-manufacturing in 1990. In other words, the half of commuting zones with more skill-intensive services industries in 1990 increased their college intensity and college wage premium due to being exposed to the China shock. The negative effects concentrate in the least educated half of the country.

Graphical Representation

The previous results have an intuitive graphical representation. Figure 1.1a and fig. 1.1b plots the predicted marginal effects on the share of college-educated workforce and college premium in the 60 largest commuting zones, computed as in eq. (1.4). The figure plots the commuting zone-specific marginal effects against the initial levels of skill intensity in the local non-manufacturing sector. The figure illustrates that the zero average contribution of the China shock to spatial skill polarization and divergence in college wage premium is the consequence of a positive effect among regions at the top of the skill-intensity

[17] All the additional controls have been demeaned. The ratio shows the level of non-manufacturing skill intensity at which the effect of $\Delta\text{IP}_{c,t}$ changes its sign for a region with average values of the rest of controls.

[18] I provide this statistic only in those cases in which the estimate $\widehat{\beta_{\text{IS}}}$ is statistically significant at the 10%.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Table 1.1: - Effect of Import Penetration on Skill Sorting and Skill Premium

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	Share College-Educated Workforce				*College Premium*			
$\Delta \text{IP}_{c,t}$	-0.01	-0.61**	-1.27***	-1.28***	0.03	-3.35***	-3.59**	-3.71**
	[0.02]	[0.25]	[0.43]	[0.44]	[0.11]	[0.99]	[1.67]	[1.66]
$\Delta \text{IP}_{c,t} \cdot \text{Skill}_{c,t-1}$		1.74**	3.82***	3.83***		10.42***	10.27**	10.78**
		[0.78]	[1.33]	[1.34]		[3.02]	[5.18]	[5.19]
Interacted Controls:								
Mfg. Sector Controls		✓	✓	✓		✓	✓	✓
Demographics			✓	✓			✓	✓
Exports				✓				✓
$\hat{\beta}_{\text{I}}/\hat{\beta}_{\text{IS}}$		35.1%	33.2%	33.4%		32.1%	35.0%	34.4%
SW F-Statistic								
$\Delta \text{IP}_{c,t}$	60.70	30.13	27.96	25.22	51.63	31.53	36.24	38.36
$\Delta \text{IP}_{c,t} \cdot \text{Skill}_{c,t-1}$		28.69	26.61	23.98		29.96	33.61	34.86

NOTE - N=632 (321 Urban Commuting Zones × 2 time periods). Two stacked ten-year equivalent differences between 1990-2000 and 2000-2007. All the models include the full set of controls in levels described in the text. Columns 2-4 include sequentially the sets of interacted controls. Regressions include time trends interacted with Census regions fixed effects, $\text{Skill}_{c,t-1}$, and the sum of employment in directly exposed industries. Regressions include the pre-trend between 1980 and 1990 of the dependent variable. Robust standard errors clustered at the state level. Models are weighted by start of the period commuting zone share of national population. * $p < .1$, ** $p < .05$, *** $p < .01$

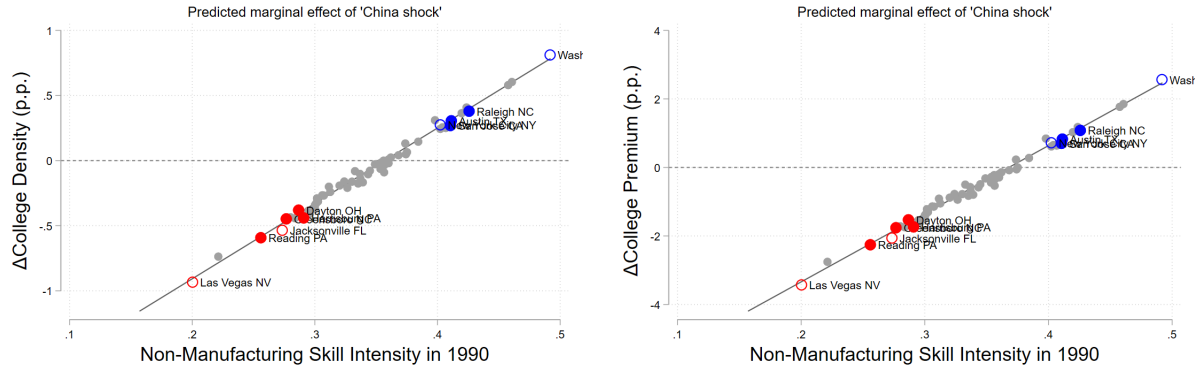
distribution and a negative one among those at the bottom of the distribution.

$$\tilde{\beta}^{c}_{\Delta \text{IP}} = \hat{\beta}_{\text{I}} + \hat{\beta}_{\text{IS}} \cdot \text{Skill}_{c,t-1} \tag{1.4}$$

On top of that, I compute the total predicted effect of the China shock as the product of the commuting zone-specific estimated marginal effects above and the level of import penetration of each commuting zone.

$$\Delta \tilde{y}_{cz} = \left[\hat{\beta}_{\text{I}} + \hat{\beta}_{\text{IS}} \cdot \text{Skill}_{c,t-1}\right] \cdot \Delta \text{IP}_{c,t} \tag{1.5}$$

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.



(a) Share of college-educated workers (b) College wage premium

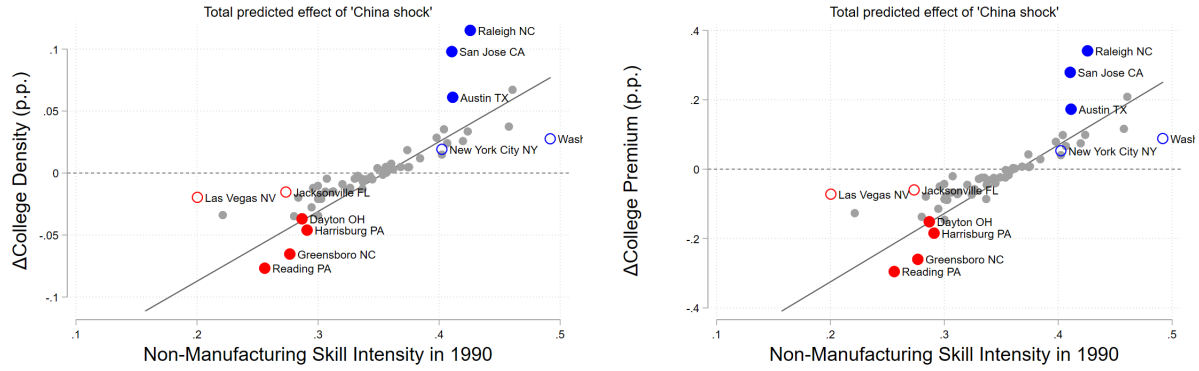
Figure 1.1: Predicted marginal effects of import competition by commuting zone

Figure 1.2a and fig. 1.2b show the estimated effects for the 60 largest commuting zones. The two pairs of figures illustrate the contribution of import competition to regional diverge. First, conditional on a similar level of exposure to import competition, the estimated marginal effects creates a wedge between the most and the least educated areas. Second, conditional on a similar level of skill intensity, differences in exposure to import competition have differential effects. Among the most educated regions, areas like Raleigh, Austin or San Jose benefit from a large exposure to foreign competition. Other similarly highly-educated area like Washington or New York experience little changes due to the low level of exposure. The opposite happens among the least educated areas. The negative marginal effect of import competition is exacerbated on areas like Reading or Greensboro due to a large increase in import penetration. On the other hand, the total predicted effect in areas like Las Vegas or Jacksonville is very close to zero due to the low exposure to China shock.

1.4.1 Contribution of Import Penetration to Regional Divergence

This section computes how much does import penetration explain of the total variation in changes of the share of college-educated workforce and the college wage premium between

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.



(a) Share of college-educated workers (b) College wage premium

Figure 1.2: Predicted total effects of import competition by commuting zone

1990 and 2007. I compare the actual change in each commuting zone of the two features of regional divergence with the predicted effects of import competition on them, as computed in Equation (1.5).

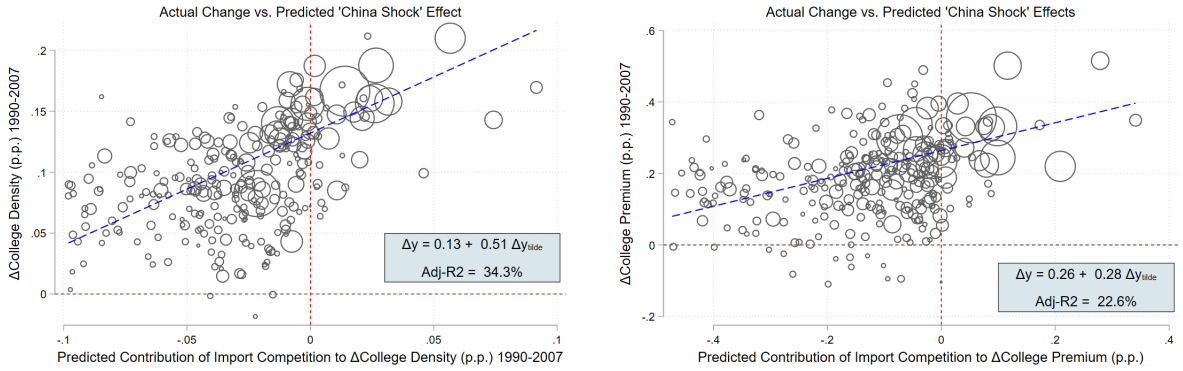
Figure 1.3a plots the observations for the change of the share of college-educated workforce and the predicted causal effect of import competition, conditional on the skill intensity of local non-manufacturing industries. The size of each observation corresponds with the start-of-the-period population. The adjusted-R^2 of the regression is 0.34. In other words, import competition, taking into account the heterogeneity of effects due to local services' skill intensity, explains around one third of the variation in the college density of local labor markets between 1990 and 2007.

Figure 1.3b shows the same graph for the case of the divergence in college wage premium. The predicted contribution of import competition, conditional on local skill intensity, accounts for slightly more than one fifth of the variation on the returns to skills among local labor markets.[19]

In the following subsections I analyze through which particular demographics does import competition affect the share of college-educated workers. Similarly, I document which are

[19]The predicted effects of import competition, without accounting for the effect heterogeneity due to skill intensity, account respectively only for the 3.33% and 1.01% of the variation of actual changes

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.



(a) Share of college-educated workers (b) College wage premium

Figure 1.3: Actual changes and predicted contribution of import competition.

the salaries that drive the trade-induced changes in college wage premium. Additionally, to provide a meaningful economic interpretation of the estimates, I compute interquartile comparatives in the predicted effects of the China shock exploiting differences in skill-intensity and degree of exposure.

1.4.2 Import Competition and Demographic Changes

Table 1.2 shows the effects of rising import competition on demographic changes in urban commuting zones. The three panels show the log changes of working-age population at aggregate level and by level of education. Each panel replicates the scheme of Table 1.1; Column 1 reproduces the analysis in ADH and columns 2-4 analyze the heterogeneous effects of $\Delta \text{IP}_{c,t}$ according to local skill-intensity of non-manufacturing industries. Similarly to the case in Table 1.1, the average effect of import competition on population changes is not significantly different from zero for any group. The specialization of local employment in exposed industries does not create demographic changes per se. Again, the analysis of heterogeneous effects sheds light on the actual effect of import competition on population counts and how the average effect masks systematic differences in the consequence of the China shock.

The results in Table 1.2 show that changes in the share of workforce with a college degree

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

shown in Table 1.1 are entirely driven by the change of college-educated population. When import competition meets a region with skill-intensive service industries, the consequence is a growth of the college-educated workforce. The effects are clearly significant only for this population group. Looking at the log change of workforce without a college degree, the effects are smaller and only marginally significant in the least restrictive specification. For this group, the effect of import competition is not significant neither on average nor accounting for heterogeneous effects. Nonetheless, it is noteworthy that there is not a crowding out effect of workers without college education. In other words, among the most skill-intensive half of commuting zones, a higher level of exposure increases the number of working-age college-educated individuals, while the population of workers without a college-degree seems to remain unaffected by the trade shock. The combination of these two facts gives the increase in the density of college-educated workers found in Table 1.1.

Comparative Effects

To provide a more meaningful economic interpretation of the estimated coefficients of table 1.2, I compute three different interquartile comparisons. Exploiting local differences in terms of manufacturing exposure to the China shock and in the share of college-educated workforce in local non-manufacturing industries, I compare 1) regions with similar exposure to import competition and differences in skill intensity, 2) skill-intensive commuting zones with differences in exposure to the China shock, and 3) skill-scarce commuting zones with different levels of import penetration.[20] [21]

First, comparing commuting zones with the median level of exposure to the China shock,

[20] Figure 1..4 plots the ranking of college education in non-manufacturing in 1990 and the ranking of of import penetration in the period 1990-20007 for the 60 urban commuting zones.

[21] The formula of the comparison are:

$$\Delta\hat{y}_{\Delta\text{IP}^{50},\text{Skill}^{75}} - \Delta\hat{y}_{\Delta\text{IP}^{50},\text{Skill}^{25}} = \underbrace{\hat{\beta}_{\text{IS}}}_{+} \cdot \left[\Delta\text{IP}^{50} \cdot \left(\text{Skill}^{75} - \text{Skill}^{25}\right)\right]$$

$$\Delta\hat{y}_{\Delta\text{IP}^{75},\text{Skill}^{75}} - \Delta\hat{y}_{\Delta\text{IP}^{25},\text{Skill}^{75}} = \underbrace{\left(\hat{\beta}_{\text{I}} + \hat{\beta}_{\text{IS}} \cdot \text{Skill}^{75}\right)}_{+} \cdot \left[\Delta\text{IP}^{75} - \Delta\text{IP}^{25}\right]$$

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Table 1.2: - Effect of Import Penetration on Working-age Population

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	Log Population 25-60 y.o.				*Log College Workforce*				*Log Non College Workforce*			
$\Delta \text{IP}_{c,t}$	-0.09	-2.94**	-2.89	-2.98	-0.04	-4.30**	-6.54**	-6.72**	-0.06	-2.34*	-1.56	-1.64
	[0.10]	[1.23]	[1.95]	[2.02]	[0.16]	[1.70]	[2.61]	[2.72]	[0.10]	[1.25]	[1.99]	[2.06]
$\Delta \text{IP}_{c,t} \cdot \text{Skill}_{c,t-1}$		9.20**	8.04	8.44		13.42**	19.45**	20.17**		7.48*	4.02	4.39
		[3.87]	[6.10]	[6.35]		[5.37]	[8.08]	[8.45]		[3.90]	[6.20]	[6.44]
Interacted Controls:												
Mfg. Sector Controls		✓	✓	✓		✓	✓	✓		✓	✓	✓
Demographics			✓	✓			✓	✓			✓	✓
Exports				✓				✓				✓
$\hat{\beta}_{\text{I}}/\hat{\beta}_{\text{IS}}$		35.1%	-	-		32.0%	33.6%	33.3%		31.3%	-	-
SW F-Statistic												
$\Delta \text{IP}_{c,t}$	74.83	28.04	28.70	25.69	60.70	30.13	27.96	25.22	79.59	27.35	30.00	26.95
$\Delta \text{IP}_{c,t} \cdot \text{Skill}_{c,t-1}$		26.85	28.02	25.04		28.69	26.61	23.98		26.04	29.28	26.22

NOTE - N=632 (321 Urban Commuting Zones × 2 time periods). Two stacked ten-year equivalent differences between 1990-2000 and 2000-2007. All the models include the full set of controls in levels described in the text. Columns 2-4 include sequentially the sets of interacted controls. Regressions include time trends interacted with Census regions fixed effects, $\text{Skill}_{c,t-1}$, and the sum of employment in directly exposed industries. Regressions include the pre-trend between 1980 and 1990 of the dependent variable. Robust standard errors clustered at the state level. Models are weighted by start of the period commuting zone share of national population. * $p < .1$, ** $p < .05$, *** $p < .01$

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZALEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

a region at the 75th percentile of services skill intensity will experience a 12.5 log points faster growth of college-educated population per decade than a region at the 25th percentile (equivalent to 1.1 standard deviations).[22] Second, comparing two commuting zones at the 75th percentile of non-manufacturing skill-intensity, a commuting zone at the 75th percentile of exposure to the China shock will have a 8.2 log points faster growth of college-educated population per decade than a region at the 25th percentile of exposure (equivalent to 0.73 standard deviations). Finally, comparing regions at the 25th percentile of services skill-intensity, a commuting zone with a level of import penetration equal to the 75th percentile of import exposure will experience a 6.9 log points faster drop in college-educated population per decade than a region at the 25th percentile of exposure (equivalent to 0.62 standard deviations).

Migration Flows

Table 1.3 shows the results of the regression of migration flows on import competition and its interaction with local services' skill intensity. Each panel shows the net and gross migration flows of workers by level of education. Migration flows are computed as the ratio over the population of reference in the commuting zone at the beginning of the period. With this definition, the magnitudes in Table 1.3 are comparable with the population growth rates estimates in table Table 1.2.

The results in table 1.3 deliver two messages. First, almost all of the changes in college-educated workforce from table 1.2 are due to migration of workers. This finding rules out other potential channels such as endogenous changes in graduation rates in favor of actual movement of factors across regions.

Second, the net migration flows of college-educated workers to skilled-and-exposed labor

$$\Delta\hat{y}_{\Delta \text{IP}^{75},\text{Skill}^{25}} - \Delta\hat{y}_{\Delta \text{IP}^{25},\text{Skill}^{25}} = \underbrace{\left(\hat{\beta}_{\text{I}} + \hat{\beta}_{\text{IS}} \cdot \text{Skill}^{25}\right)}_{-} \cdot \left[\Delta \text{IP}^{75} - \Delta \text{IP}^{25}\right]$$

[22] I use the estimates from Column 4, which include the full set of controls

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

markets are almost entirely driven by positive immigration flows rather than lower out-migration rates. In other words, the China shock induces demographic adjustments by changing the destination, rather than the origin, of college-educated migrants.[23] This finding underlines the importance of taking into account the transformation of local labor markets after the shock to understand the contribution of the China shock to regional divergence in the US. It is more important to know which regions will actually benefit from the shock (the skilled-and-exposed commuting zones will receive an inflow of college-educated workers) than just what regions are directly affected by the shock (import competition does not induce workers to leave more exposed commuting zones)

Table 1.3: - Effect of Import Penetration on Migration Flows

	Net Migration	Immigration	Outmigration	Net Migration	Immigration	Outmigration
	(1)	(2)	(3)	(1)	(2)	(3)
	College-Educated Population			Non College-Educated Population		
$\Delta IP_{c,t}$	-5.01**	-7.00***	-2.00	-0.81	-1.01	-0.21
	[2.03]	[2.56]	[1.90]	[0.79]	[1.04]	[0.49]
$\Delta IP_{c,t} \cdot Skill_{c,t-1}$	19.21***	25.71***	6.50	3.87	4.61	0.74
	[6.69]	[8.61]	[6.42]	[2.74]	[3.62]	[1.68]
Interacted Controls:						
Mfg. Sector Controls	✓	✓	✓	✓	✓	✓
Demographics	✓	✓	✓	✓	✓	✓
Exports	✓	✓	✓	✓	✓	✓

NOTE - N=632 (321 Urban Commuting Zones × 2 time periods). Two stacked ten-year equivalent differences between 1990-2000 and 2000-2007. All the models include the full set of controls in levels described in the text. Columns 2-4 include sequentially the sets of interacted controls. Regressions include time trends interacted with Census regions fixed effects, $Skill_{c,t-1}$, and the sum of employment in directly exposed industries. Regressions include the pre-trend between 1980 and 1990 of the dependent variable. Robust standard errors clustered at the state level. Models are weighted by start of the period commuting zone share of national population. * $p < .1$, ** $p < .05$, *** $p < .01$

[23] Monras (2018) finds similar patterns in the context of the housing bubble burst around the years 2006-2008

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

1.4.3 Import Competition and College Wage Premium

In this section I analyze the contribution of the China shock to the geographical divergence of returns to skills. Table 1.1 shows that among the most skill-intensive regions, the exposure to manufacturing import competition increases the skill premium; while among the least skill-intensive ones, the trade shock reduces the wage difference between college-educated and non-college-educated workers. In this section I analyze which changes in wages actually drive the movements of the college wage premium.

Table 1.4 introduces the estimation of the regression of the changes of average real weekly wages in the commuting zone, as well as real wages for workers with different educational attainment. For each panel, the table reproduces the scheme in table 1.1 and table 1.2. Column 1 regresses the dependent variable on the change in import penetration, without any interactive term. Columns 2-4 takes into account the heterogeneous effects according to local services' skill intensity, sequentially including different sets of interactive controls. The effect of manufacturing import competition on the salary of college-educated workers is significantly different for commuting zones for diverse levels of skill intensity in local non-manufacturing industries. Similar to the case in table 1.2, the interaction of import penetration and local skill-intensity has a positive effect. Approximately, for the best-educated half of the US, the net effect of import competition on real wages of college workers is positive. On the other hand, among the least educated commuting zones, the benefits from the interaction $\Delta \text{IP}_{c,t} \cdot \text{Skill}_{c,t-1}$ do not offset the initial negative impact of $\Delta \text{IP}_{c,t}$. The effect on real wages for workers without a college-education are not significant under any specification. Then, I cannot reject the hypothesis that the effects of import competition on salaries for unskilled workers are the same across the country.

Then, from table 1.4, the China shock contributed to the dispersion of college-wage premium across commuting zones in the US only through its contribution to the divergence of real wages of college-educated workers. Conditioning two local labor markets to the same level of exposure to import competition, the effect is a growth of real college wages

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

if the commuting zone has a skill intensive non manufacturing sector, while there will be a drop in real college wages if the commuting zone is skill-scarce.

Comparative Effects

The consequences of the rise in import competition on the divergence of the college wage premium are statistically significant, but also economically sizable. Below I provide the interquartile comparisons of the effect on real wages of college-educated workers.
Comparing to commuting zones at the median level of import competition, an area at the 75th percentile of non-manufacturing skill-intensity will have a 6.2 log points faster decade growth of real wages for college-educated workers than one at the 25th percentile of skill intensity (this is equivalent to 0.91 standard deviations). Comparing to regions at the 75th percentile of services' skill intensity, in a commuting zone at the 75th percentile of exposure to import competition real wages of college-educated workers will grow 3.5 log points faster per decade than if the commuting zone was at the 25th percentile of exposure to the China shock (equivalent to 0.52 standard deviations). Finally among commuting zones at the 25th percentile of skill-intensity, having an exposure equal to the 75th percentile of the distribution implies a 4 log points faster drop of real college wages per decade that being at the 25th percentile of exposure to the trade shock (equivalent to 0.59 standard deviations).

College Wages by Sector

Table 1.5 provides additional insights on the contribution of the China shock to the skill premium and college wages divergence. The dependent variables are the log change of real wages of college educated workers in the manufacturing and the non-manufacturing sector. The estimates show that rising import competition in manufacturing has an effect on the wages of college-educated workers in non-manufacturing industries. The sign of this effects depends on the skill-intensity of the local non-manufacturing industries. The

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Table 1.4: - Effect of Import Penetration on Real Wages

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	Average Log Real Weekly Wage				*College workers - Log Real Wage*				*Non-College workers - Log Real Wage*			
$\Delta IP_{c,t}$	-0.13**	-0.60	-1.61**	-1.50*	-0.09	-2.55**	-3.43**	-3.43**	-0.12	0.56	-0.10	0.03
	[0.07]	[0.83]	[0.81]	[0.82]	[0.08]	[1.10]	[1.57]	[1.60]	[0.08]	[0.77]	[0.81]	[0.85]
$\Delta IP_{c,t} \cdot Skill_{c,t-1}$		1.72	4.58*	4.13*		8.10**	10.06**	10.08**		-1.75	0.32	-0.23
		[2.57]	[2.41]	[2.44]		[3.30]	[4.80]	[4.91]		[2.44]	[2.51]	[2.63]
Interacted Controls:												
Mfg. Sector Controls		✓	✓	✓		✓	✓	✓		✓	✓	✓
Demographics			✓	✓			✓	✓			✓	✓
Exports				✓				✓				✓
$\hat{\beta}_I/\hat{\beta}_{IS}$		-	35.2%	36.3%		31.5%	34.1%	34.0%		-	-	-
SW F-Statistic												
$\Delta IP_{c,t}$	51.64	30.74	34.41	35.10	54.16	30.97	34.95	34.97	52.81	30.70	34.26	35.25
$\Delta IP_{c,t} \cdot Skill_{c,t-1}$		29.43	31.97	31.96		29.60	32.19	31.59		29.43	31.90	32.13

NOTE - N=632 (321 Urban Commuting Zones × 2 time periods). Two stacked ten-year equivalent differences between 1990-2000 and 2000-2007. All the models include the full set of controls in levels described in the text. Columns 2-4 include sequentially the sets of interacted controls. Regressions include time trends interacted with Census regions fixed effects, $Skill_{c,t-1}$, and the sum of employment in directly exposed industries. Regressions include the pre-trend between 1980 and 1990 of the dependent variable. Robust standard errors clustered at the state level. Models are weighted by start of the period commuting zone share of national population. * $p < .1$, ** $p < .05$, *** $p < .01$

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZALEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

baseline effect of $\Delta \text{IP}_{c,t}$ is negative, but this might be partially compensated or fully reversed by the positive effect of the interaction $\Delta \text{IP}_{c,t} \cdot \text{Skill}_{c,t-1}$.

This finding hints to the importance of the interplay between the negative shock to the manufacturing sector and the characteristics of the non-manufacturing part of local economies. The effect on manufacturing wages of the China shock is not significantly different across local labor markets. Instead, the geographical divergence in the skill premium happens through the divergence of the salaries of college-educated workers in the sector that is not directly exposed to trade competition.

Table 1.5: - Effect of Import Penetration on Real Wages of College-Educated Workers

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	College workers - Manufacturing				*College workers - Non-Manufacturing*			
$\Delta \text{IP}_{c,t}$	0.00	0.25	1.26	1.10	-0.13	-2.83**	-4.19**	-4.17**
	[0.13]	[1.46]	[2.55]	[2.56]	[0.10]	[1.12]	[1.81]	[1.87]
$\Delta \text{IP}_{c,t} \cdot \text{Skill}_{c,t-1}$		0.36	-3.25	-2.62		8.65***	12.31**	12.24**
		[4.52]	[8.17]	[8.19]		[3.35]	[5.49]	[5.72]
Interacted Controls:								
Mfg. Sector Controls		✓	✓	✓		✓	✓	✓
Demographics			✓	✓			✓	✓
Exports				✓				✓
$\hat{\beta}_{\text{I}}/\hat{\beta}_{\text{IS}}$		-	-	-		32.7%	34.0%	34.1%

NOTE - N=632 (321 Urban Commuting Zones × 2 time periods). Two stacked ten-year equivalent differences between 1990-2000 and 2000-2007. All the models include the full set of controls in levels described in the text. Columns 2-4 include sequentially the sets of interacted controls. Regressions include time trends interacted with Census regions fixed effects, $\text{Skill}_{c,t-1}$, and the sum of employment in directly exposed industries. Regressions include the pre-trend between 1980 and 1990 of the dependent variable. Robust standard errors clustered at the state level. Models are weighted by start of the period commuting zone share of national population. * $p < .1$, ** $p < .05$, *** $p < .01$

1.5 Labor Reallocation across Sectors

The previous section showed that the combination of the import competition shock to local manufacturing and skill intensity in non-manufacturing creates simultaneously an

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

increase in the supply and real wages of college-educated workers. In particular, this increase in wages happens in service industries, which are not competing directly with Chinese imports.

In this section I show that the reallocation of labor from directly-exposed manufacturing industries to the non-manufacturing sector is a relevant force behind the findings in Section 1.4. Service industries have access to production factors previously employed in manufacturing industries. Consistent with the large literature on agglomeration effects[24], when the local non-manufacturing sector is densely populated by skill-intensive industries, the reallocation of employment is accompanied by an increase in wages.

In regions where the non-manufacturing sector is densely populated by skill-intensive industries, the consequence of the China shock is a positive shift in the labor demand of skilled services. In regions with low skill-intensity service industries, the non-manufacturing sector does not compensate the the drop in wages and employment in manufacturing.

1.5.1 Labor Market Exposure to the China shock

In this section I introduce my novel measure of 'labor market exposure' to the China shock. This variable captures how non-manufacturing industries are exposed to the import competition faced by manufacturing sectors through the local labor market. Industries in the non-manufacturing sector benefit from the decline in labor demand of those industries competing directly with Chinese imports. In particular, this effect will be stronger when two industries employ a more similar set of occupations.

I construct the variable of 'labor market' import penetration ($\Delta \text{LP}_{i,c,t}$) exploiting the geographical distribution of directly exposed industries, the uneven geographical co-location of different manufacturing and non-manufacturing industries, and occupational similari-

[24] Combes and Gobillon (2015) provides an extensive review of the empirical evidence and the microfundations of positive productivity effects of the agglomeration of industry employment in a location. Among other authors, Elvery (2010) and Florida et al. (2011) document that these agglomeration externalities are stronger for skill-intensive industries

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

ties between sectors.

The measure of labor market import penetration follows a double shift-share strategy. First, it computes the exposure of each occupation in a region to import penetration according to the industries in which it is most intensively employed in the area. Second, it computes the indirect exposure of non-manufacturing industries according to how intensively they employ each occupation.

$$\Delta \text{LP}_{i,c,t} = \underbrace{\Sigma_j \frac{L_{ijt}}{L_{it}}}_{\text{B}} \cdot \underbrace{\Sigma_{h \in \text{mfg}} \frac{L_{hjct}}{L_{jct}} \Delta \text{IP}_{ht+1}}_{\text{A}} \tag{1.6}$$

Term A in eq. (1.6) shows the change of import penetration that an occupation j faces in a commuting zone c. This is the weighted sum of the change in import penetration of each manufacturing industry h (this term is industry-specific, and does not change across locations), weighted by the importance that each industry has for a given occupation in the city.[25] This term has geographical variation as long as some local labor markets are more specialized in exposed industries.

Term B in eq. (1.6) captures the 'labor market' exposure to import penetration of an industry i according to the type of occupations that it employs. It weights the exposure to the China shock of each occupation j in a commuting zone c by the weight that the occupation has in the employment of industry i.

The variation of the 'labor market' import penetration measure is at the industry-commuting zone level. Comparing the same industry across different locations, the source of variation comes from the fact that some commuting zones employs a larger share of the workforce in directly exposed industries. Within commuting zones, non-manufacturing industries differ in the level of exposure due to differences in the occupational requirements with the directly exposed industries

[25] Due to data limitations, I assume that the occupational requirements of each narrowly-defined industry is the same in every commuting zone.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

1.5.2 Labor Reallocation and Sectoral Transfromation

In this section, I test whether the labor reallocation is an empirically relevant channel for the propagation of the import competition shock from directly exposed manufacturing industries to the non-manufacturing sector. Armed with the novel measure of 'labor market' exposure to the China shock introduced in Section 1.5.1, I regress the log change of employment of service industries in different commuting zones on their indirect labor supply shock.

$$\Delta \ln \text{emp}_{ict} = \beta \cdot \Delta \text{LP}_{i,c,t} + \gamma_{ct} + \gamma_{it} + \varepsilon_{ict} \tag{1.7}$$

The variation within and between commuting zones of the 'labor market exposure' to the China shock allows to include industry-time and commuting zone-time fixed effects. In this setting, the estimate β provides a comparison of the employment growth rate of the same industry located in areas with different levels of import penetration. Therefore, this analysis gets rid of contemporaneous covariates such as technological changes, aggregate demand, or other potential factors operating at the industry level.

$$\Delta \ln \text{emp}_{ict} = \Sigma_{k \in H,M,L} \left[\beta_k \cdot \Delta \text{LP}_{i,c,t} \cdot \mathbb{I}_k\right] + \gamma_{ct} + \gamma_{it} + \varepsilon_{ict} \tag{1.8}$$

Besides, I estimate the specification in eq. (1.7) allowing for differential estimates for service industries by terciles of skill intensity. In this setting, I compare how industries with different levels of skill intensity react to the trade-induced labor supply shock.[26] Table 1.6 shows the results of the regression of log employment change in industry-

[26] Under the hypothesis from section 1.B, the estimates should be positive, and increasing in the level of skill intensity. In other words, comparing the same sector across locations, those industries located in commuting zones more exposed to the China shock should grow faster, and this effect should be stronger among industry employing a larger share of college-educated workers.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

commuting zones on the 'labor market exposure' to the China shock (eq. (1.6)). The units of observations are two ten year-equivalent changes for each observation. Columns 1 and 3 show the results of the specification in eq. (1.7), and columns 2 and 4 the results in eq. (1.8).

Table 1.6: - Effect of 'labor market-mediated' import penetration on employment

	Δ Log employment Non-exposed industries			
	(1)	(2)	(3)	(4)
All industries	0.729**		0.672*	
	(0.326)		(0.343)	
Low Skill industries		0.211		0.244
		(0.427)		(0.359)
Mid Skill industries		1.087***		0.918***
		(0.190)		(0.252)
High Skill industries		1.404**		1.326**
		(0.685)		(0.536)
Industry-year FE	✓	✓	✓	✓
CZ-year FE			✓	✓
N	55150	55150	55150	55150
Sh. local emp	✓	✓	✓	✓
Lag Δ ln emp	✓	✓	✓	✓

Table 1.6 shows that the competition on local labor markets is a relevant channel in the propagation of the China shock from directly exposed industries to the rest of the economy. Columns 1 and 3 show that the elasticity between the predicted lost employment in manufacturing and employment expansion in the non-manufacturing sector is close to 0.7. Columns 2 and 4 show that the effects are significantly different for groups of industries with diverse skill intensity. Service industries with the lowest skill intensity do not benefit from a contraction of local manufacturing employment. Instead, high skill industries expand their employment significantly. The most skill intensive industries benefit from the 'labor market exposure' to the China shock and absorb part of the

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

labor leaving the exposed industries. The estimated elasticity is larger than 1, which indicates that skill-intensive service industries increase more than proportionally their level of employment.

Table 1.7 provides additional evidence of the sectoral reallocation of labor following the China shock. The two panels in table 1.7 show commuting zone-level changes in the employment of directly exposed industries and STEM-intensive industries. The econometric specification for these regression are the eq. (1.1) as in section 1.4, in which I regress decade changes in the log number of workers in each sector in the level of exposure to import competition.

Column 1 in the left panel in table 1.7 shows the main result in ADH. Commuting zones with a higher exposure to the China shock suffer a contraction of employment in industries competing with foreign manufacturers. Columns 2-4 show that this reduction in employment is stronger in areas in which the non-manufacturing industries are relatively more skill intensive. Conditional on having a similar manufacturing sector (and therefore a similar exposure to Chinese import competition), more workers leave the sector when the services industries in the region are skill intensive.

The right panel in table 1.7 complements the previous paragraph. The interaction of the China shock and the skill intensity of services industries has a positive effect in terms of employment of STEM-sectors. Combining both panels, among skill intensive regions, a higher exposure to import competition produces a reduction of employment in exposed manufacturing industries and the expansion of industries employing intensively college-educated workers. The employment contraction in manufacturing is stronger in these regions, as a consequence of the stronger demand of labor from service industries. On the other hand, among the least skilled regions, the effect of the China shock is still an employment contraction in exposed industries, but it is not compensated by the growth of employment in other sectors.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Table 1.7: - Effect of Import Penetration on Exposed and STEM Industries

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	Log Employment in Exposed sectors				*Log Employment in STEM sectors*			
$\Delta IP_{c,t}$	-1.04***	4.90**	8.01*	9.16**	-0.1	-4.47***	-5.81***	-5.19***
	[0.09]	[1.97]	[4.25]	[4.33]	[0.19]	[1.47]	[2.22]	[1.80]
$\Delta IP_{c,t} \cdot Skill_{c,t-1}$		-19.54***	-34.93**	-38.26***		12.34***	20.60***	18.68***
		[6.52]	[14.09]	[14.11]		[4.35]	[5.97]	[4.40]
Interacted Controls:								
Mfg. Sector Controls		✓	✓	✓		✓	✓	✓
Demographics			✓	✓			✓	✓
Exports				✓				✓

NOTE - N=632 (321 Urban Commuting Zones × 2 time periods). Two stacked ten-year equivalent differences between 1990-2000 and 2000-2007. All the models include the full set of controls in levels described in the text. Columns 2-4 include sequentially the sets of interacted controls. Regressions include time trends interacted with Census regions fixed effects, $Skill_{c,t-1}$, and the sum of employment in directly exposed industries. Regressions include the pre-trend between 1980 and 1990 of the dependent variable. Robust standard errors clustered at the state level. Models are weighted by start of the period commuting zone share of national population. * $p < .1$, ** $p < .05$, *** $p < .01$

These results are consistent with the findings in Section 1.4, and they highlight the importance of accounting for the characteristics of the non-manufacturing sector. When the China shock affects a commuting zone in which the non-manufacturing sector is densely populated by skill intensive sectors, there is a shift in the labor demand on high-skill industries. This fact drives the reallocation of workers across sectors as well as an inflow of college-educated workers migrating to the skilled-and-exposed regions.

1.6 Conclusions

In this paper I document the contribution of import competition to the regional divergence among local labor markets in the US. I analyze the impact that the sharp rise of Chinese manufacturing imports had on the spatial skill polarization and the divergence of skill premium over the period between 1990 and 2007.

Although the average effect of the China shock on this variable was not significant, there

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

were systematic differences depending on characteristics of the local labor markets. In particular, the skill intensity of local non-manufacturing sectors shaped the impact of rising import competition on regional divergence. Among commuting zones where the service sector employed a large fraction of college-educated workers, a higher exposure to the China shock meant a higher density of college-educated workers and an increase of the college-wage premia. On the other hand, when import competition affected local labor markets where the non-manufacturing sector had a low skill intensity, the density of college-educated workers and the skill premia dropped. I find that the heterogeneous effects of the China shock explains above than one third and one fourth of the variation of the spatial skill polarization and the divergence of skill premium, respectively.

I find that the interaction between the China shock and the level of skill intensity in the non-manufacturing sector increases simultaneously the supply and the wages of college-educated workers in non-manufacturing industries. When the non-manufacturing sector of a commuting zone is skill-intensive, the trade-induced manufacturing decline is followed by a growth of real wages of college-educated workers and positive migration flows of skilled workers to the region.

Finally, I document that the reallocation of labor from manufacturing to non-manufacturing industries explain the systematic differences in the effect of import competition. Non-manufacturing industries benefit from the contraction in the local manufacturing sector. These industries in regions with a high exposure to the China shock benefit from having access to a larger pool of labor. When the non-manufacturing is densely populated by skill intensive industries, the agglomeration externalities increase the productivity of the sector and the negative shock to the manufacturing industry turns a shift in the demand of college-educated labor. In commuting zones with skill intensive non-manufacturing industries, the same shock of import competition entails a larger reduction in manufacturing employment and a faster expansion of skilled services.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

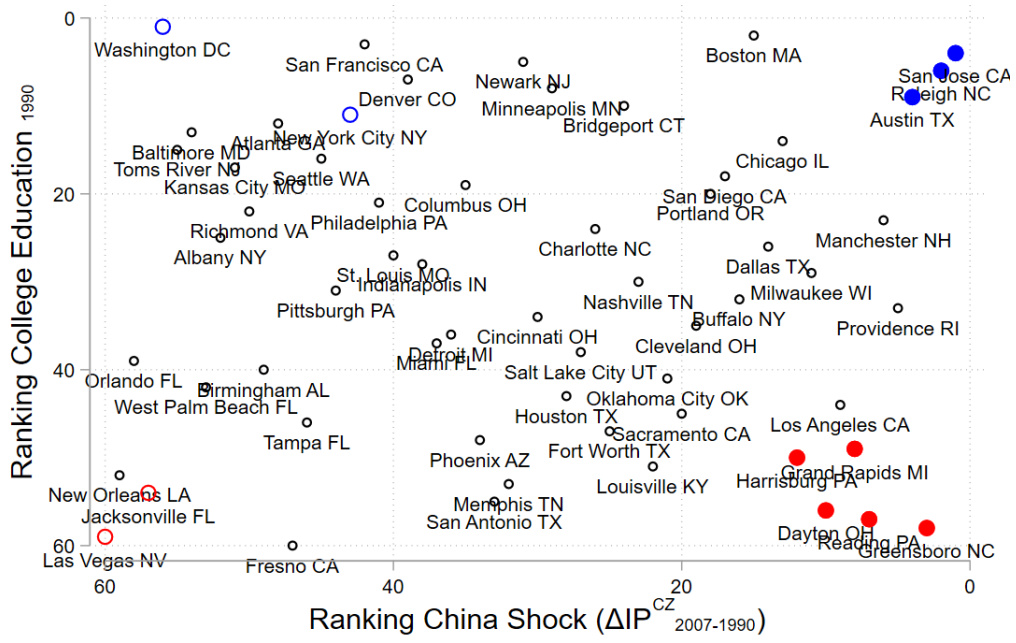


Figure 1..4: Ranking of college-educated workforce and change in import penetration

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Table 1..8: - Correlation of covariates with non-manufacturing skill intensity

	$\left(\text{Skill}_{i,t_0}^{\text{CZ}}, \text{X}_{i,t_0}^{\text{CZ}}\right)$	$\left(\Delta\text{IP}_{c,t} \cdot \text{Skill}_{i,t_0}^{\text{CZ}}, \Delta\text{IP}_{c,t} \cdot \text{X}_{i,t_0}^{\text{CZ}}\right)$
Manufacturing sector characteristics		
Skill-intensity	0.70	-0.01
Share Management occupations	0.62	-0.06
Offshorability index	-0.63	-0.16
Share Routine occupations	-0.40	0.07
Average wage	0.43	-0.04
Demographic characteristics		
Log Population	0.52	-0.19
Share foreign born pop.	0.21	0.02
Female labor participation	0.49	0.18
Share young pop. (25-35 y.o.)	0.44	0.01
Export Potential (Feenstra et al. (2017))	-0.07	0.16

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

1.A Data and Sample Appendix

This section describes the sample and data sources employed in the empirical analysis of the paper. There are two main empirical settings in the paper. In the first one, the level of analysis is the local labor market. In the second one, the units of analysis are pairs of industries and local labor markets.

The geographical units in both parts are commuting zones (CZ), as defined by Tolbert and Sizer (1996). I restrict my sample to the 321 urban commuting zones overlapping with Metropolitan Statistical Areas in contiguous continental US.[27] These commuting zones are clusters of US counties that replicate local labor markets.

The first econometric setting analyzes changes in outcomes of commuting zones. Following the previous literature (Autor et al. (2013), Acemoglu et al. (2016)), the sample consists of two stacked ten-year equivalent differences in the outcomes of interest for the periods 1990-2000 and 2000-2007.

The second setting examines changes in employment in pairs of industries and commuting zones. The sample consists as well in two stacked quasi-decade changes in log employment for the periods 1990-2000 and 2000-2007.

Local labor markets

The primary source for data at the commuting zone level are the Census Integrated Public Use Micro Samples (Census IPUMS) for the years 1970, 1980, 1990 and 2000, and American Community Survey (ACS) for 2006 through 2008, again Ruggles et al. (2016). I restrict the Census samples to individuals between age 25 and 60.

Using this source I construct the main dependent variables of the analysis. I compute changes in the workforce size by educational level and changes in real wages and college wage premium. I use additional data on the characteristics of commuting zones from

[27] Excluding Alaska, Hawaii, and Puerto Rico

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Autor et al. (2013) as control variables. This variables includes characteristics of local labor markets as offshorability and routine intensity of occupations,

Real wages and Wage Premium

I compute average wages at the commuting zone level for workers with between 25 and 60 y.o. excluding self-employed workers, public employees, individuals with missing wages or weeks or who worked less than 26 weeks in the previous year. The main measure of wages are log weekly wages, computed as th log of total wage income over the number of worked weeks. Wages below the first percentile of the national distribution are set equal to the value of the first percentile.

To have a more meaningful estimation of changes in labor conditions across regions, I compute change in real wage changes rather than nominal ones. I deflate wages by commuting zone-specific price indexes. These deflators might be potentially correlated with changes in import penetration. As long as import competition affects the demand for local goods through nominal wages and local employment, prices in more exposed regions could potentially fall. Similarly, higher housing prices may offset nominal gains in booming areas (Feler and Senses (2017),Hsieh and Moretti (2015),Xu et al. (2019)).

Given that there is no off-the-shelf index that covers the entire sample, I follow Moretti (2013) and I deflate changes in nominal wages as

$$\Delta LogRealWage_{i,t} = \Delta LogNominalWage_{i,t} - \frac{1}{3} \cdot \Delta MedianRentalPrice_{i,t} - \frac{2}{3} \cdot \Delta CPU_t \tag{1.9}$$

In order to get city-specific prices, I discount log changes in nominal weekly wages by one third of the log change of the median rental house price. The underlying logic is that most of the disparities in the cost of living between cities comes from differences in housing prices. Following Albouy (2016), I assume that housing expenditure accounts for roughly

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

one third of disposable income.

On the other hand, the national CPU index captures the change in prices of tradable goods[28], accounting for two thirds of the consumption. However, this component vanishes in the econometric setting with the inclusion of time fixed effects.

Finally, the change in college wage premium is the difference between the log change of wages for workers with and without a college degree. My definition of real wage changes does not affect the change of college wage premium, as long as the local deflator assumes the same share of consumption of local goods for workers with any level of education.

Migration Rates

Migration rates are defined as

$$\text{Migration rate}_{i,s,t+1} = \frac{F_{i,s,t+1}}{N_{i,s,t}} \tag{1.10}$$

Where $F_{i,t+1}$ are the in-migration or out-migration flows of population group s in commuting zone i between t and $t+1$. I compute migration flows for total population, college and non-college educated groups. I express migration rates as the ratio of migration flows over the initial size of the respective population group at the beginning of the period ($N_{i,s,t}$). Hence, the migration rate are the contribution of migration to the growth rate of the respective population subgroup.[29][30]

Industrial Composition

I use the County Business Patterns (CBP) to retrieve data on local industrial structure. CBP provides information on employment by county and industry. In many cases, infor-

[28] I am implicitly assuming that changes in tradable consumption goods are homogeneous across locations.

[29] To avoid the concern of individual moving to contiguous CZs while keeping their place of work, I restrict the sample to migrants changing their state of residence.

[30] Census provides information of the place of living 5 years ago and ACS in the place of living 1 year ago. I multiply proportionally the migration flows so they can be expressed in decade-equivalent terms

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

mation at the most disaggregated level is not fully disclosed and it is only reported on brackets. I use the algorithm in Autor et al. (2013) to impute employment by county and 4-digit SIC.

I compute the change in employment in STEM-intensive sectors in the CZ and the overall growth in STEM-intensive occupation. I define an occupation as STEM-intensive following the definitions of the O*Net database (Farr and Shatkin (2004))

Exporting Potential

I take the measure of exposure to exports constructed by Feenstra et al. (2017). This is a Bartik measure of export exposure of CZ constructed in an analogous way to the import exposure variable in Acemoglu et al. (2016). National growth in exports in each industry, divided by of start-of-the-period shipments, are proportionally imputed to CZs according to their share of employment in each of the industry sectors.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

1.B Model of Labor Reallocation

This section introduces a parsimonious model of labor reallocation across sectors and regions. The goals are twofold. First, provide a theoretical framework that rationalizes the findings on import competition and regional divergence from the Section 1.4. The negative shock to the local manufacturing sector increases simulatenously the supply and the salary of college-educated workers in those local labor markets with skill-intensive service industries. The theoretical model clarifies the role of local labor market competition on turning the negative shock to manufacturing into positive for local service industries. The skill intensity of local non-manufacturing industries determines the extent of the shift of college-educated workers.

Second, motivated by the theoretical model, I introduce a novel measure of exposure to manufacturing import competition of service industries. The variable of 'labor market' exposure to the China shock captures the changes that each pair of industry-location faces in the labor market conditions following the contraction of manufacturing industries in the same region.

The model solves a spatial equilibrium of endogenous workers' location and optimal industry size in a set of local labor markets. In the model, industries in different locations compete for workers in a set of occupations versus other industries in the same city and the same industry in the rest of the country. Workers choose their location endogenously. They get utility from their salary and from idiosyncratic preferences for locations. A negative shock to manufacturing industries alters the equilibrium of the model. Following manufacturing' contraction of labor demand, service industries expand its workforce. The reallocation of workers across sectors is subject to retraining costs. There are positive externalities from the agglomeration of an industry in a city. These externalities are stronger for industries employing a larger share of college-educated workers.

In regions where manufacturing industries exposed to the China shock employ a large

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

share of local workforce, non-manufacturing industries expand absorbing part of the lost employment. These growing industries increase their productivity due to agglomeration externalities. Scale benefits are stronger for skill-intensive industries. This rationalizes the findings in the previous section of the heterogeneous effects of import competition according to local services' skill-intensity. In regions with a high density of skill-intensive service industries, the reallocation of labor following the China shock shifts up the demand for skilled workers.

Workers

Workers have occupation-specific skills and they are mobile across cities. They supply inelastically one unit of labor in occupation j in city c. Workers choose endogenously the utility-maximizing location. Individuals get utility from their salary and from their idiosyncratic taste for different locations. An individual s working on an occupation j in city c gets an utility equal to

$$U_{sjct} = \ln w_{jct} + z_{sc}$$

z_{sc} is the taste of individual s for city s. I assume that the distribution across individuals with occupation j of the idiosyncratic preferences (z_{sc}) for locations follow a Type I Extreme Value distribution, with parameter $\frac{1}{\eta_j}$. In other words, $\frac{1}{\eta_j}$ reflects how extreme are the preferences of individuals for different locations. Conversely, η_j is proportional to the responsiveness of workers with occupation j to changes in objective economic conditions.

Given the assumption on the distribution of z_{sc}, the elasticity of employment in occupation j with respect to changes in local economic conditions is

$$\widehat{L}_{jct+1} = \eta_j \underbrace{(\widehat{w}_{jct+1} - \widehat{w}_{jt+1})}_{\text{Change in relative wages}} \tag{1.11}$$

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

where $\widehat{w}_{jct+1}$ is the growth rate of wages for occupation j in city c between t and t+1, and $\widehat{w}_{jt+1}$ is the average change in the country of wages for occupation j during the same period.

Assumption 1: the propensity to migrate increases with education.

From Assumption 1, η_j is larger in those occupations in which the typical worker has a college education. As a consequence, industries employing a larger share of occupations that require a college degree will face a more elastic labor supply.

Firms

Each firm operates in a giving industry i and is located in city c. Firms take prices as given and each industry combines labor in each occupation to produce output.

$$Y_{ict} = A_{ict} \prod_{j \in J} (L_{jict})^{\alpha_{ji}} \tag{1.12}$$

$$\text{with} \quad \Sigma_{j \in J} \alpha_{ji} = 1$$

The importance of each occupation j within an industry i (α_{ji}) is the same across cities. However, the productivity of an industry-commuting zone pair (A_{ict}) increases with the number of workers in the sector. Industries benefit from (factor neutral) agglomeration externalities. Firms operating in an industry i and city c are more productive when the density of workers in the industry-commuting zone pair increases.

$$A_{ict} = \exp\left(G_i \ln L_{ict}\right) \tag{1.13}$$

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Assumption 2: the strength of agglomeration externalities (G_i) increases with skill-intensity of the industry

Firms' Labor Demand

The optimization problem of firms consists in choosing the optimal level of employment in each occupation (L_{ict}). Firms pay competitive wages and take the labor supply as given. When hiring workers previously employed in a different industry, firms has to pay re-training costs. Firms have to devote a fraction of their current workforce to train workers switching their industry for their new positions. These re-training costs are convex in the growth rate of employment in each occupation.

Although every unit of labor within an occupation enters symmetrically in the production function, the contribution of workers to the profit function will be different if they are switching their industry (L^s_{jt}, - *switchers*) or they were already employed in the same industry. Among the workers already in the industry, firms can keep their workforce from the previous period (L_{jt-1}) or adjust their workforce with workers in the same industry migrating from a different city (L^m_{jt}, - *migrants*).

$$\max_{\left\{L^m_{jt},L^s_{jt}\right\}_{j\in J}} A_t \prod_{j\in J}(L_{jt-1}+L^m_{jt}+L^s_{jt})^{\alpha_j} - \Sigma_{j\in J} w^m_{jt}L^m_{jt} - \Sigma_{j\in J} w^s_{jt}L^s_{jt} - \Sigma_{j\in J}\mathbb{C}\left(\frac{L^s_{jt}}{L_{jt-1}}\right) \tag{1.14}$$

The optimal labor demand will be different for workers switching from manufacturing to services than for workers in the same industry changing location, as long as the former entails an additional marginal cost for the firm.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

$$\begin{aligned}\frac{\partial Y_t}{\partial L_{jt}} &= w_{jt}^m \\ \frac{\partial Y_t}{\partial L_{jt}} &= w_{jt}^s + \mathbb{C}'\left(\frac{L_{jt}^s}{L_{jt-1}}\right)\end{aligned}$$

Given that adjustment costs are a function of the growth rate of employment in each occupation, the level of employment at the beginning of the period becomes a state variable for the firm. With convex adjustment costs, industries increase the workforce in each occupation j in period t+1 proportionally to the number of workers in the occupation they employed in period t. This implies that, conditional on the contraction of local manufacturing employment, service industries will grow faster in regions where it has a comparative advantage.

I take these comparative advantages as exogenous and I solve the model in terms of changes from the existing equilibrium instead of levels. The solution of the model will deliver elasticities between industry-commuting zone employment and the China shock

$$\max_{\widehat{L}^{\mathrm{s}}_{jt+1},\widehat{L}^{\mathrm{n}}_{jt+1}} Y_t\widehat{Y}_{t+1} - \mathbb{C}\left(\widehat{L}^{\mathrm{s}}_{jt+1}\right) - w^{\mathrm{s}}_{jt+1}L_{jt}\widehat{L}^{\mathrm{s}}_{jt+1} - w^{\mathrm{m}}_{jt+1}L_{jt}\widehat{L}^{\mathrm{m}}_{jt+1} \tag{1.15}$$

where $\widehat{L}^{\mathrm{s}}_{jt+1} = \frac{L^{\mathrm{s}}_{jt+1}}{L_{jt}}$ is the growth of employment from workers switching sectors, $\widehat{L}^{\mathrm{m}}_{jt+1} = \frac{L^{\mathrm{m}}_{jt+1}}{L_{jt}} - 1$ is the growth of employment from hiring workers in the same industry and different location, and $\mathbb{C}\left(\widehat{L}^{\mathrm{s}}_{jt+1}\right) = C\left(\frac{\widehat{L}^{\mathrm{s}^2}_{jt+1}}{2}\right) w_{jt}L_{jt}$ are the re-training costs.

Convex re-training costs pins down the growth rate of hiring of switching workers in each occupation proportionally to the industry productivity growth ($\widehat{A}_{t+1}$) and the relative drop of the cost of labor ($\widehat{w}^{\mathrm{s}}_{jt+1} = \frac{w^{\mathrm{s}}_{jt+1}}{w_{jt}} - 1$)

Workers moving from the same industry in a different location do not entail any re-training costs, so the wage that an industry i in city c offers increases proportionally to

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

the productivity change.

$$\widehat{A}_{t+1} - \widehat{w}^{\mathrm{s}}_{jt+1} = \widehat{L}^{\mathrm{s}}_{jt+1} \tag{1.16}$$

$$\widehat{A}_{t+1} = \widehat{w}^{\mathrm{m}}_{jt+1} \tag{1.17}$$

Equation (1.16) highlights the fact that different occupations are complementary through the existence of the agglomeration externalities.

Labor market clearing conditions

The amount of *switching* workers hired in service industries equates the quantity of workers leaving the manufacturing sector following the China shock

$$\Sigma_i L_{ijt} \widehat{L}^{\mathrm{s}}_{ijt+1} = L_{jct} \Delta \mathrm{IP}_{jct+1} \tag{1.18}$$

The right-hand side of eq. (1.18) shows the employment lost in an occupation j in city c. The term $\Delta \mathrm{IP}_{jct+1}$ is the level of exposure to import penetration of an occupation j in city c. This value is the weighted sum of the change in import penetration of each industry, weighted by the employment share that each manufacturing industry has on the occupation in the city.

The spatial equilibrium from eq. (1.11) pins down the supply of *migrant* workers in occupation j for firms in industry i and city c.

$$\widehat{L}^{\mathrm{m}}_{jict+1} = \eta_j \left(\widehat{w}^{\mathrm{m}}_{jct+1} - \widehat{w}_{jt+1} \right) \tag{1.19}$$

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

I assume that the supply of labor in an occupation does not change at the national level, so the total flows of workers must cancel out at the aggregate level.

$$\Sigma_c L_{ijct} \widehat{L}^{\mathrm{m}}_{ijct+1} = 0 \tag{1.20}$$

Labor market equilibrium

For each occupation j a firm in industry i and city c hires workers from the manufacturing sector increasing its workforce by $\widehat{L}^{\mathrm{s}*}_{jict+1}$

$$\widehat{L}^{\mathrm{s}*}_{jict+1} = \widehat{A}_{ict+1} + (1 - G_i)\, \Delta \mathrm{IP}_{jct+1} \tag{1.21}$$

Additionally, it adjusts its workforce with migrant workers $\widehat{L}^{\mathrm{m}*}_{jict+1}$

$$\widehat{L}^{\mathrm{m}*}_{jict+1} = \eta_j \left(\widehat{A}_{ict+1} - \widehat{w}_{ijt+1} \right) \tag{1.22}$$

Aggregating up the growth rate in each occupation and adding the two sources of employment growth, the total employment growth in industry i and city c is

$$\widehat{L}^{*}_{ict+1} = \left(1 + \Sigma_j \frac{L_{jict}}{L_{ict}} \eta_j \right) \widehat{A}_{ict+1} + (1 - G_i)\, \Sigma_j \frac{L_{jict}}{L_{ict}} \Delta \mathrm{IP}_{jct+1} - \Sigma_j \frac{L_{jict}}{L_{ict}} \eta_j \widehat{w}_{ijt+1} \tag{1.23}$$

The first term in eq. (1.23) corresponds to the increase in demand due to the increase of total productivity of the industry. The second term reflects the fact that service industries in cities exposed to greater import penetration benefit from having access to a larger supply of labor. The third term is the term that reflects the increase in competition at the national level and its common to an industry in any region.

Finally, substituting the expression of the agglomeration effects by actual changes in employment (eq. (1.13)), the growth rate of employment in industry i and city c between t and t+1 is

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

$$\widehat{L}^{*}_{ict+1} = \left[\frac{1-G_i}{1-G_i\left(1+\Sigma_j \frac{L_{ijt}}{L_{it}}\eta_j\right)}\right]\Sigma_j \frac{L_{jict}}{L_{ict}}\Delta \text{IP}_{jct+1} + \Gamma_{it+1} \tag{1.24}$$

Equation (1.24) delivers the elasticity between employment in non-exposed industries and the rise of import penetration in exposed industries. It contains three elements: the 'labor market exposure' to the China shock of non-manufacturing industries, the skill-dependent elasticity of employment with respect to the previous component, and an industry-time fixed effect.

1.B.1 Labor Market-mediated exposure to the China shock

The term $\Sigma_j \frac{L_{jict}}{L_{ict}}\Delta \text{IP}_{jct+1}$ illustrates the transmission of the China shock from the directly exposed manufacturing sector to non-exposed service industries. Non-manufacturing industries face a change in the supply of labor following the employment contraction in the manufacturing sector. This shock is not the same for an industry in different locations neither for all the industries within the same location.

$$\Delta \ln \text{Supply}_{ict+1} \equiv \Sigma_j \frac{L_{jict}}{L_{ict}}\Delta \text{IP}_{jct+1} = \underbrace{\Sigma_j \frac{L_{ijt}}{L_{it}}}_{\text{B}} \cdot \underbrace{\Sigma_{h\in \text{mfg}} \frac{L_{hjct}}{L_{jct}}\Delta \text{IP}_{ht+1}}_{\text{A}} \tag{1.25}$$

Term A in eq. (1.6) shows the change of import penetration that an occupation j faces in city c. This is the weighted sum of the change in import penetration of each manufacturing industry h (this term is industry-specific, and does not change across locations), weighted by the importance that each industry has for a given occupation in the city. This term has geographical variation as long as some local labor markets are more specialized in exposed industries.

Term B in eq. (1.6) weights the exposure to the China shock of each occupation j in a city c by the weight that the occupation has in the employment of industry i.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

1.B.2 Skill Intensity and Labor Reallocation

Conditional on a given level of 'labor market exposure' to the China shock, the growth rate of employment of non-manufacturing industries will vary depending on its skill-intensity. The term $\frac{1-G_i}{1-G_i\left(1+\Sigma_j \frac{L_{ijt}}{L_{it}}\eta_j\right)}$ illustrates the two mechanisms why skill-intensive service industries in a city will grow faster that their less skill-intensive counterparts.

First, skill-intensive industries benefit from stronger agglomeration externalities (G_i). The productivity of sectors employing a high share of college-educated workers benefit from a higher density of workers in the industry more than less skill-intensive industries. Thus, conditional on any number of workers moving from manufacturing to services, skill-intensive industries in highly exposed regions become more productive than their peers in other locations and will be able to poach workers from their competitor in the rest of the country.

Second, skill-intensive industries face a more elastic labor supply $\left(\Sigma_j \frac{L_{ijt}}{L_{it}}\eta_j\right)$. This is the consequence of the increasing propensity to migrate with respect to the level of education. Conditional on any increase of productivity (due to agglomeration forces), the shift of the demand of skill-intensive sectors will translate into a larger growth of employment as long as they employ a larger share of college-educated (and therefore more mobile) workers. On the other hand, industries employing mainly unskilled (and therefore relatively immobile) workers would have to restrict the hiring to workers already in their area.

The predictions of the model reconcile the findings of Section 1.4. The impact of import competition depresses wages and employment in exposed regions. The lost employment reallocates to local service industries with competitive advantages, these industries benefit from agglomeration externalities, and they become more productive than their industry counterparts in regions without exposure to import competition. Therefore, the overall effect is not homogeneous and depends on the characteristics of the non-manufacturing

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

sector. Skill-intensive industries benefit from stronger agglomeration effects and a more elastic labor supply. In regions where the non-manufacturing sector is densely populated by skill-intensive industries, the consequence of the China shock is a positive shift in the labor demand of skilled services. Therefore, in skilled-and-exposed regions, the wages of college-educated workers rise because of the China shock at the same time that they receive positive migration flows. In regions with low skill-intensity service industries, the non-manufacturing sector does not compensate the the drop in wages and employment in manufacturing.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Chapter 2

Import Competition, Regional Divergence: : A model of skill-biased sector change

2.1 Introduction

The impact on local economies of the rise of Chinese imports has been widely studied. An increase in import competition directly affects local economies by decreasing employment in sectors with a higher level of exposure. Therefore, the level of intensity in manufacturing[1] in the different areas will influence the extent to which trade competition affects local economic outcomes. However, I argue in this paper that this is not enough to fully describe the induced changes in local economies.

Beyond the manufacturing sector, the rest of the local economy, even if it is not directly exposed to trade competition, is also affected by its consequences. An important transmission channel is the reallocation of productive factors. Part of the resources that were

[1]Throughout the chapter I use manufacturing intensity and exposure to Chinese import competition as equivalent terms. In actual data, US did not import Chinese goods in every manufacturing industry. Nonetheless, the correlation between the two variables is 0.69 in the period 1991-2007.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

employed in manufacturing, such as labor or office space, turn idle after the negative shock hits the sector. These productive factors can be reallocated to other parts of the local economy where returns stay higher.

Even if this is an indirect way in which rising trade competition affects local labor markets, its weight on final outcomes might not be small. Given that the share of the labor force that is employed in the manufacturing sector is a minority fraction, even in the most intensive regions, any transmission of effects into the nonmanufacturing part of the economy will be highly amplified. Thus, the ability of the rest of the economy to absorb the trade shock will be decisive in determining changes in the economic performance of the area as a whole.

The magnitude of this reallocation will depend on the relative size of manufacturing industries in each local market, but also the overall characteristics of the local economy will play a relevant role. The importance of local characteristics will be inversely proportional to the geographic mobility of productive factors. If factors such as industrial space or unskilled labor are perfectly or partially immobile, elasticity between sectors will be determined by local characteristics.

However, not all the relevant productive factors are equally immobile. For instance, empirical evidence shows that college-educated workers are more mobile than those without a college education[2]. Concerning relatively mobile factors, differences in the reallocation process within local markets will imply a reallocation of factors across regions. Those markets that reallocate more local resources to the skill-intensive nonmanufacturing sector, will become a more attractive destination for skilled workers.

[2]Wozniak (2010)

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

2.2 Related Literature

This chapter relates to several strands of literature. First of all, the theoretical model links the effects of rising Chinese import competition (an extensive literature covers this topic, with Autor et al. (2013) as a basic reference) with the divergence process among US metropolitan areas over the last decades. Skill sorting and disparities in skill premium are two features part of the much broader "Great Divergence" process, as coined by Moretti (2012).

A necessary reference that links trade competition and changes in skill premium among regions is Dix-Carneiro and Kovak (2015). In the later, the effect of trade competition on skill premium arises from differences in employment of skilled and unskilled labor in manufacturing industries. In the model that this chapter introduces, the only difference across local manufacturing sectors is the relative size, not its skill intensity. Instead, the source of regional differences in skill premium is the difference in skill intensity of non-manufacturing sectors.

This chapter also relates to the extensive literature of skill-biased changes and their effects on skill premium. A vast majority of this literature focuses on skill-biased technical change (*SBTC*, Acemoglu and Autor (2011) summarizes the literature) with technological improvements that enhance the productivity of skilled workers. On the other hand, other articles such as Buera et al. (2015) focus on skill-biased structural change. In this case, changes in skill premium arise from an income effect and a subsequent increase in the demand of skill-intensive sectors.

In this paper, changes in economic structure does not arise from technological or demand shocks. Instead, the source of sectoral change is an exogenous trade shock to the manufacturing sector. Moreover, unlike most of the literature in SBTC and SBSC, this article focuses on local economies. It includes relevant features of regional and urban economics such as agglomeration effects or imperfect factor mobility. Therefore, one of

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

the main findings is that the sectoral reallocation process following the trade shock is highly uneven in sign and magnitude.

A closer reference is Bustos et al. (2019), that show that the release of unskilled labor from Brazilian agriculture following the adoption of labor-saving technologies, induces and unskilled change in manufacturing. In this chapter, the inflow of unskilled workers from manufacturing to non-manufacturing sectors reduces the productivity of skilled workers. However, this does not imply that the reduction of manufacturing employment creates an unskilled biased change in every region due to three reasons. First, the existence of non-linear agglomeration externalities. Second, the existence of local factors, such as office space, that also reallocates away from manufacturing. And finally, the fact that some regions will attract skilled workers.

This chapter highlights the importance of differences in geographical and sectoral mobility of production factors. Similarly to Forslid and Ottaviano (2003), this theoretical model assumes that workers are highly mobile across industries, but only skilled workers are geographically mobile. This chapter highlights the relevance of differences in mobility on local labor composition, contributing to existing literature such as Wozniak (2010) and Notowidigdo (2011).

Finally, this work connects with Glaeser and Saiz (2003) and the 'reinvention city' hypothesis. The authors document that skilled cities are better at adapting to adverse economic shocks because human capital enables to adapt well to change. Findings in this work support the 'reinvention city' view; areas with a higher college education dodge the adverse effects of exposure to Chinese imports, and they leverage out the losses in employment in manufacturing to grow more skill-intensive sectors. Also Glaeser and Ponzetto (2007) looks at the differences in fate of US cities according to their skill levels. The later focuses on the decline of communication costs as the source of divergence. Similarly than in the case of SBTC, this is a compatible argument with the one of uneven skilled transformation that this paper proposes.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

2.3 Theoretical Model

To illustrate the reason why the level of skill intensity in a region would play a relevant role when it interacts with higher import competition, I introduce a model of structural transformation in local economies. The model exemplifies the reaction of regions to a trade shock hitting their manufacturing sector. I show that, even if the shock is the same for every local labor market, areas with a higher skill-intensity react by shifting their production from manufacturing to more skill-intensive sectors. Stickiness of production factors such as unskilled labor or office space and the migration of skilled workers from low to high-skill regions are the primary drivers of the differences in effects of trade competition.

The model has four main ingredients: 1) local economies with two productive sectors that differ in their intensity of skilled employment; 2) positive agglomeration externalities for skilled workers; 3) existence of local production factors supplied in a fixed quantity, and 4) a spatial equilibrium that solves the allocation of skilled workers across locations.

This is a partial analysis focused on the production side of the economy, so it neglects the consumption side. Each local economy is composed of two different productive sectors: manufacturing sector and an advanced sector. Regions are assumed to be small open economies, and their firms sell their products in the international market taking prices as given.

The only ex-ante difference between cities that I feed into the model are the parameters $\mathbb{M}_c$ and $\mathbb{H}_c$. The first one represents the idiosyncratic productivity of cities in the production of manufacturing goods, while the second parameter pins down the stock of skilled workers at the beginning of the period. The variation in $\mathbb{M}_c$ and $\mathbb{H}_c$ determines the initial diversity in manufacturing and skill intensity across cities. These two parameters are necessary to replicate the initial variation in manufacturing and skill intensity across cities in the data. Figure 2.3.1 plots the ranking in skill and manufacturing intensity among the

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

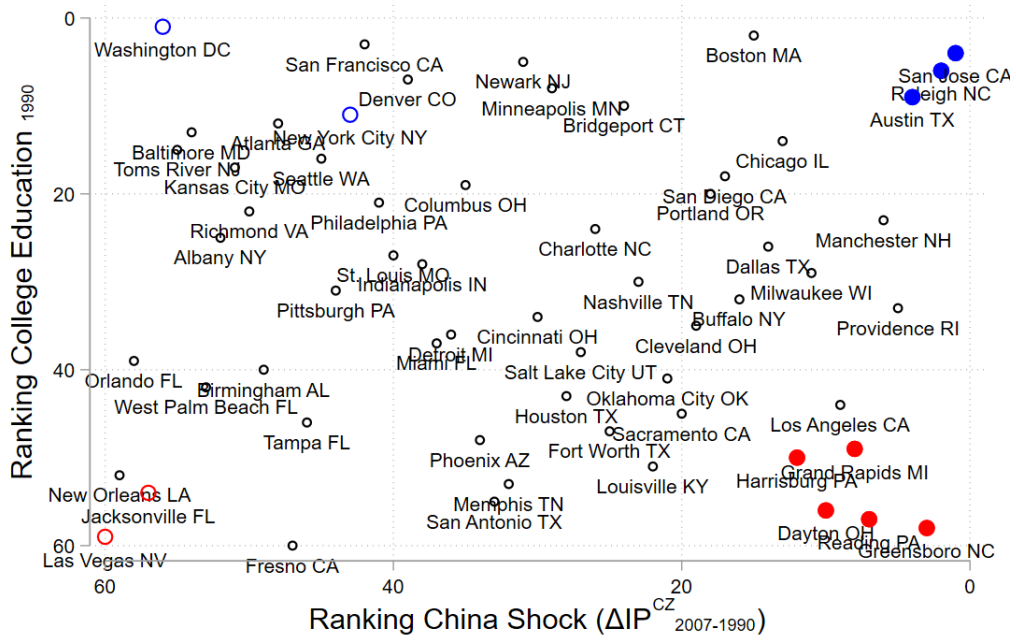


Figure 2.3.1: Ranking of college-educated workforce and change in import penetration

60 largest local labor markets in US. It is clear from the plot that a perfect (negative) correlation between skill intensity and manufacturing employment does not fit actual data. Thus, variation in the two variables is needed to replicate observed differences. Including variation only in manufacturing productivity or prior stock of skilled workers will result in a perfect sorting of skill-abundant regions to specialize only in the advanced sector, and vice versa.

Productive sectors

Local economies consist of two productive sectors, manufacturing and advanced sector, that differ in their skill intensity. Manufacturing sector uses office space and employs unskilled workers following a Cobb Douglas function with constant returns to scale. Cities have an idiosyncratic productivity level in manufacturing $\mathbb{M}_c$ that determines the relative size of the two sectors in the local equilibrium. Production is sold at price $P_{M,c}$. The growth in competition due to Chinese imports is represented in the model as a negative

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

shock to the price of the good produced in the manufacturing sector.

$$P_{M,c} \cdot Y_{M,c} = P_{M,c} \cdot \mathbb{M}_c \cdot O_{M,c}^{\alpha} L_{M,c}^{1-\alpha}$$

The advanced sector also follows a Cobb Douglas production function with office space and labor as inputs. However, the labor component combines both skilled and unskilled workers with a constant elasticity of substitution. Its price is normalized to 1.

$$P_{A,c} \cdot Y_{A,c} = O_{A,c}^{\alpha} \left(\psi \cdot L_{A,c}^{\sigma} + (1-\psi) \cdot \mathbb{X}_c H_c^{\sigma} \right)^{\frac{1-\alpha}{\sigma}}$$

where

$$\mathbb{X}_c = \left(\frac{H_c}{H_c + L_{A,c}} \right)^{\beta} \text{ with } 0 < \beta < 1$$

Additionally, the agglomeration of skilled workers in the advanced sector creates a positive skill-specific productivity externality. Skilled workers benefit from the skill intensity of the local advanced sector. Agglomeration externalities for skilled workers help to replicate the empirical evidence of positive relationship among skill intensity in the local market and wages for skilled workers.

This captures that firms in the advanced sector with a high share of skilled workers can implement organizational or managerial practices that improves the productivity of those workers. Concavity reflects that when the advanced sector employs a vast majority of skilled workers, changes in skill density affect little to their productivity as those practices are well established. Instead, when the skill density is low, productivity of skilled workers is more sensitive to changes in skill density.

Production factors

There are three production factors in the economy: office space, unskilled and skilled labor. There is a fixed amount of office space in the region that is competitively allocated by the owners between the manufacturing and the advanced sector $O_c = O_c^M + O_c^A$.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Unskilled workers are also geographically immobile[3] and they are also employed in both sectors $L_c = L_c^M + L_c^A$.

Skilled workers are employed only in the advanced sector, and they are imperfectly mobile across regions[4]. Migration of skilled workers has an elasticity with respect to the relative salary in the region of $0 < s < \infty$

$$H_c = \mathbb{H}_c \cdot \left(\frac{w_{H,c}}{\tilde{w}_H} \right)^s$$

where $\mathbb{H}_c$ is a local idiosyncratic parameter that sets pre-existing differences in skill intensity and $\tilde{w}_H = \left(\sum_c w_c^s \cdot \frac{H_c^c}{H} \right)^{\frac{1}{s}}$ is the national weighted average wage for skilled workers[5][6]. It is important to point out that, even if the amount of skilled population depends positively on the wages of skilled workers, the relevant quantity is the wage relative to the national average. Even if at first a trade shock might rise skilled wages across the board, in a spatial equilibrium skilled workers will reallocate only to those regions where skilled wages grew the most.

Then, the driving force for changes in the model is the competition for productive factors. This competition takes places in two dimensions. In the first place, within each region, the advanced sector competes against the manufacturing sector for the locally supplied business space and unskilled labor. The negative import competitions shock sector re-

[3]This assumption is a simplification of the empirical finding that college educated workers are more mobile than workers without college education (Wozniak (2010);Malamud and Wozniak (2012)).

[4]This assumption is a simplification of the empirical finding that manufacturing sector is relatively more intensive in low-skilled labor (Bound and Holzer (2000); Notowidigdo (2011); Buera et al. (2015)).

[5]This is a direct derivation from models of spatial equilibrium as in Rosen (1979) and Roback (1982). A recent update can be found in Moretti (2011).

[6]The rationale for s can be twofold. First, it is assuming that each worker has location specific preferences for every region drawn from a given distribution. The value of s is inversely related to the variance of such distribution. If workers draw their location specific preferences from an infinite variance distribution then $s = 0$ and they do not migrate as any potential salary gain from doing so is offset by their strong preferences for their current location. If the distribution is zero variance $s = \infty$ and wages are perfectly equalized across regions as the only thing workers value about a region is the potential wage. Second, if we consider that local housing supply has positive slope, elasticity of migration with respect to nominal wage changes will be attenuated by the hike of local housing prices. Thus, s will be proportional to the inverse of the sum of the slope of local housing supply and the strength of idiosyncratic location preferences.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

duces their returns in manufacturing. On the other hand, the return to local factors in the advanced sector depends positively on the number of skilled workers due to factor complementarity.

In the second place, advanced sectors from every region compete at the national level against other regions' advanced sectors to attract skilled labor. The direction of the flow depends on the competitive salary offered to workers. Again, the productivity of skilled employees in a region depends positively on how intensive in the advanced sector is the region.

Both flows feedback each other. A region that displaces more factors from manufacturing to the advanced sector increases its productivity in the latter, attracting skilled workers. An advanced sector with more skilled workers hoards up a larger fraction of local factors.

2.4 Impact of Trade

As stated above, I show the differential relocation of productive factors between sectors following a negative trade shock. I model the import competition shock as a drop in the price at which manufacturing producers in a city sell their products ($P_1 < P_0$). It is important to notice that the price drop is the same in every region. However, the magnitude of the shock will not be the same in every city as long as the share of factors employed in the manufacturing sector differs. Therefore, the magnitude of sector change will be directly affected by $\mathbb{M}_c$.

In order to properly understand the underlying mechanism, I present the case without skilled-workers mobility as an intermediate step. I show how the reallocation of locally supplied factors depends on regional characteristics. Afterwards, I analyze the uneven consequences of such reallocation of local factors on the productivity of skilled workers. Finally, as long as skilled workers are geographically mobile, there will be a migration of this type of workers following the reallocation of local factors.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

2.4.1 Trade shock without geographical mobility

The negative shock to the price of manufacturing goods decreases the profitability of employing locally-supplied factors (office space and unskilled workers), so part of those resources are transferred to the advanced one. This transfer happens in every region, but the magnitude will depend on the relative size of the local manufacturing sector. Those regions with a high specialization in manufacturing will have a larger inflow of factors to the advanced sector. Assuming that skilled workers are not geographically mobile, the relevant elasticities are the ones of sectoral reallocations. The elasticty of office space in the advanced sector with respect to the price of manufacturing goods is proportional to the share of local office space used in the manufacturing sector.

$$\frac{\partial \ln O_A}{\partial \ln P_M} = -\frac{1}{1-\alpha}\frac{O_M}{\overline{O}}$$

And the elasticity of unskilled labor employed in the advanced sector with respect to the price of manufacturing goods is

$$\frac{\partial \ln L_A}{\partial \ln P_M} = -\frac{1}{(1-\alpha)(1-\sigma)}\left[1+\frac{1-\psi}{\psi}\left(\frac{L_A}{\mathbb{X}H}\right)^{\sigma}\right]$$

Productivity of skilled workers

Producers in the advanced sector pay competitive wages for skilled workers. The total effect from reallocating locally-supplied factors from manufacturing to the advanced sector on the productivity of skilled workers breaks down into two terms with opposite signs. On the one hand, employing a larger fraction of office space in the advanced sector has a net positive effect on the productivity of skilled workers. This is due to the complementarity of labor component and office space. As argued above, this magnitude will be larger in more manufacturing-intensive regions.

On the other hand, the cheaper unskilled labor will have a negative effect on the demand

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

for skilled labor. There are two reasons for that. First, the substitution effect between the two types of labor. Second, the flood of unskilled workers reduces the skill-enhancing externalities. However, the extent of this effect depends on the prior level of skill intensity of the advanced sector. Given the concavity of $\mathbb{X}_c$ with respect to the skill density in the advanced sector, the drop is larger in areas where the non-manufacturing sector is less skill-intensive. The same inflow of unskilled workers can critically affect organizational or managerial practices that benefit skilled labor if the share of skilled workers is low. Instead, if the advanced sector employs a vast majority of skilled labor, the inflow of unskilled workers will barely affect the productivity of their skilled counterparts.

$$\frac{\partial \ln w_H}{\partial \ln P_M} = \alpha \underbrace{\frac{\ln O_A}{\partial \ln P_M}}_{\mathbb{M}_c} + \underbrace{\left[(1-\alpha-\sigma)\frac{\psi L_A^{\sigma}}{\psi L_A^{\sigma} + (1-\psi)\,\mathbb{X} H^{\sigma}} + \frac{\partial \ln \mathbb{X}}{\partial \ln L_A}\right]}_{\mathbb{H}_c} \cdot \underbrace{\frac{\partial \ln L_A}{\partial \ln P_M}}_{\mathbb{M}_c} \tag{2.1}$$

Then the trade shock will shift the demand for skilled workers in the advanced. However, the direction will depend on the prior characteristics of the region. On those cities a large existing stock of skilled the first term in eq. (2.1) will dominate, as long as the loss in specialization externalities will be low. Instead, in regions where the advanced sector was not highly skill intensive, the second term will dominate. The gains from using a larger share of office space in the advanced sector will be offset by the losses in externalities. Thus, $\mathbb{H}_c$ (skill intensity) determines the sign of the effect on skilled wages, while $\mathbb{M}_c$ (manufacturing intensity) determines the absolute magnitude of the effect.

2.4.2 Trade shock with geographical mobility

The uneven change in wages of skilled workers across regions induces movement of this type of workers to cities with higher wages. This ignites a spiral of divergence. In regions attracting skilled workers, its wage will further increase. This is a consequence of an

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

even higher skill density in the advanced sector, as well as the fact that those regions will reallocate even more office space away from the manufacturing to the advanced sector. On the other hand, the reallocation of factor will unravel in regions losing skilled workers. In regions with outflows of skilled workers, the return of local factors in the advanced sector decreases. Then, the factors previously reallocated away from manufacturing return to the sector.

A nation-wide negative shock in the manufacturing sector makes the advanced sector in skill-intensive regions to grow at the expense of their respective manufacturing sectors (by using more offices space and unskilled workers) and at the expense of the advanced sector in low-skill intensity regions (by attracting skilled workers).

On the other hand, the reallocation of factors from manufacturing to the advanced sector is reversed in regions with low prior skill intensity. The dry up of skilled labor intensity inflicts a negative productivity shock in the advanced sector. Then, the negative productivity shock in the advanced sector compensates the negative shock in manufacturing.

The model provides testable implications. The effect of a national negative shock to manufacturing will have a different effect according to the prior manufacturing and skill-intensive of the region.

- A skill-intensive region with high exposure to competition:
  - becomes relatively more skill intensive
  - increases its skill wage premium
  - reallocates more resources from manufacturing to the advanced sector
- A low skill-intensity region with high exposure to competition:
  - losses skilled population
  - reduces its skilled wages

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

- A region with low exposure to competition:
  - smaller effects than regions with similar education and higher exposure

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

2.A Derivation of equilibrium office space allocation

$$P_M \cdot Y_M = P_M \cdot \mathbb{M} \cdot O_M^{\alpha} L_M^{1-\alpha} \tag{2.2}$$

$$r_M = \alpha \cdot P_M \cdot \mathbb{M} \cdot O_M^{\alpha-1} L_M^{1-\alpha} \tag{2.3}$$

$$Y_A = O_A^{\alpha} \cdot \left(\psi \cdot L_A^{\sigma} + (1-\psi)\,\mathbb{X} \cdot H^{\sigma}\right)^{\frac{1-\alpha}{\sigma}} \tag{2.4}$$

$$r_A = \alpha \cdot O_A^{\alpha-1} \cdot \left(\psi \cdot L_A^{\sigma} + (1-\psi)\,\mathbb{X} \cdot H^{\sigma}\right)^{\frac{1-\alpha}{\sigma}} \tag{2.5}$$

$$\alpha P_M \mathbb{M} O_M^{\alpha-1} L_M^{1-\alpha} = \alpha O_A^{\alpha-1} \left(\psi L_A^{\sigma} + (1-\psi)\,\mathbb{X} H^{\sigma}\right)^{\frac{1-\alpha}{\sigma}} \tag{2.6}$$

$$\frac{O_A}{O_M} = \frac{O_A}{\overline{O} - O_A} = (P_M \mathbb{M})^{\frac{1}{1-\alpha}} \cdot \frac{\left(\psi L_A^{\sigma} + (1-\psi)\,\mathbb{X} H^{\sigma}\right)^{\frac{1}{\sigma}}}{L_M} \frac{\partial \ln O_A}{\partial \ln P_M} = -\frac{1}{1-\alpha} \frac{O_M}{\overline{O}} \tag{2.7}$$

2.B Derivation of equilibrium unskilled labor

$$P_M \cdot Y_M = P_M \cdot \mathbb{M} \cdot O_M^{\alpha} L_M^{1-\alpha} \tag{2.8}$$

$$w_M = (1-\alpha) \cdot P_M \cdot \mathbb{M} \cdot O_M^{\alpha} \cdot L_M^{-\alpha} \tag{2.9}$$

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

$$Y_A = O_A^{\alpha} \cdot \left(\psi \cdot L_A^{\sigma} + (1-\psi)\,\mathbb{X} \cdot H^{\sigma}\right)^{\frac{1-\alpha}{\sigma}} \tag{2.10}$$

$$w_A = (1-\alpha) \cdot O_A^{\alpha} \cdot \left(\psi \cdot L_A^{\sigma} + (1-\psi)\,\mathbb{X} \cdot H^{\sigma}\right)^{\frac{1-\alpha}{\sigma}-1} \cdot \psi \cdot L_A^{\sigma-1} \tag{2.11}$$

$$P_M \cdot \mathbb{M} \cdot O_M^{\alpha} \cdot L_M^{-\alpha} = O_A^{\alpha} \cdot \left(\psi \cdot L_A^{\sigma} + (1-\psi)\,\mathbb{X} \cdot H^{\sigma}\right)^{\frac{1-\alpha}{\sigma}-1} \cdot \psi \cdot L_A^{\sigma-1} \tag{2.12}$$

$$\frac{L_A^{1-\sigma}}{L_M^{\alpha}} = \left(\frac{O_A}{O_M}\right)^{\alpha} \cdot \left(\psi \cdot L_A^{\sigma} + (1-\psi)\,\mathbb{X} \cdot H^{\sigma}\right)^{\frac{1-\alpha}{\sigma}-1} \frac{1}{P_M \cdot \mathbb{M}} \tag{2.13}$$

Plugging from equilibrium values of office space

$$L_A^{1-\sigma} = \left(P_M \mathbb{M}\right)^{-\frac{1}{1-\alpha}} \cdot \left(\psi \cdot L_A^{\sigma} + (1-\psi)\,\mathbb{X} \cdot H^{\sigma}\right)^{\frac{1-\sigma}{\sigma}} \tag{2.14}$$

$$\frac{\partial \ln L_A}{\partial \ln P_M} = -\frac{1}{(1-\alpha)\,(1-\sigma)}\left[1 + \frac{1-\psi}{\psi}\left(\frac{L_A}{\mathbb{X}H}\right)^{\sigma}\right] \tag{2.15}$$

2.C Derivation of skilled wages

$$w_H = O_A^{\alpha}\frac{1-\alpha}{\sigma}\left(\psi L_A^{\sigma} + (1-\psi)\,\mathbb{X}H^{\sigma}\right)^{\frac{1-\alpha-\sigma}{\sigma}}(1-\psi)\,\mathbb{X}\sigma H^{\sigma-1} \tag{2.16}$$

$$\ln w_H = \alpha \ln O_A + \ln(1-\psi) + \frac{1-\alpha-\sigma}{\sigma}\ln\left(\psi L_A^{\sigma} + (1-\psi)\,\mathbb{X}H^{\sigma}\right) + \ln \mathbb{X} - (1-\sigma)\ln H \tag{2.17}$$

$$\frac{\partial \ln w_H}{\partial \ln P} = \alpha\frac{\ln O_A}{\partial \ln P} + \left[(1-\alpha-\sigma)\,\frac{\psi L_A^{\sigma}}{\psi L_A^{\sigma} + (1-\psi)\,\mathbb{X}H^{\sigma}} + \frac{\partial \ln \mathbb{X}}{\partial \ln L_A}\right] \cdot \frac{\partial \ln L_A}{\partial \ln P} \tag{2.18}$$

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Chapter 3

A New Measure of Utilization-Adjusted Total Factor Productivity Growth

3.1 Introduction

Total Factor Productivity (TFP) is among the most important concepts in macroeconomics, playing a crucial role both in the analysis of long-run growth and short-run fluctuations. Robert Solow's groundbreaking 1957 article defined TFP growth as the change in real output that cannot be attributed to changes in factor inputs. However, computing this "Solow residual" is subject to a large number of measurement challenges. In this paper, we focus on one particularly important challenge: the correct measurement of inputs. Standard datasets measure capital stocks and hours worked, but not the utilization rate of machines or the number of productive tasks undertaken during an hour of work. However, the latter margins fluctuate considerably over time. Ignoring these fluctuations leads to a biased measure of capital and labour input, and therefore to a biased measure of TFP growth.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Over time, many economists have tried to tackle this issue. The most successful approach is due to a series of papers by Basu, Fernald and Kimball (see, for instance, Basu and Fernald (2001), Basu et al. (2006) and Fernald (2014b)). The main insight in these papers is that cost-minimizing firms simultaneously adjust unobservable margins such as the utilization rate of machines and observable margins such as hours per worker. Under some technical assumptions on production functions and adjustment costs, there is a constant elasticity between observable and unobservable margins, so that changes in hours per worker can be used as a proxy for unobservable utilization changes. Therefore, a utilization-adjusted measure of TFP growth can be obtained as the residual of a regression of the unadjusted Solow residual (typically computed at the industry-level) on changes in hours per worker, instrumenting the latter with shocks that are exogenous to TFP. Basu, Fernald and Kimball (henceforth, BFK) have used this methodology to produce utilization-adjusted TFP growth series for the United States which have become a standard reference in macroeconomics.[1] However, there are no similar series for European countries: the OECD, the European Commission and EU KLEMS all provide annual TFP growth rates, but these are not utilization-adjusted. Given Europe's economic importance, this lack of data significantly constrains research about TFP dynamics.

Our paper attempts to fill this knowledge gap, making two main contributions. First, we show that using hours per worker as a utilization proxy has significant drawbacks for several European countries, and propose an alternative adjustment method. Second, we use our method to provide utilization-adjusted series for five European countries (and for the United States), both at the industry and at the aggregate level.

A straightforward way to obtain utilization-adjusted TFP series for Europe would be to apply the BFK methodology to European data. However, we show that this is problem-

[1] A quarterly version of the series is regularly updated at `https://www.frbsf.org/economic-research/indicators-data/total-factor-productivity-tfp/`. In contrast to the annual series, which uses industry-level data, the quarterly series only relies on aggregate data. In November 2018, Fernald's paper describing the data had 447 Google Scholar citations, illustrating its widespread use.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

atic, as changes in hours per worker are a poor proxy for changes in factor utilization in some European countries. The most striking example is Spain, where hours per worker slightly increase during the 2008/2009 Great Recession. Thus, the BFK methodology would suggest that Spanish firms increased their labour and capital utilization during these years, which seems strongly counterfactual. To make this point more formally, we compare (industry-level) changes in hours per worker with an independent survey-based measure of capacity utilization, collected by the Federal Reserve or the European Commission. In the United States and in some European countries such as Germany, the two measures are highly correlated. However, in other countries, such as Spain or the United Kingdom, they are not (for instance, the survey indicates a massive fall in Spanish capacity utilization in 2008/2009). One reason for the counterintuitive movements of hours per worker in Spain and in other countries could be composition effects between temporary and permanent workers. Formally, we show that if hours and employment of both types of workers react differently to shocks, movements in aggregate hours per worker are no longer a good proxy, as the elasticity between aggregate hours per worker and unobserved utilization becomes time-varying. Spanish labour market data shows that both types of workers were indeed very differently affected by the Great Recession, confirming the relevance of this issue.

Given these problems, we propose a different adjustment method, using the aforementioned survey measures as a proxy for unobservable utilization changes. In practice, this amounts to estimating a BFK-style regression of industry-level Solow residuals on changes in the survey-based measure of capacity utilization, where the latter is instrumented with shocks that are orthogonal to TFP. We implement this methodology using annual industry-level growth accounting data from EU and World KLEMS for the United States and the five largest European economies, covering a time span between 25 and 40 years. We use as instruments shocks to monetary policy, oil prices, and financial conditions. Estimating the BFK regressions (using hours per worker as a utilization proxy)

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

on this sample provides further confirmation for the anticipated problems: instruments are often weak, and the estimated elasticities between hours per worker and unobserved utilization are sometimes negative. Using the survey as a proxy considerably improves the regressions' performance: instruments are stronger, and almost all estimated elasticities are positive.

The utilization-adjusted TFP series that we obtain is generally less volatile than the KLEMS Solow residuals, and much less correlated with aggregate output growth. Unsurprisingly, in countries in which hours per worker are highly correlated with the utilization survey (such as the United States and Germany), our series is highly correlated with the one obtained using the BFK methodology. However, in countries where hours and utilization surveys are virtually uncorrelated (such as in Spain or the United Kingdom), the series are quite different. Perhaps the most striking result from the new series is a sizeable upward correction of Spanish and Italian TFP growth in the first years of the Great Recession, consistent with a cleansing effect. In future work, we plan to further investigate these movements, using firm-level data. We also want to analyze the role of adjustment costs for growth accounting and for aggregate fluctuations, and extend our results to a quarterly frequency.

Our paper is related to a large literature on productivity measurement, especially to efforts to account for changing factor utilization. Solow (1957) was already well aware of the issue, and in his seminal paper assumed that the fraction of capital not used in production was equal to the unemployment rate.[2] In later research, Costello (1993) proposed using electricity consumption as a proxy for capital services. Burnside et al. (1995) also used electricity consumption (and hours per worker) to infer the capital utilization rate at a quarterly level.[3] Finally, Imbs (1999) developed a alternative model-based methodology

[2]In Solow's words, "*What belongs in a production function is capital in use, not capital in place. [...] Lacking any reliable year-by-year measure of the utilization of capital I have simply reduced the Goldsmith figures [for the capital stock] by the fraction of the labor force unemployed in each year, thus assuming that labor and capital always suffer unemployment to the same percentage. This is undoubtedly wrong, but probably gets closer to the truth than making no correction at all.*"

[3]The major difference between their approach and BFK is that Burnside et al. assume a unit elasticity

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

for a utilization adjustment, using aggregate data. Currently, the BFK methodology is the leading approach on this issue, but its application has been largely limited to US data. The only exception, to the best of our knowledge, is Levchenko and Pandalai-Nayar (2018), who use the standard BFK methodology to calculate utilization-adjusted TFP series for a large panel of countries (imposing that the relationship between hours per worker and unobserved utilization is the same in all countries). In contrast, we stress the limitations of the hours per worker proxy, and propose an alternative adjustment.

Besides factor utilization, TFP measurement obviously faces a line of other challenges. For instance, we also rely on the insights from the extensive literature on the aggregation of firm or industry-level TFP growth (see Hulten (1978) and Baqaee and Farhi (2017)). However, we abstract from other issues, such as the ones relating to the correct measurement of output in the presence of quality improvements, especially for new products or products subject to creative destruction (Boskin et al. (1996), Aghion et al. (2017)). Even though these issues are clearly important for long-run growth, they are less likely to matter for short-run TFP fluctuations.

The remainder of the paper is organized as follows. Section 3.2 discusses the assumptions underlying the BFK methodology. Section 3.3 illustrates the limitations of the methodology for European data, and discusses our alternative approach. Section 3.4 describes the data, presents our empirical results and analyses the properties of the resulting new TFP series. Section 3.5 concludes.

between changes in hours per worker and capital utilization, while BFK estimate it.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

3.2 Growth accounting with fluctuations in factor utilization

3.2.1 Assumptions

The growth accounting problem

Consider an economy with I industries. In each industry i, a representative firm produces with the production function

$$Y_{it} = Z_{it} F_i \left(K_{it}, L_{it}, M_{it} \right), \tag{3.1}$$

where K_{it} is the capital input, L_{it} the labour input, M_{it} materials and Z_{it} a Hicks-neutral residual, to whom we refer from now on as TFP. F_i is homogeneous of degree γ_i in the three production factors. Then, up to a first-order approximation, we can write the growth rate of industry output as

$$dY_{it} = \frac{\partial F_i}{\partial K_{it}} \frac{K_{it}}{F_i} dK_{it} + \frac{\partial F_i}{\partial L_{it}} \frac{L_{it}}{F_i} dL_{it} + \frac{\partial F_i}{\partial M_{it}} \frac{M_{it}}{F_i} dM_{it} + dZ_{it}, \tag{3.2}$$

where for any variable X, $dX_{it} \equiv \ln\left(X_{it+1}\right) - \ln\left(X_{it}\right)$. Equation (3.2) shows that in order to decompose output growth into input growth and TFP growth, we need to know the elasticities of the production function with respect to the inputs. The fundamental insight of the growth accounting literature, due to Solow (1957) and Hall (1988), is that these elasticities can be related to observable quantities using the optimality conditions of a cost-minimizing firm. In the next section, we lay out a variation of the dynamic model of cost minimization of Basu and Fernald (2001) and Basu et al. (2006), which underlies our empirical work.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

A dynamic cost minimization problem

The representative firm takes factor prices as given and needs to carry out a sequence of productions $(Y_t)_{t\in\mathbb{N}}$.[4] We assume that labour input L_t is given by $E_t H_t N_t$, where N_t is the number of workers, H_t is the number of hours per worker, and E_t is the number of productive tasks that a worker undertakes in one hour ("worker effort"). While effort and hours per worker can be adjusted within the period, the level of employment must be chosen one period before production takes place. The total wage bill in period t equals $w_t N_t G(H_t, E_t)$, where G is increasing and convex in both arguments. Adjusting employment is costly: to hire A_t workers in period t (who can start production in period $t+1$), the firm needs to pay an adjustment cost $w_t N_t \Psi\left(\frac{A_t}{N_t}\right)$, where Ψ is increasing, convex, and holds $\Psi(0) = \Psi'(0) = 0$. Finally, the firm owns its capital stock. The law of motion of capital is given by $K_{t+1} = (1-\delta) K_t + I_t$, and the cost of investing I_t units in period t are $P_t^I K_t \Phi\left(\frac{I_t}{K_t}\right)$, where Φ is increasing, convex, and holds $\Phi(\delta) = \delta$, $\Phi'(\delta) = 1$. The cost minimization problem of the firm is thus given by

$$\begin{gathered}\min \mathbb{E}_0\left(\sum_{t=0}^{+\infty}\left(\prod_{s=0}^{t}\frac{1}{1+r_s}\right)\left(w_t N_t G(H_t,E_t) + P_t^M M_t + w_t N_t \Psi\left(\frac{A_t}{N_t}\right) + P_t^I K_t \Phi\left(\frac{I_t}{K_t}\right)\right)\right) \\ \text{such that} \\ N_{t+1} = N_t + A_t \\ K_{t+1} = (1-\delta) K_t + I_t \\ Y_t = Z_t \widetilde{F}(U_t K_t, E_t H_t N_t, M_t) = Z_t F(K_t, E_t H_t N_t, M_t).\end{gathered} \tag{3.3}$$

This model is identical to the one in BFK, with one important exception: BFK consider the utilization rate of capital U_t as an independent production factor and assume that it has a wage cost, so that the total wage bill is given by $w_t G(H_t, E_t) V(U_t) N_t$. We think that this way of modeling capital utilization has unconvincing implications. For instance, it implies that the wage bill may change even if the numbers, hours and effort of the firm's

[4] For convenience, we drop the industry subscript i from now on.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

workforce remain unchanged. More importantly still, it implies that the firm can change the utilization rate of its buildings or machines without changing its workforce, hours, effort and/or materials. However, it is hard to imagine any production process in which this would be possible.

In contrast, we consider the utilization rate of capital as an outcome that depends on the relative use of labour and materials with respect to the capital stock. Intuitively, this captures the fact that machines and buildings cannot produce by themselves. For example, the utilization rate of a machine depends on how many hours it is operated by workers, how much electricity it consumes, and how many material inputs it receives. The utilization rate of a bank branch building depend on how many clerks work in the bank, and on how many customers they serve within an hour of work. Formally, U_t is a function of K_t, L_t and M_t, and therefore does not appear in our reduced-form production function F. This modeling choice provides a useful clarification on the fundamental problem posed by changes in factor utilization. As the utilization rate is a function of inputs, there would be no problem if all other inputs to production are perfectly observable. The crux of the matter is precisely that they are not: in particular, the effort of workers E_t is essentially never observed in real-world datasets. It is this unobservability that justifies the use of proxies, not the fact that capital utilization fluctuates.

As we will see later, this conceptual difference with respect to the BFK framework has actually no direct implications for measurement, as it does not affect the reduced-form measurement equation. Nevertheless, we believe that it does simplify the model and clarifies the issue at hand. We are now ready to proceed to the issue of how to do growth accounting in this model.

Optimality conditions

The Bellman Equation of the problem shown in (3.3) is

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

$$V_t(N_t, K_t) = \min \left(w_t N_t G(H_t, E_t) + P_t^M M_t + w_t N_t \Psi\left(\frac{A_t}{N_t}\right) + P_t^I K_t \Phi\left(\frac{I_t}{K_t}\right) + \frac{\mathbb{E}_t\left(V_{t+1}(N_{t+1}, K_{t+1})\right)}{1+r_t} \right) \quad (3.4)$$

$$\text{such that} \quad N_{t+1} = N_t + A_t; \quad K_{t+1} = (1-\delta) K_t + I_t; \quad \text{and } Y_t = Z_t F(K_t, E_t H_t N_t, M_t)$$

The first-order condition for the three inputs choosen within-period are then

$$w_t N_t \frac{\partial G}{\partial H_t} = \lambda_t Z_t \frac{\partial F}{\partial L_t} E_t N_t, \quad (3.5)$$

$$w_t N_t \frac{\partial G}{\partial E_t} = \lambda_t Z_t \frac{\partial F}{\partial L_t} H_t N_t, \quad (3.6)$$

$$\text{and } P_t^M = \lambda_t Z_t \frac{\partial F}{\partial M_t}, \quad (3.7)$$

where λ_t is the Lagrange multiplier on the output constraint, measuring the firms (intertemporal) marginal cost. For the investment in new workers and capital goods, we get

$$w_t \Psi'\left(\frac{A_t}{N_t}\right) + \frac{1}{1+r_t} \mathbb{E}_t \left(\frac{\partial V_{t+1}}{\partial N_{t+1}}\right) = 0, \quad (3.8)$$

$$P_t^I \Phi'\left(\frac{I_t}{K_t}\right) + \frac{1}{1+r_t} \mathbb{E}_t \left(\frac{\partial V_{t+1}}{\partial K_{t+1}}\right) = 0. \quad (3.9)$$

Finally, the envelope conditions on employment and capital yield

$$\frac{\partial V_t}{\partial N_t} = w_t G(H_t, E_t) + w_t \Psi\left(\frac{A_t}{N_t}\right) - w_t \frac{A_t}{N_t} \Psi'\left(\frac{A_t}{N_t}\right) - \lambda_t Z_t \frac{\partial F}{\partial L_t} E_t H_t + \frac{1}{1+r_t} \mathbb{E}_t \left(\frac{\partial V_{t+1}}{\partial N_{t+1}}\right), \quad (3.10)$$

$$\frac{\partial V_t}{\partial K_t} = P_t^I \Phi\left(\frac{A_t}{N_t}\right) - P_t^I \frac{I_t}{K_t} \Phi'\left(\frac{A_t}{N_t}\right) - \lambda_t Z_t \frac{\partial F}{\partial K_t} + \frac{1-\delta}{1+r_t} \mathbb{E}_t \left(\frac{\partial V_{t+1}}{\partial K_{t+1}}\right). \quad (3.11)$$

From these first-order conditions, we can now deduce an expression for the production function elasticities as a function of observable quantities.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

3.2.2 Fundamental growth accounting results

Elasticities and factor shares

Define a firm's mark-up as $\mu_t = \frac{P_t}{\lambda_t}$. Then, from Equation (3.7), we get

$$\frac{\partial F}{\partial M_t}\frac{M_t}{F} = \mu_t \frac{P_t^M M_t}{P_t Y_t}. \tag{3.12}$$

That is, the elasticity of the production function with respect to materials equals the (observable) sales share of materials, multiplied by the mark-up.

Combining Equations (3.8) and (3.10), we get an expression for the elasticity of the production function with respect to labour input:

$$\frac{\partial F}{\partial L_t}\frac{L_t}{F} = \mu_t \frac{w_t N_t G\left(H_t, E_t\right) + w_t N_t \Psi\left(\frac{A_t}{N_t}\right) + \frac{1}{1+r_t} N_{t+1}\mathbb{E}_t\left(\frac{\partial V_{t+1}}{\partial N_{t+1}}\right) - N_t \mathbb{E}_t\left(\frac{\partial V_t}{\partial N_t}\right)}{P_t Y_t}. \tag{3.13}$$

Likewise, by combining Equations (3.9) and (3.11), we get an equivalent expression for capital:

$$\frac{\partial F}{\partial K_t}\frac{K_t}{F} = \mu_t \frac{P_t^I K_t \Phi\left(\frac{I_t}{K_t}\right) + \frac{1}{1+r_t} K_{t+1}\mathbb{E}_t\left(\frac{\partial V_{t+1}}{\partial K_{t+1}}\right) - K_t \mathbb{E}_t\left(\frac{\partial V_t}{\partial K_t}\right)}{P_t Y_t}. \tag{3.14}$$

Thus, labour and capital elasticities are also equal to the sales share of these two factors multiplied by the mark-up. However, importantly, the sales share is not limited to current expenses, but also includes adjustment costs, and the shadow value of having a high labour or capital stock today (which allows the firm to avoid paying adjustment costs in the future).

Steady state results

To make further progress, BFK assume that the industry is always in the neighbourhood of the steady state. Then, we can interpret Equation (3.2) as a first-order approximation around that steady state, where the elasticities are equal to their steady state values.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

This considerably simplifies the task of relating the elasticities to observables, because BFK's assumptions on adjustment costs imply that these are zero in the steady state. For instance, we can combine Equations (3.8) and (3.13), using the fact that $A^* = 0$ (stars denote steady-state variables) and $\Psi(0) = \Psi'(0) = 0$, to get

$$\frac{\partial F}{\partial L^*}\frac{L^*}{F} = \mu^* \frac{wN^* G(H^*, E^*)}{P^* Y^*}. \tag{3.15}$$

Thus, in the steady state, the labour elasticity is just equal to the product of the (observable) labour share of sales and the steady-state markup. In the same way, combining equations (3.9) and (3.13) and using $\frac{I^*}{K^*} = \delta$ as well as $\Phi(\delta) = \delta$ and $\Phi'(\delta) = 1$ yields

$$\frac{\partial F}{\partial K^*}\frac{K^*}{F} = \mu^* \frac{(r^* + \delta) P^{I*} K^*}{P^* Y^*}. \tag{3.16}$$

Note that the basic logic does not change in the (empirically more relevant) case of a balanced growth path (BGP). However, we do need to slightly change our assumptions on adjustment costs. To be concrete, Equations (3.12) to (3.14) continue to hold on the BGP. Then, assuming that adjustment costs are zero on the BGP (both in levels and at the margin), the BGP elasticities are still given by Equations (3.15) and (3.16), where asteriscs now denote BGP values.

Accounting and Aggregation

Using our previous results, we can now derive a first measurement equation. To do so, note that the degree of homogeneity of the production function γ equals the sum of the three elasticities, so that we have $\gamma = \mu^* (s_K^* + s_L^* + s_M^*)$, where s_F^* is the sales share of expenditure on production factor F in the steady state. BFK make the crucial assumption that there are no pure profits, that is, the sales shares of all factors sum to 1. Thus, the sales share of capital can be computed as $s_K^* = 1 - s_L^* - s_M^*$, which is important in practice, as it is difficult to measure the return to capital. This also implies $\gamma = \mu^*$. Using these

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

insights, we can now write the growth accounting Equation (3.2) as

$$dY_{it} = \gamma_i \left(s^*_{Ki} dK_{it} + s^*_{Li} \left(dN_{it} + dH_{it} + dE_{it} \right) + s^*_{Mi} dM_{it} \right) + dZ_{it}. \tag{3.17}$$

Thus, to compute industry-level TFP growth dZ_{it}, we need to know the value of the parameter γ_i, the growth rates of output and inputs, and factor shares (except for capital).[5] Finally, following Hulten (1978), industry-level growth rates can be aggregated up to aggregate TFP growth by calculating a sales-weighted average[6] of industry-level TFP changes:

$$dZ_t = \sum_{i=1}^{I} \frac{P_{it} Y_{it}}{P_t Y_t} dZ_{it}. \tag{3.18}$$

In practice, of course, we cannot directly calculate dZ_{it}, as changes in worker effort (dE_{it}) are not observable. In the next section, we describe how the BFK methodology addresses this issue.

3.2.3 Unobserved short-run fluctuations

A proxy for unobserved changes in worker effort

To find a proxy for changes in worker effort dE_{it}, note that the first-order conditions on hours and effort, Equations (3.5) and (3.6), imply the elasticity of wage costs to effort must always equal the elasticity of wage cost to hours:

$$\frac{\partial G}{\partial H_{it}} \frac{H_{it}}{G} = \frac{\partial G}{\partial E_{it}} \frac{E_{it}}{G}. \tag{3.19}$$

[5] Recall that factor shares should be computed at the steady state. BFK implement this by taking simple averages of the time series for factor shares.

[6] Hulten showed that in an efficient economy with an arbitrary input-output structure, Equation (3.18) is true up to a first-order approximation. This result does not hold in the presence of distortions, as industry-level productivity shocks change the allocation of resources. In an efficient economy, the allocation is optimal to begin with, and the first-order effect of changes in allocation on aggregate productivity is zero. In an inefficient economy, this is not true any more (Baqaee and Farhi (2017)). Note, furthermore, that BFK use a slight variation of Equation (3.18) by calculating Törnqvist indexes (which use a simple average of sales shares to weight industry-level TFP growth rates). That is, $dZ_t = \sum_{i=1}^{I} \frac{1}{2} \left(\frac{P_{it-1} Y_{it-1}}{P_{t-1} Y_{t-1}} + \frac{P_{it} Y_{it}}{P_t Y_t} \right) dZ_{it}$.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Therefore, as long as G is such that there is a one-to-one mapping between E_{it} and H_{it}, we can write, as a first-order approximation, $dE_{it} = \zeta_i dH_{it}$, where ζ_i is the (unknown) elasticity of effort with respect to hours. Replacing this into Equation (3.17), we get the final measurement equation:

$$\begin{gathered} dY_{it} = \gamma_i dX_{it} + \beta_i dH_{it} + dZ_{it}, \\ \text{where } dX_{it} = s^*_{Ki} dK_{it} + s^*_{Li} \left(dN_{it} + dH_{it}\right) \text{ and } \beta_i \equiv s^*_{Li}\zeta_i. \end{gathered} \tag{3.20}$$

While the elasticity β_i (and the degree of homotheticity γ_i) are not directly observable, they can be estimated as regression coefficients. The next section briefly discusses how this is done in practice.

Empirical implementation

Estimating the parameters β_i and γ_i in Equation (3.20) using OLS faces a simultaneity issue: firms choose inputs knowing productivity, and therefore input choices are correlated with dZ_{it}. To solve this issue, BFK propose an IV approach, using oil price, fiscal policy and monetary policy shocks as instruments for dX_{it} and dH_{it}. It is worthwhile to note two implementation details. First, in order to increase power, BFK restrict coefficients to be equal across three broad industry groups (durable manufacturing, nondurable manufacturing, and non-manufacturing). Second, as hours per worker have a downward trend, they detrend the natural logarithm of this series using the Christiano and Fitzgerald (2003) band pass filter, isolating components between 2 and 8 years, and use the first difference of the detrended series as their measure of dH_{it}.

A straightforward way to obtain utilization-adjusted TFP series for Europe would be to apply the BFK methodology outlined in this section to European data. However, given the important institutional differences between Europe and the United States (and between European countries themselves), it may be worthwhile to ask whether changes in hours per worker are indeed a good proxy for capacity utilization everywhere. As we explain in

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

greater detail in the next section, this does not appear to be the case.

3.3 Hours per worker and factor utilization

3.3.1 Fluctuations in hours per worker over the business cycle

Throughout the paper, we focus on the five largest European economies: Germany, France, Spain, Italy and the United Kingdom. For comparison purposes, we also always consider the United States.

Figure 3.3.1 summarizes fluctuations in hours per worker for these six countries. Data on hours per worker are annual and cover the business economy, with the exception of agriculture and mining. They are taken from EU KLEMS (for European countries) and World KLEMS (for the United States).[7] Following BFK, we detrend the logarithm of the series using a band pass filter, isolating components between 2 and 8 years, and plot first differences of this series (i.e., the BFK utilization proxy). Shaded bars indicate recession years.[8]

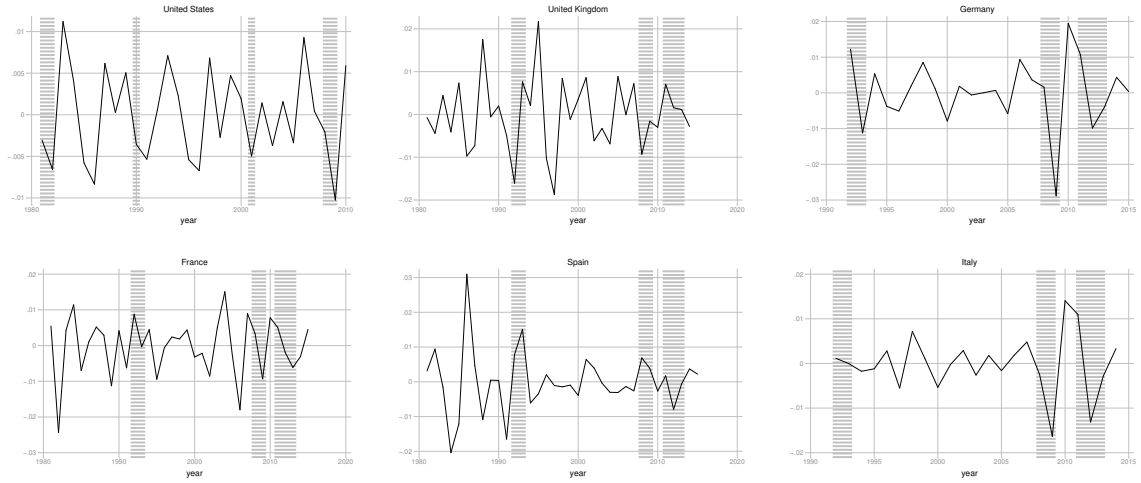
In some countries, hours per worker closely track the business cycle. This is true, for instance, for the United States and Germany, where hours per worker systematically fall during recessions. It is also broadly true for Italy, where hours per worker are stable over time, and only move in the large recessions of 2008/2009 and 2011/2013. However, for the other three countries, the situation is quite different. Spain is the most striking case: hours per worker increase in the 1992/1993 and 2008/2009 recessions, and fall only slightly in the 2011/2013 recession. Through the lens of the BFK methodology, this would suggest that Spanish firms increase their factor utilization during recessions, which seems counterintuitive. Likewise, for the United Kingdom (and to a lesser extend for France), hours per worker also do not seem to track the business cycle: they do not always fall

[7] Data sources are described in greater detail in Section 3.4 and Appendix 3.A.

[8] For the United States, recession dates are taken from the NBER. For European countries, recession dates are taken from the CEPR's Euro Area Business Cycle Dating Committee.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Figure 3.3.1: Fluctuations in hours per worker



Source: EU KLEMS, World KLEMS and authors' calculations. See main text for further details.

in recessions, and there are sometimes large variations which appear to be unrelated to aggregate fluctuations.

This limited comovement between hours per worker and the business cycle in some countries is a first warning sign, as one would typically expect factor utilization to fall in recessions. However, it does not directly discredit the use of hours per worker as a proxy: indeed, they are supposed to proxy for unobserved utilization, not for the state of the business cycle. Thus, in the next section, we compare the behaviour of hours per worker to another proxy of utilization changes, coming from capacity utilization surveys.

3.3.2 Comparing hours per worker and capacity utilization surveys

Both in Europe and in the United States, capacity utilization surveys have a long history. In Europe, the European Commission coordinates since the early 1990s a quarterly survey of manufacturing firms in each EU member state, asking each firm *"At what capacity is your company currently operating (as a percentage of full capacity)?"*. In the United

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

States, the Federal Reserve Board provides measures of capacity utilization for manufacturing and energy-producing firms, which are mostly based on the Census Bureau's Quarterly Survey of Plant Capacity (QSPC). This survey asks plants to report both their current production and their full production capacity, defined as "*the maximum level of production that this establishment could reasonably expect to attain under normal and realistic operating conditions fully utilizing the machinery and equipment in place*". Capacity utilization is defined as the ratio between the two numbers.[9]

If hours per worker and the survey capture the same cyclical variation in factor utilization, one would expect them to be highly correlated. Figure 3.3.2 examines this hypothesis for the manufacturing sector (the main focus of the utilization surveys), by comparing fluctuations in hours per worker to fluctuations in survey-based capacity utilization. Hours per worker measure are computed as in Figure 3.3.1, detrending the logarithm of the raw series with a band-pass filter. The utilization survey is aggregated across manufacturing industries with constant value added shares (see Appendix 3.A for details). We then take the logarithm of this variable and detrend it with a band-pass filter isolating frequencies between 2 and 16 years (this choice is due to the fact that the survey does not exhibit a long-run trend in many countries. We further comment on this choice in Section 3.3.4).

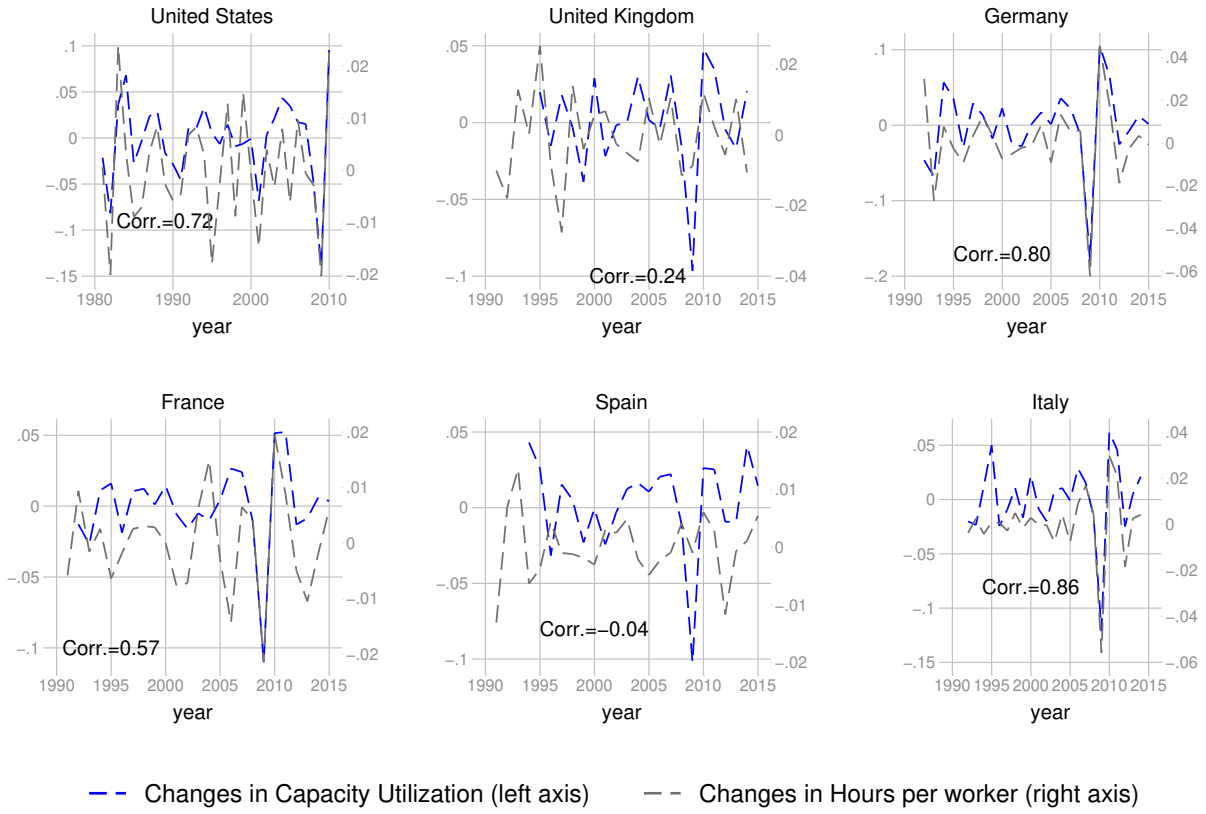
Figure 3.3.2 shows that in the United States, Germany and Italy, hours per worker are strongly procyclical also in the manufacturing sector. They are also highly correlated with survey-based capacity utilization, which is itself strongly procyclical. In Spain and in the United Kingdom, on the other hand, hours per worker and survey-based capacity utilization are virtually uncorrelated. This is most striking in the 2008/2009 recession, where hours per worker slightly increase in Spain and barely fall in the United Kingdom, but survey-based capacity utilization plunges in both countries. Finally, France is in an intermediate position between these two groups of countries.

Figure 3.3.2 seems to contradict the scepticism of many researchers about the information

[9]Both surveys are described in much greater detail in Section 3.4 and Appendix 3.A.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Figure 3.3.2: Capacity utilization and hours per worker in the manufacturing sector



Notes: See main text for a description of the series.

content of survey-based utilization measures, especially in the United States.[10] Indeed, US hours per worker and the survey are strongly correlated, meaning that if the former is a valid proxy for utilization, the latter must be as well. However, in general, the two potential utilization proxies do not perform equally well in all countries. In countries such as Spain and the United Kingdom, where the two measures strongly disagree, which one should we prefer? In our opinion, at least two arguments plead in favour of the survey. First, it behaves more reasonably during the Great Recession. Second, it is difficult to why the survey would be a better indicator in some countries than in others: it is administered

[10]For instance, Shapiro (1989) has criticized the Federal Reserve's capacity utilization measures on the grounds that full capacity was not a well-defined concept, and that it was not clear how firms answer the survey question.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

with the same questionnaire and protocol in Germany (where it is highly correlated with hours per worker) and in Spain (where it is not). On the other hand, it is easy to point out differences in labour market institutions which could explain differences in the cyclicality of hours per worker across countries. In the next section, we use the dynamic cost minimization problem from Section 3.2 to show how differences in adjustment costs across different types of workers can affect changes in aggregate hours per worker, and potentially make them an ineffective utilization proxy.

3.3.3 Worker heterogeneity and biases in the BFK methodology

In this section, we extend the framework laid out in Section 3.2 to allow for two types of labour, which we label A and B. The production function then becomes $F_i\left(K_{it}, L_{it}^A, L_{it}^B, M_{it}\right)$. Just as we allow for the two types of labour to enter differently in the production function, we also allow for adjustment costs (summarized by the G and Ψ functions) to be type-specific. It is then straightforward to show that Equation (3.20) becomes

$$\begin{aligned} dY_{it} &= \gamma_i \left(dX_{it} + dU_{it}\right) + dZ_{it}. \\ \text{with } dX_{it} &= s_{Ki}^* dK_{it} + s_{Li}^{A*}\left(dN_{it}^A + dH_{it}^A\right) + s_{Li}^{B*}\left(dN_{it}^B + dH_{it}^B\right) + s_{Mi}^* dM_{it} \ . \\ \text{and } \ dU_{it} &= s_{Li}^{A*} dE_{it}^A + s_{Li}^{B*} dE_{it}^B \end{aligned} \tag{3.21}$$

Just as in Section 3.2, we can show that there exist constants ζ_i^A and ζ_i^B such that, up to a first-order approximation, $dE_{it}^A = \zeta_i^A dH_{it}^A$ and $dE_{it}^B = \zeta_i^B dH_{it}^B$. Therefore, we can rewrite Equation (3.21) as

$$dY_{it} = \gamma_i dX_{it} + \beta_i^A dH_{it}^A + \beta_i^B dH_{it}^B + dZ_{it}, \tag{3.22}$$

where changes in hours per worker for each type proxy for changes in type-specific effort. When this model with heterogeneous workers is the data-generating process, we can

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

rewrite the BFK measurement equation (3.20) as

$$dY_{it} = \gamma_i dX_{it} + \beta_i dH_{it} + \chi_{it} + dZ_{it}, \tag{3.23}$$

where $\chi_{it} = \left(\beta_i^A dH_{it}^A + \beta_i^B dH_{it}^B - \beta_i dH_{it}\right)$ is the potential bias arising by relying only on aggregate hours per worker as a utilization proxy. By definition, aggregate hours per worker are a weighted average of hours per worker for the two types, holding $H_{it} = p_{it}^A H_{it}^A + p_{it}^B H_{it}^B$, where $p_{it}^A = \frac{N_{it}^A}{N_{it}^A + N_{it}^B}$. Therefore, we can write the deviations of hours from their BGP value as

$$dH_{it} = \frac{p^{A*} H^{A*}}{H^*} dH_{it}^A + \frac{p^{B*} H^{B*}}{H^*} dH_{it}^B + \frac{p^{A*}\left(H^{A*} - H^{B*}\right)}{H^*} dp_{it}^A. \tag{3.24}$$

Replacing this expression into Equation (3.23), we get that the BFK approach is unbiased if and only if in every period,

$$\beta_i = \frac{\beta_A + \beta_B \frac{dH_{it}^B}{dH_{it}^A}}{\frac{p^{A*} H^{A*}}{H^*} + \frac{p^{B*} H^{B*}}{H^*} \frac{dH_{it}^B}{dH_{it}^A} + \frac{p^{A*}(H^{A*} - H^{B*})}{H^*} \frac{dp_{it}^A}{dH_{it}^A}}. \tag{3.25}$$

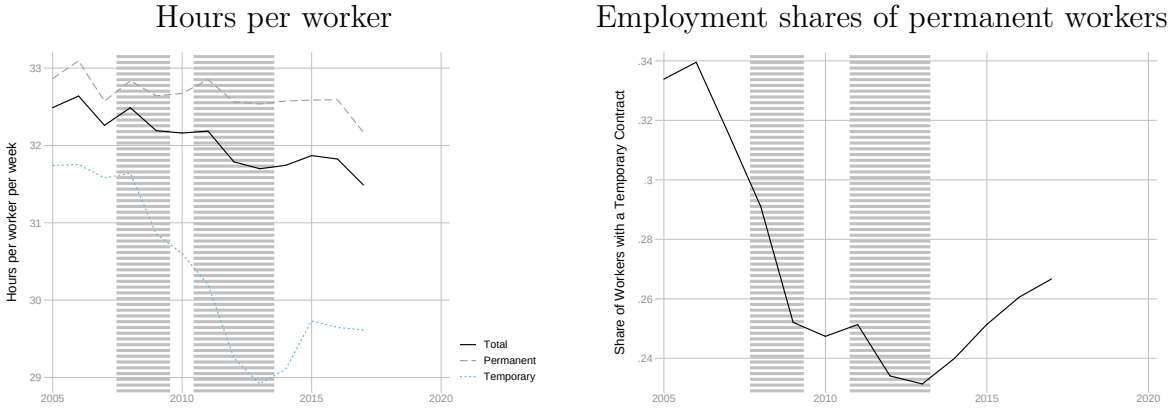
As this equality must hold in every period, the right-hand side of Equation (3.25) must be constant over time. This requires a constant elasticity between changes in hours per worker for both types (so that $\frac{dH_{it}^B}{dH_{it}^A}$ is constant). Furthermore, it requires that there are either no differences in the steady-state hours of the two types, no changes in employment shares, or a constant elasticity between changes in hours per worker and employment shares. Intuitively, this means that changes in hours per worker for both types must be proportional, and composition changes either do not occur or do not matter.

Do these assumptions hold in the data? To assess this, we turn to the country in which aggregate hours per worker were least correlated with survey-based utilization, Spain. Spain is characterized by a strongly dual labour market, with a high share of workers on temporary contracts, offering very different conditions from permanent ones (see e.g.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Bentolila et al. (2012)). Thus, a useful breakdown of the Spanish workforce is between permanent and temporary workers.

Figure 3.3.3: Hours and employment of temporary and permanent workers in Spain



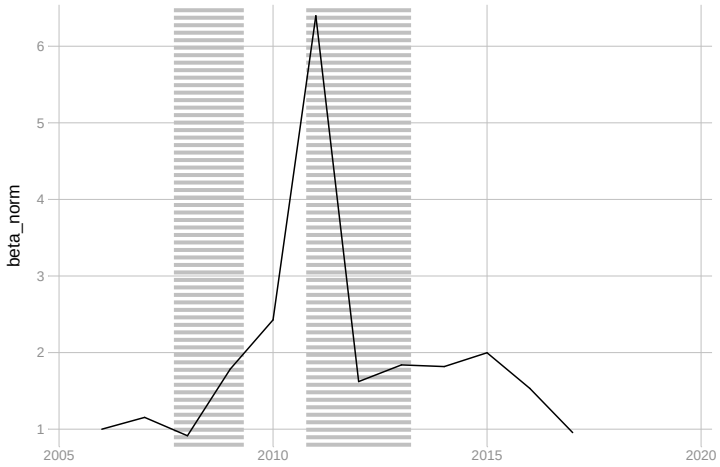
Source: European Labour Force Survey.

Figure 3.3.3, using data from the Spanish Labour Force Survey, confirms that on average, temporary workers work less hours per week than permanent workers. Furthermore, the crisis affected both types in a very different way: temporary workers faced both a much larger reduction in hours (left panel) and a much larger reduction in employment (right panel). These heterogenous reactions violate the restrictions needed for the BFK methodology to continue to hold: composition changes occur, they matter for aggregate hours per worker, and changes in hours per worker for both types are not proportional (hours per worker for temporary and permanent workers behave similarly through the boom and the recovery, but not during the crisis). Thus, there is no reason for the right-hand side of Equation (3.25) to be constant in the data.

Figure 3.3.4 illustrates this point, by plotting the value of β_i (normalized to 1 in 2006) implied by Equation (3.25), using the Spanish data for dH_{it}^P, dH_{it}^T and dp_{it}^P and assuming that $\beta_P = \beta_T = 1$ and that the Spanish economy was in steady state in 2005. The implied β_i is far from being constant, which it would have to be for the BFK methodology to be unbiased despite the underlying heterogeneity. In particular, note that the implied β_i appears to be higher during the crisis than during normal times.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Figure 3.3.4: Implied Value for β_i



Source: European Labour Force Survey.

Summing up, this section shows that composition changes in the labour force and heterogeneity in the fluctuations of hours for different types of workers make aggregate hours per worker an unreliable indicator of factor utilization. This could explain their low correlation with the capacity utilization survey. Of course, this problem need not be practically relevant for all countries, and our previous result seem to indicate that it is not important for countries such as the United States and Germany. However, in countries where it is relevant, it creates important issues with the BFK methodology. Given these issues, we propose and discuss an alternative adjustment method in the next section.[11]

3.3.4 An alternative utilization proxy

Our alternative relies on the use of survey-based capacity utilization instead of hours per worker as a proxy for unobserved changes in worker effort. Thus, our underlying assumption is that there is a stable relationship between changes in survey-based capacity

[11] In principle, the issue described in this section could be addressed in a relatively simple way, by using separate data on hours per worker for each of the two types of workers. However, these series are not readily available, especially at the industry level. Furthermore, composition changes are one problem affecting the reliability of aggregate hours per worker, but they may not be the only one. Thus, we believe that our alternative proxy is both a more general and a simpler solution.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

utilization, denoted dS_{it}, and unobserved changes in worker effort, dE_{it}. Then, the BFK measurement equation (3.20) can be rewritten as

$$dY_{it} = \gamma_i dX_{it} + \beta_i^S dS_{it} + dZ_{it}, \tag{3.26}$$

and just as before, we can estimate the coefficients γ_i and β_i using instrumental variables. As discussed above, we believe that the survey measure is a superior proxy for unobserved changes in factor utilization, as it behaves more reasonably during the Great Recession and is less likely to be biased by cross-country institutional differences. However, the survey measure also has a drawback: its coverage is largerly limited to the manufacturing sector. Nevertheless, during the last couple of years, statistical agencies have begun to fill this gap. Most importantly, the European Commission has been collecting quarterly survey data on capacity utilization for service firms since 2011.[12] As shown in Table 3.3.1, the quarterly time series for average capacity utilization in services is strongly correlated with average capacity utilization in manufacturing during the period in which both series are available.

Table 3.3.1: Correlation coefficients between survey-based capacity utilization in manufacturing and services

	United Kingdom	Germany	France	Spain	Italy
Correlation coeff.	0.61	0.75	0.68	0.83	0.67
Observations	25	27	24	25	31

Notes: The table gives the correlation coefficients between the quarter-on-quarter growth rates of average capacity utilization in service industries and average capacity utilization in manufacturing industries.

Given this high correlation, we explore two different proxies for service industries. First,

[12]The question is formulated somewhat differently from the manufacturing one: firms are asked "*If the demand addressed to your firm expanded, could you increase your volume of activity with your present resources? If so, by how much?*" The first question needs to be answered by Yes or No, the second with a percentage.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

we just use the manufacturing capacity utilization average (this is the only option for the United States, where we do not have survey data for the service sector). Second, we use the service data for all available years, and back-cast it for the missing years by projecting it (separately for each industry) on the manufacturing average. Our results do not change depending on the approach that we use.

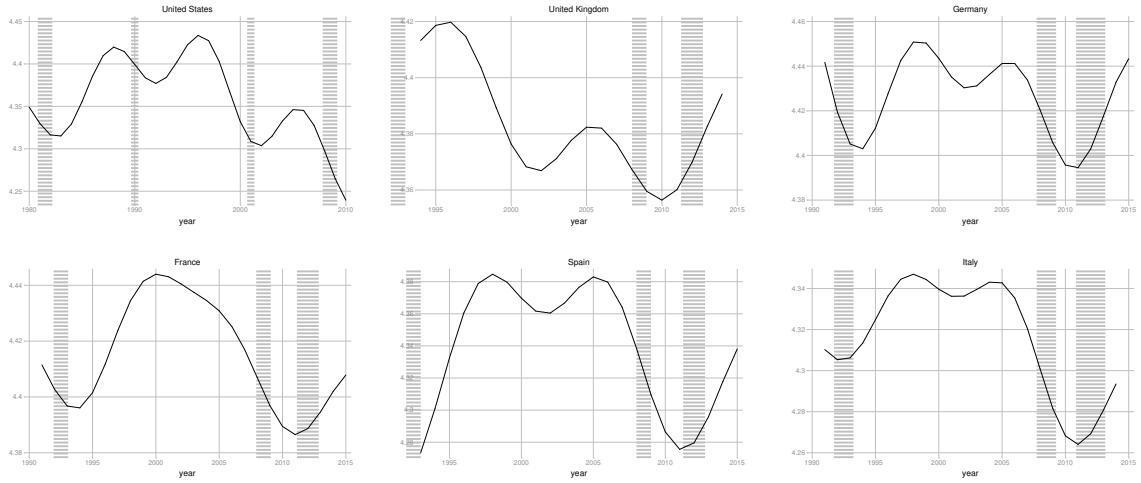
The European Commission also provides a construction sector survey, available since the early 1990s. Construction firms are not directly asked about capacity utilization, but they are asked a closely related question, namely how many months of work are guaranteed by their current level of orders. Our results are robust to using this series as a measure for capacity utilization (alternatively, we use the manufacturing average).

Finally, we need to discuss the important question of detrending. As mentioned earlier, BFK detrend their utilization proxy, hours per worker, with a band-pass filter isolating frequencies between 2 and 8 years. It is not clear that this is the best choice for the survey. Indeed, while the survey measure of capacity utilization has a downward trend in the United States (described and analyzed in greater detail in Pierce and Wisniewski (2018)), there is no apparent trend in Europe. Moreover, detrending the series with the same band-pass filter used by BFK gives counterintuitive results, shown in Figure 3.3.5, which plots the trends in the logarithm of average manufacturing capacity utilization. While the US series does show a clear downward trend since the early 1990s, this is not true in continental Europe. In Germany, France, Spain and Italy, capacity utilization in 2015 is essentially equal to its 1995 level. Instead, the "trend" appears to mainly capture business cycle fluctuations.

Given these results, we choose to detrend the natural logarithm of the utilization series with a band-pass filter with a larger amplitude, between 2 and 16 years, in order not to capture too much business cycle fluctuations. Our results are also robust to not detrending at all for European countries (so that dS_{it} simply equals log changes in the survey series). This completes the discussion of our adjustment methodology. In the next section, we

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Figure 3.3.5: "Trends" in average capacity utilization in manufacturing



Source: EU KLEMS, World KLEMS and authors' calculations. Hours per worker refer to the non-farm, non-mining business economy. For each country, the natural logarithm of the original series was detrended using a band pass filter, isolating frequencies between 2 and 8 years, and the graph plots the first differences of the detrended series.

describe in greater detail the data and instruments that we use, and then present our results.

3.4 Data and results

3.4.1 Growth accounting data

Our growth accounting data comes from EU KLEMS, which provides annual data at the industry level for a large sample of European countries (see www.euklems.net, O'Mahony and Timmer (2009) and Jäger (2017)). In this paper, we consider the five largest European economies (Germany, Spain, France, Italy and the United Kingdom) as well as the United States. Our US data comes from the World KLEMS dataset, described in Jorgenson et al. (2012), which has been constructed using very similar methods. Throughout, we restrict our attention to the non-farm, non-mining market economy,[13] leaving us with 19 distinct

[13]The market economy as defined by EU KLEMS excludes all industries except public administration and defence, social security, education, health and social work, household activities, activities of extraterritorial bodies, and real estate. The latter is excluded because, as noted by O'Mahony and Timmer

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

industries. The time span of the growth accounting data varies, ranging between 1947-2010 for the United States, 1972-2014 for the United Kingdom, 1980-2015 for France and Spain, and 1991-2015 for Italy and Germany. Appendix 3.A contains a detailed description of the data.

The KLEMS databases rely on a growth accounting approach very similar to the one outlined in Section 3.2.1. However, they provide much more disaggregated information on production factors, distinguishing three different types of intermediate inputs (energy, materials and services), ten types of capital, and eighteen types of labour (distinguishing workers according to their gender, education level and age). With these more detailed data, Equation (3.17) becomes

$$\begin{aligned} dY_{it} &= \gamma_i dX_{it} + \beta_i dH_{it} + dZ_{it}, \\ \text{with } dX_{it} &= \textstyle\sum_k s^K_{kit} d\widetilde{K}_{kit} + \sum_l s^L_{lit} \left(dH_{it} + dN_{lit}\right) + \sum_m s^M_{mit} dM_{mit} \ , \\ dU_{it} &= \textstyle\sum_k s^K_{kit} dA_{kit} + \sum_l s^L_{lit} dE_{lit} \end{aligned} \tag{3.27}$$

where s^K_{kit} is the sales share of capital of type k, $d\widetilde{K}_{kit}$ is the growth rate (measured as log changes) of the stock of capital of type k, etc. Labour input is measured as total hours worked of the labour type considered. However, KLEMS does not have series on hours per worker for the eighteen different labour categories, and therefore imputes the same (aggregate) growth rate dH_{it} for all labour types l. Thus, composition changes in the labour input series are entirely driven by the composition of employment and not of hours.

With respect to the BFK methodology, EU KLEMS then makes two additional assumptions. First, it assumes constant returns to scale in all industries (that is, $\gamma_i = 1$). Second, it ignores changes in factor utilization. As a result, EU KLEMS defines the annual growth

(2009), "*for the most part the output of the real estate sector [...] is imputed rent on owner-occupied dwellings",* which makes productivity measures for this industry hard to interpret. From this sample, we further drop agriculture, forestry and fishing, mining and quarrying, and manufacturing of coke and refined petroleum products.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

rate of industry-level TFP as $dY_{it} - dX_{it}$, and aggregates these industry-level growth rates using the Hulten formula provided in Equation (3.18).[14]

Figure 3.4.1 plots the resulting aggregate TFP series for the six countries in our sample, starting in 1980 (or 1992 for Italy and Germany). The figure immediately illustrates the pitfalls of not adjusting for factor utilization. For instance, KLEMS TFP series indicates a huge drop in aggregate TFP during the Great Recession (strongest in Germany, where TFP falls by 8% from 2008 to 2009, and Italy, where it falls by 6%). It also indicates huge rebounds in 2010, with TFP growth exceeding 5% in Germany and in the United States. At least part of these movements is likely to be to unobserved reductions in factor utilization.

Both the BFK methodology and our alternative described in the previous sections have been designed to address these issues. Before discussing the results of these two methodologies, we briefly describe the data sources for the instruments used in our analysis, as well as for our capacity utilization surveys.

3.4.2 Data for instrumental variables and capacity utilization surveys

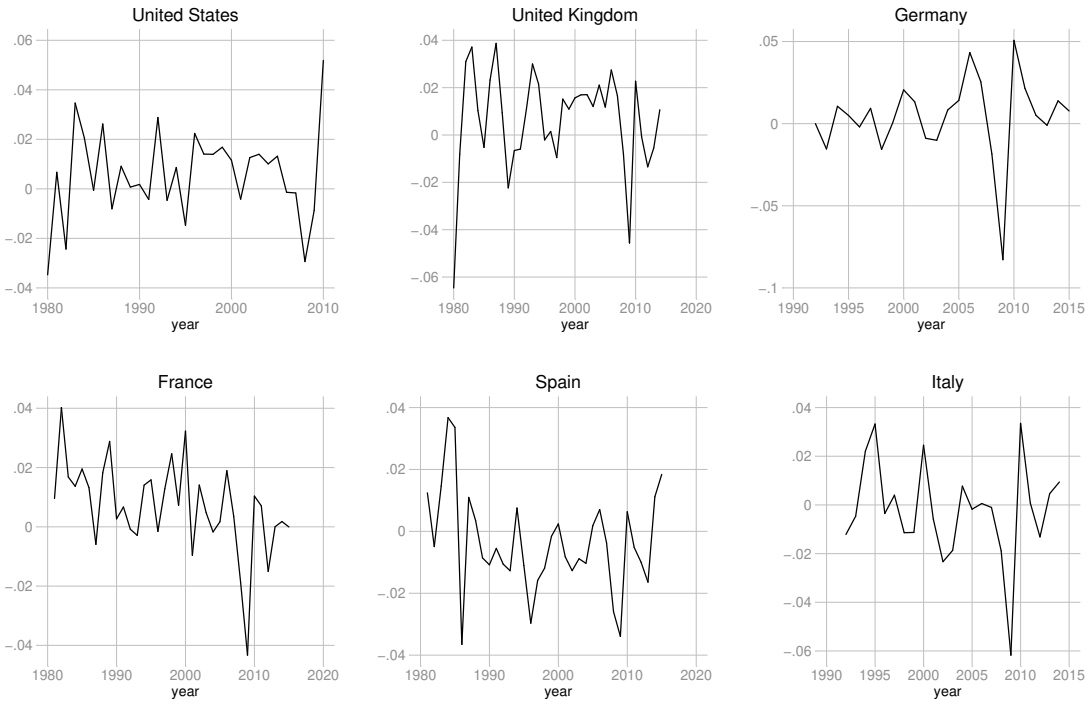
Instrumental variables

In our baseline estimation, we use three instrumental variables: oil price shocks, monetary policy shocks, and financial conditions. In robustness checks, we have also experimented with shocks to fiscal policy and changes in Economic Policy Uncertainty, but introducing these additional instruments does not affect our results. In this section, we describe our

[14]There are a few more minor details worth noting. EU KLEMS calculates factor shares as the simple average of current and last year's shares. However, using average factor shares over the whole period, as BFK, does not change results. Furthermore, EU KLEMS defines a value-added based measure of TFP growth, which at the industry level equals $\frac{dY_{it}-dX_{it}}{1-s_{Mi}}$. This measure is then aggregated using nominal value-added weights. However, defining TFP on a gross output basis as $dY_{it} - dX_{it}$ and aggregating using Domar weights (as we do in this paper) delivers virtually identical aggregate TFP series (see OECD (2001)). Note that just like BFK, EU KLEMS uses a Törnqvist index for aggregation.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Figure 3.4.1: TFP growth for the non-farm, non-mining market economy, EU KLEMS



Note: TFP growth rates shown in this figure are slightly differ from the "Total market economy" TFP growth rates reported in the KLEMS database, mainly because our aggregation excludes agriculture, mining and petroleum. At the industry level, our KLEMS TFP measures and the ones provided in the database are virtually identical (the correlation coefficient of both series is 0.96).

baseline set of instruments in greater detail.

Oil price shocks We use quarterly data on oil prices and, following BFK, we compute oil price shocks as the log difference between the current quarterly real oil price and the highest real oil price in the preceding four quarters. We define the annual oil price shock as the sum of the four quarterly shocks, and use the shock in year $t-1$ as an instrument for changes in hours per worker between years $t-1$ and t.

Monetary Policy shocks For members of the European Monetary Union, we use monetary policy shocks as identified by Jarocinski and Karadi (2018) using ECB policy announcements. Using surprise movements in Eonia interest rate swaps, the authors

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

identify monthly monetary policy shocks starting in March 1999. We aggregate these shocks to the annual level by taking the average of monthly values. Similarly, for the UK, we follow Cesa-Bianchi et al. (2016), which identifies monetary policy shock through changes in the price of 3-month Sterling future contracts immediately following policy announcements by the Bank of England.

Finally, for the United States, we use the series of narratively identified monetary policy shocks from the seminal work of Romer and Romer (2004), as updated in Wieland and Yang (2016) and provided at an annual frequency in the latter paper.[15] For all countries, we use the shock in year $t-1$ as an instrument for changes in hours per worker between years $t-1$ and t.

Financial conditions In order to capture financial conditions, we use the excess bond premium measure introduced by Gilchrist and Zakrajšek (2012).[16] This measure is computed as the difference between the actual spread of corporate unsecured bonds of US firms and its predicted level based on firm-specific measure of expected default and bond-specific characteristics. It should represent variation in the average price of bearing exposure to US corporate credit risk, above and beyond the compensation for expected defaults. We aggregate this monthly variable to its annual average. Our instrument is the lag of the first difference of the annual value excess bond premium.

Capacity utilization surveys

Surveys of capacity utilization have a long history, both in the United States and in Europe. For Europe, we rely on the European Commission's Harmonised Business and Consumer Surveys (described in greater detail in the Appendix). The survey includes a quarterly question on capacity utilization for manufacturing firms, asking them *"At*

[15] Alternatively, we can use the measure provided by Gertler and Karadi (2015), which relies on surprise movements in interest rates after monetary policy announcements.

[16] Updated series of the variable is available in `http://people.bu.edu/sgilchri/Data/data.htm`

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

what capacity is your company currently operating (as a percentage of full capacity)?". The survey is carried out for all EU member states, and results are reported for 24 distinct manufacturing industries, starting between the first quarter of 1991 and the first quarter of 1994. We aggregate results up to the yearly frequencey using simple averages, and to the 11 EU KLEMS manufacturing industries by using value added weights. The Commission survey also provides some data on capacity utilization for service firms, from 2011 onwards.

For the United States, we rely instead on the Federal Reserve Board's reports on Industrial Production and Capacity Utilization (G.17), which provides industry-level measures of capacity utilization which are based on a series of underlying surveys, most importantly, the Census Bureau's Quarterly Survey of Plant Capacity (QSPC). This survey measures capacity utilization by asking plants to report both their current level of production their full production capacity, defined as "*the maximum level of production that this establishment could reasonably expect to attain under normal and realistic operating conditions fully utilizing the machinery and equipment in place*". Capacity utilization is defined as the ratio between current and full production. We consider the annual version of the Fed dataset, providing data for 17 manufacturing industries between 1972-2010, and aggregate these up to the 12 US KLEMS manufacturing industries by using value-added weights. More detailed descriptions of both capacity utilization surveys are provided in Appendix 3.A.

3.4.3 Estimation results

Implementation

Just as BFK, we restrict β coefficients to be equal across three broad sectors (durable manufacturing, non-durable manufacturing, and non-manufacturing). Furthermore, we currently impose $\gamma_i = 1$, i.e., constant returns to scale in all industries. Basu et al. (2006)

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

find that this is a good approximation, and Fernald (2014b) makes this assumption as well. We then estimate, for each country-sector, the equation

$$dY_{it} - dX_{it} = \alpha_i + \beta_j dUP_{it} + \varepsilon_{it}, \tag{3.28}$$

where α_i are industry dummies, and UP stands for the utilization proxy: changes in hours per worker in the BFK methodology, and changes in the survey-based measure of capacity utilization in our alternative methodology. Once we estimated the coefficients in Equation (3.28) using two-stage least squares (and the instruments described above) our measure of TFP changes at the industry-level is $dZ_{it} = \alpha_i + \varepsilon_{it}$. We then aggregate industry-level TFP growth rates using a Törnqvist index of Domar weights, as described above.

In our baseline results, presented in the main text, it is worth noting the following points:

- As the monetary policy shock for EMU countries is only available from 1999 onwards, we backcast its value for the missing years by projecting it on the two other instruments. Our results are robust to not doing this (and therefore estimating the first-stage regression on a shorter time sample). This is shown in the Appendix.

- For non-manufacturing industries, we use the manufacturing average of the capacity utilization survey troughout for construction and utilities. For service industries, we use the industry-specific service capacity utilization survey whenever available. For years with missing observations, we backcast these series at the industry-level by projecting them on the manufacturing average. Results are robust to using the manufacturing survey throughout, as shown in the Appendix.

- The Appendix also shows a specification in which we separate non-manufacturing into construction and utilities on the one side, and services on the other side.

- In the baseline specification, we detrend the log of the capacity utilization series with

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

a band-pass filter isolating frequencies between 2 and 16 years. In the Appendix, we show the results obtained when we instead do not detrend the survey at all.

Results for the BFK hours per worker proxy

Table 3.4.1 shows our IV estimates for the β parameters in Equation (3.28). We report robust standard errors of the second stage regression and the Cragg-Donald Wald F statistic of the first-stage regression.

Table 3.4.1: Estimated β coefficients on hours per worker (BFK methodology)

	United States			United Kingdom		
	(1)	(2)	(3)	(4)	(5)	(6)
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Hours/Emp.	0.971***	0.509	1.258	-0.282	0.716***	0.899**
	(0.263)	(1.007)	(0.842)	(0.506)	(0.0804)	(0.397)
Observations	396	297	260	234	240	216
First-stage Fstat	29.66	1.703	0.871	1.811	110.3	21.49

US: 1985-2010. Intrumental variables: Oil, Monetary(RR), Excess Bond Premium (GZ)
UK: 1995-2015. Intrumental variables: Oil, Excess Bond Premium (GZ)
Robust standard errors in parenthesis. Observations: Industry x year

	Germany			France		
	(1)	(2)	(3)	(4)	(5)	(6)
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Hours/Emp.	0.642***	0.546	-0.279	-0.873	0.684***	-0.0573
	(0.157)	(0.402)	(0.364)	(0.741)	(0.0800)	(0.423)
Observations	270	243	270	243	230	207
First-stage Fstat	38.10	7.059	4.048	4.374	79.88	6.639

Germany: 1995-2015. Intrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
France: 1995-2015. Intrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parenthesis. Observations: Industry x year

	Spain			Italy		
	(1)	(2)	(3)	(4)	(5)	(6)
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Hours/Emp.	-0.156	-0.643	-0.873	0.660***	0.727***	-0.0573
	(0.452)	(0.662)	(0.741)	(0.0772)	(0.167)	(0.423)
Observations	135	135	243	115	115	207
Creaig-Davis F-stat	4.777	0.968	4.374	57.67	28.09	6.639

Spain: 1995-2015. Intrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Italy: 1995-2014. Intrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parenthesis. Observations: Industry x year

- Note that we do not quite replicate BFK results for the US (our time span is different than the one in the original paper, and we also use different instruments).

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

- It is interesting to note that the results roughly mirror the correlation patterns with the capacity utilization series shown above. In the high-correlation countries US, DE and IT, things more or less work. In the no-correlation countries UK and ES, nothing works: F-statistics are very low, coefficients are all over the place (and frequently negative, inconsistent with BFK's theoretical foundations for standard cost and production function). In the intermediate country FR, things also do not work that well.

- In the countries in which the approach works, are the βs similar? It does not seem so: for instance, the β for non-manufacturing in the United States is about twice as high as the one for Italy. This appears to contradict the approach in Levchenko and Pandalai-Nayar (2018), who apply the BFK methodology to an international dataset assuming that β does not vary across countries.

Results for the survey-based proxy

Table 3.4.2 shows our IV estimates for the β parameters using the survey measure of capacity utilization as a proxy for unobserved factor utilization. The instrumental strategy is the same than in the regressions in Table 1.

- Overall, this seems to perform better. All of the estimates, except UK non-durable mfg., are positive and significant (only half of them were positive and significant in our estimation of the BFK setting). Only the non significant estimate is borderline negative, while there was 5 cases in the BFK estimation (one of them statiscally significant). All the regressions, except 2, have F-statistics larger than 10.

3.4.4 Properties of the adjusted TFP series

Figures 3.4.2 and 3.4.3 shows the series of adjusted aggregate TFP growth using the BFK methodology (grey dashed lines) and our methodology (red solid lines). The graphs

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Table 3.4.2: Estimated β coefficients on survey-based capacity utilization

	United States			United Kingdom		
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Survey Cap	0.183***	0.144**	0.128**	0.142***	-0.0645	0.139***
	(0.0437)	(0.0569)	(0.0635)	(0.0416)	(0.101)	(0.0534)
Observations	165	231	297	100	100	180
First-stage Fstat	38.64	31.17	108.8	35.42	6.223	82.76

US: 1985-2010. Intrumental variables: Oil, Monetary(RR), Excess Bond Premium (GZ)
UK: 1995-2015. Intrumental variables: Oil, Excess Bond Premium (GZ)
Robust standard errors in parenthesis. Observations: Industry x year

	Germany			France		
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Survey Cap	0.297***	0.464***	0.197*	0.174***	0.120*	0.116***
	(0.0367)	(0.0660)	(0.106)	(0.0508)	(0.0658)	(0.0348)
Observations	120	120	216	120	120	216
First-stage Fstat	47.59	17.02	57.01	45.46	30.15	152.0

Germany: 1995-2015. Intrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
France: 1995-2015. Intrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parenthesis. Observations: Industry x year

	Spain			Italy		
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Survey Cap	0.180***	0.153***	0.183*	0.285***	0.373***	0.169***
	(0.0338)	(0.0519)	(0.0968)	(0.0285)	(0.0843)	(0.0613)
Observations	110	110	198	115	115	207
Creaig-Davis F-stat	14.38	13.38	62.58	45.28	15.55	63.19

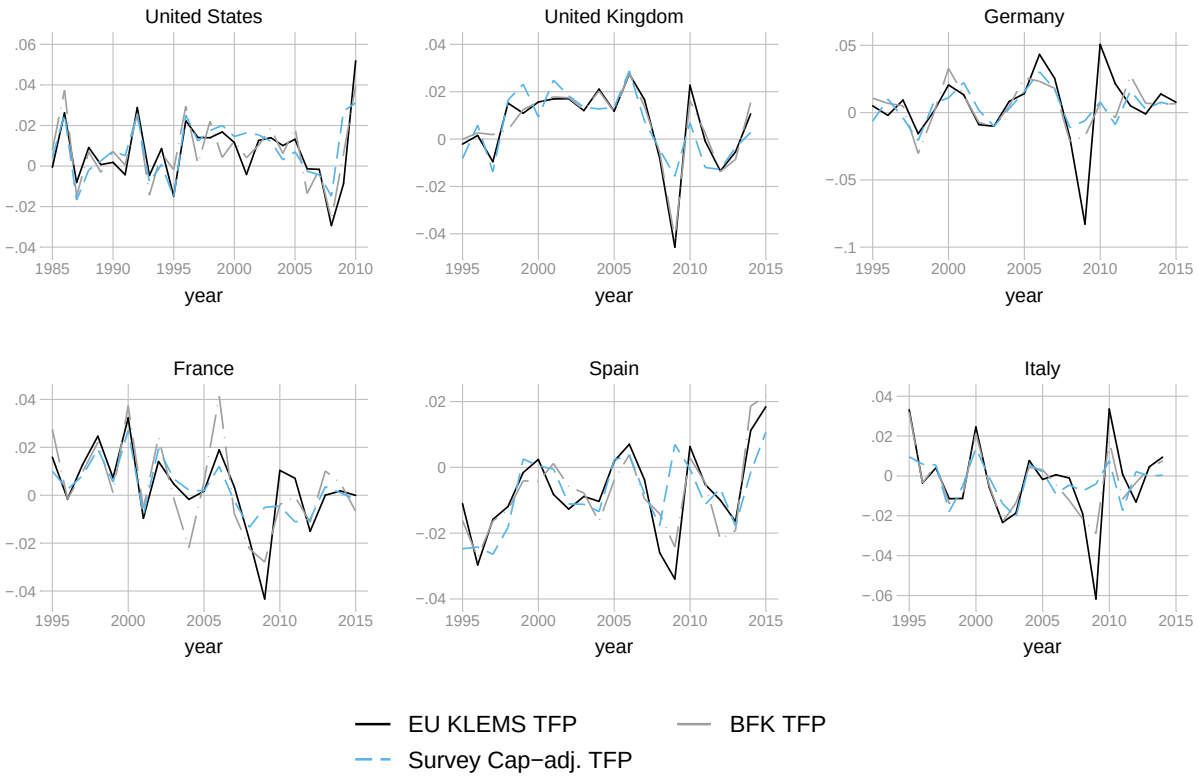
Spain: 1995-2015. Intrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Italy: 1995-2014. Intrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parenthesis. Observations: Industry x year

also include the EU KLEMS measure of productivity growth (blue dashed lines), that is, productivity growth without any adjustments for factor utilization. In Figure 3.4.3, which shows TFP levels, all series are normalized to 100 in 2008.

These graphs indicate that different adjustment methods do not affect long-run productivity trends, which is intuitive, as the adjustment is designed to capture cyclical variations in factor utilization. Thus, it does not change, for instance, the negative trends in Spanish and Italian TFP since 1995. However, they do change the time-series patterns of TFP: the Great Recession is now no longer characterized by large negative TFP shocks. In Spain, Italy, UK, some increases in TFP and to some extent a decrease in the downward trend. In Germany, on the other hand, the adjusted TFP series seems to have strong growth until 2006/2007, and then a much lower trend afterwards. This is consistent with

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Figure 3.4.2: Adjusted TFP series, growth rates

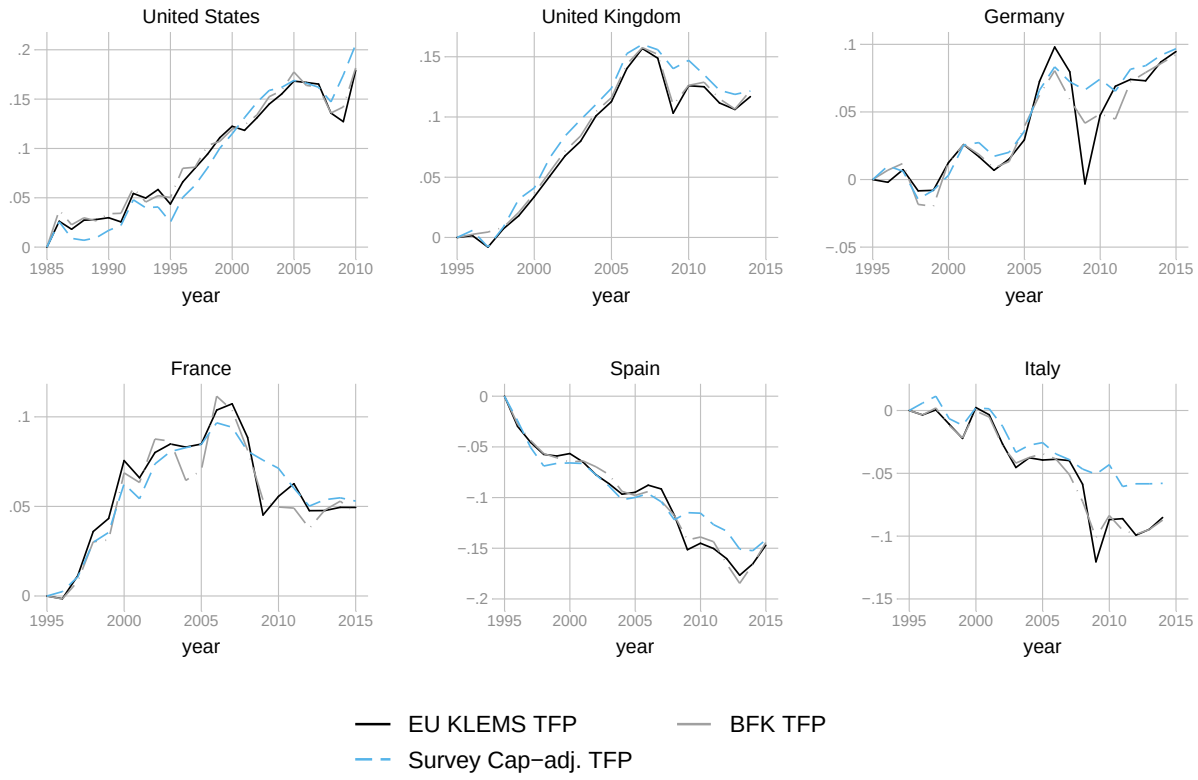


the general narrative about the history of US productivity growth by Fernald (2014a) and Gordon (2016), according to which US productivity growth slowed down since roughly 2005, with the productivity effects of the IT Revolution fading. In Germany, this point could have been reached later, given a lag in the IT diffusion process.

Table 3.4.3 summarizes some properties of the adjusted aggregate series. The main insights can be summarized as follows. Average TFP growth is roughly unchanged, as the adjustment is cyclical and does not affect long-run trends. Our adjustment substantially lowers the standard deviation of TFP growth rates, showing that the unadjusted TFP contained a lot of spurious fluctuations which were not related to TFP. However, our TFP measure is substantially less procyclical than the KLEMS one: while KLEMS TFP growth rates are quite strongly positively correlated with aggregate value added growth, growth rates of our TFP measure are not. In line with this, the correlation KLEMS TFP

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Figure 3.4.3: Adjusted TFP series, levels



growth and our TFP growth is positive but far from perfect, showing that our measure implies substantial adjustments.

Not surprisingly, our measure is very highly correlated with the one obtained using the BFK methodology in US, Germany, France and Italy, as hours per worker and the capacity utilization survey are themselves highly correlated. In the other countries, such as Spain, this is not the case and the measures are substantially different. As in the comparison with KLEMS TFP, adjusting with the survey measure of capacity utilization substantially reduces the standard deviation of the TFP measure.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Table 3.4.3: Properties of the adjusted series: growth rates and volatility

United States	1973-2010		**United Kingdom**	1995-2015	
	Mean	SD		Mean	Std. Deviation
VA	2.56	2.56	VA	2.23	2.57
TFP_{KLEMS}	0.72	1.62	TFP_{KLEMS}	0.62	1.72
TFP_{BFK}	0.73	1.61	TFP_{BFK}	0.54	1.86
TFP_{Survey}	0.75	1.38	TFP_{Survey}	0.62	1.29
Germany	1995-2015		**France**	1995-2015	
	Mean	Std. Deviation		Mean	Std. Deviation
VA	1.23	3.25	VA	1.76	2.17
TFP_{KLEMS}	0.47	2.71	TFP_{KLEMS}	0.25	1.63
TFP_{BFK}	0.46	1.66	TFP_{BFK}	0.23	1.81
TFP_{Survey}	0.47	1.25	TFP_{Survey}	0.24	1.14
Spain	1995-2015		**Italy**	1995-2014	
	Mean	Std. Deviation		Mean	Std. Deviation
VA	1.70	3.12	VA	0.49	2.91
$TFP_{EU\ KLEMS}$	-0.73	1.34	$TFP_{EU\ KLEMS}$	-0.45	1.98
TFP_{BFK}	-0.72	1.30	TFP_{BFK}	-0.46	1.33
TFP_{Survey}	-0.72	1.01	TFP_{Survey}	-0.39	1.01

3.5 Conclusions

Total Factor Productivity (TFP) is among the most important concepts in macroeconomics. However, computing this "Solow residual" is subject to a large number of measurement challenges, such as the correct measure of inputs and the intensity with which they are employed.

The most successful approach is due to a series of papers by Basu, Fernald and Kimball

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Table 3.4.4: Properties of the adjusted series: TFP Correlations

	United States			
	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.656	1		
BFK	0.406	0.869	1	
Survey Cap-adj.	0.171	0.747	0.818	1
	United Kingdom			
	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.837	1		
BFK	0.847	0.965	1	
Survey Cap-adj.	0.545	0.813	0.766	1
	Germany			
	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.935	1		
BFK	0.408	0.625	1	
Survey Cap-adj.	0.344	0.551	0.854	1
	France			
	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.855	1		
BFK	0.544	0.833	1	
Survey Cap-adj.	0.477	0.740	0.808	1
	Spain			
	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.474	1		
BFK	0.448	0.883	1	
Survey Cap-adj.	0.0600	0.586	0.610	1
	Italy			
	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.796	1		
BFK	0.593	0.889	1	
Survey Cap-adj.	0.221	0.504	0.743	1

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

(see, for instance, Basu and Fernald, 2001, Basu et al., 2006 and Fernald, 2014b). These papers exploit the insight that firms adjust simultaneously unobservable margins such as utilization rates or effort and observables margins like the number hours per employee. BFK have used this methodology to produce utilization-adjusted TFP growth series for the United States, which have become a standard reference in macroeconomics. However, there are no similar series for European countries.

This chapter attempts to fill this knowledge gap, making two main contributions. First, we show that using hours per worker as a utilization proxy has significant drawbacks for several European countries, and propose an alternative adjustment method. Second, we use our method to provide utilization-adjusted series for five European countries (and for the United States), both at the industry and at the aggregate level.

We show that given the important differences in labor market institutions between the United States and Europe, as well as among European economies, the use of hours per worker is not an appropriate proxy for effort and factor utilization for every country. Spain is a paradigmatic example of the issue. Because of compositional changes between workers with different types of contract, the time series of hours per worker and survey-data on capacity utilization are indeed uncorrelated.

This paper develops an alternative adjustment method, based on survey data on capacity utilization, and use it to estimate a novel utilization-adjusted TFP series. This alternative is built under the assumption that there is a stable relationship between changes in survey-based capacity utilization and unobserved changes in effort.

Consequently, we estimate TFP time series for the five largest EU economies (Germany, Spain, France, Italy, and the United Kingdom) as well as for the United Stated applying the novel approach based on survey-data on capacity utilization. To do so, we assemble a growth accounting dataset based on several vintages of EU KLEMS for European countries and from World KLEMS for US data. This data allows estimating comparable regressions for 19 distinct industries of the non-farm, non-mining market economy of each

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

of the countries. For data on capacity utilization, we rely on the European Commission's Harmonised Business and Consumer Surveys and the Federal Reserve's reports on Industrial Production and Capacity Utilization.

We implement the 2SLS estimation using a set of instruments with oil price shocks, monetary and fiscal shocks, financial conditions and economic policy uncertainty. Instrumental variables perform notably better in the first-stage regression with survey-data than in the one with hours per employee as a proxy in countries like Spain, where arguably the latter is a worse proxy for effort and factor utilization.

Different adjustments methods do not affect long-run productivity trends. However, they do change the time-series patterns of TFP: the Great Recession is now no longer characterized by large negative TFP shocks. In Spain, Italy, UK, some increases in TFP and to some extent a decrease in the downward trend. Our adjustment substantially lowers the standard deviation of TFP growth rates, showing that the unadjusted TFP contained a lot of spurious fluctuations which were not related to TFP. However, our TFP measure is substantially less procyclical than the KLEMS one: while KLEMS TFP growth rates are quite strongly positively correlated with aggregate value added growth, growth rates of our TFP measure are not. In line with this, the correlation KLEMS TFP growth and our TFP growth is positive but far from perfect, showing that our measure implies substantial adjustments.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

3.A Data Appendix

3.A.1 Growth accounting data

Europe: EU KLEMS data

In order to construct our growth accounting dataset for the five European countries considered, we rely on different vintages of the EU KLEMS database, published on http://www.euklems.net. Our baseline dataset comes from the July 2018 revision of the September 2017 EU KLEMS release. This dataset contains information for the period 1995-2015 for 22 (NACE Rev. 2) market economy industries. As mentioned in the main text, we drop Agriculture, Forestry and Fishing (NACE code A), Mining and Quarrying (B) and Manufacturing of Coke and Refined Petroleum products (19).[17] The remaining 19 industries are listed in Table A.1.

Table A.1: List of industries

Industry name	NACE	Sector
Food products, beverages and tobacco	10-12	Non-durable manufacturing
Textiles, wearing apparel, leather and related products	13-15	Non-durable manufacturing
Wood and paper products; printing and reproduction of recorded media	16-18	Non-durable manufacturing
Chemicals and chemical products	20-21	Non-durable manufacturing
Rubber and plastics products, and other non-metallic mineral products	22-23	Non-durable manufacturing
Basic metals and fabricated metal products, exc. machinery and equipment	24-25	Durable manufacturing
Electrical and optical equipment	26-27	Durable manufacturing
Machinery and equipment n.e.c.	28	Durable manufacturing
Transport equipment	29-30	Durable manufacturing
Other manufacturing; repair and installation of machinery and equipment	31-33	Durable manufacturing
Electricity, gas and water supply	D-E	Non-manufacturing
Construction	F	Non-manufacturing
Wholesale and retail trade; Repair of motor vehicles and motorcyles	G	Non-manufacturing
Transportation and storage	H	Non-manufacturing
Accommodation and food service activities	I	Non-manufacturing
Information and communication	J	Non-manufacturing
Financial and Insurance activities	K	Non-manufacturing
Professional, scientific, technical, administrative and support service act.	M-N	Non-manufacturing
Arts, entertainment, recreation and other service activities	R-S	Non-manufacturing

We use twelve KLEMS growth accounting variables for our analysis. Changes in output

[17] For industries J (Information and communication) and R-S (Arts, entertainment, recreation and other service activities), further disaggregation into subindustries would have been possible. However, we abstain from this, as the earlier vintages of the EU KLEMS dataset (which we will use for pre-1995 data) are only available at higher levels of aggregation.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

dY are computed as changes in real gross output (nominal output GO deflated with the industry-specific price index GO_P). Likewise, changes in intermediate inputs dM are computed as changes in intermediate inputs (II) deflated with an industry-specific price index for inputs (II_P).[18] Changes in capital and labour inputs, $d\widetilde{K}$ and $dH + dN$ are directly given by the changes in the KLEMS quantity indexes for labour and capital inputs (CAP_QI and LAB_QI). As described in the main text, these indexes are obtained (just like the intermediate inputs series) by aggregating across different types of the input considered. All rates of change are calculated as log changes. To calculate factor shares, we use the data on the (nominal) remuneration of capital, labour and materials (CAP, LAB and II). Hours per employee are given as the ratio of total hours worked by persons engaged (H_EMP) and persons engaged (EMP). Finally, for some aggregations, we also use data on value added (which holds the accounting identity VA = GO - II).

To get longer time series, we have combined this baseline dataset with earlier EU KLEMS releases. We rely on two particular vintages.

2012 release Earlier EU KLEMS releases are based on a different industry classification (NACE Rev. 1), so that comparability is not always guaranteed. However, the 2012 release converts almost all growth accounting variables that we need into a NACE Rev. 2 industry format, with the exception of gross output, intermediate inputs and their respective deflators (GO, GO_P, II and II_P).

Using this information, we backcast the variables in our baseline dataset by applying the growth rates of the 2012 release to the earliest available level in our baseline dataset.[19]

[18] Spain and the United Kingdom do not have a dedicated price index for gross output or intermediate inputs. Therefore, we deflate all Spanish series with the industry-specific value added price index (VA_P). Furthermore, Italy does not have dedicated price indexes for the service industry R-S, and we use value-added deflators here as well.

[19] The only exception is the capital compensation CAP, as this variable can in some rare cases take negative values. Therefore, we infer backcasted values of CAP as VA - LAB, an accounting identity which holds in the baseline dataset.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

2011 release For the remaining four growth accounting variables not contained in the 2012 release, we rely on the March 2011 release. The data in this release were the source for the 2012 one, but the industry classification has not been adjusted, so that they are only available in the NACE Rev. 1 format. To convert data into NACE Rev. 2, we use the correspondence tables and instructions provided in the KLEMS source documents for the 2012. For most industries, this matching is relatively unproblematic and can be done one-to-one. For cases in which two or more NACE Rev. 1 industries are mapped into one NACE Rev. 2 industries, we aggregate the nominal variables GO and II as the sum of the values of subindustries, and the price indexes GO_P and II_P as weighted averages, using Tornqvist weights based on value added. There is just one case of one NACE Rev. 1 industry corresponding to two or more NACE Rev. 2 industries, for NACE Rev. 1 industry 64 (Post and Telecommunications). Here, we follow standard KLEMS practice and map this industry entirely into NACE Rev. 2 industry J (Information and Communication).[20]

Table A.2 describes the final time coverage of our dataset for every country and every variable. Note that France is absent from this table: indeed, it is the only country to provide long time series (for the period 1980-2015) already in the baseline dataset, so that no further extensions are needed.[21]

United States: World KLEMS

For the United States, we use the data provided in the April 2013 release of the World KLEMS dataset, available at http://www.worldklems.net/data.htm. This dataset, described in Jorgenson et al. (2012), contains industry-level growth accounting variables

[20]Furthermore, we do some small additional adjustments for Italy. In this country, three industries (NACE Rev. 2 31-33, M-N and R-S) have some missing observations between 1991 and 1994. To be able to start our analysis in 1991, we extended the data for these industries assuming that their split between GO and II remained the same as in 1995.

[21]Note that Spain and the United Kingdom do not have data on gross output and intermediate input deflators in the baseline dataset, but these variables are available in the 2011 and 2012 releases. To be consistent, we do not consider this information, and use value-added deflators in these two countries throughout, as described above in Footnote 18.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Table A.2: Data availability by country and variable

United Kingdom			Germany		
Variable	Availability	Source	Variable	Availability	Source
GO	1970-2014	1970-1994 X, 1995-2014 B	GO	1970-2015	1970-1994 X, 1995-2015 B
GO_P	n.a.		GO_P	1970-2015	1970-1994 X, 1995-2015 B
VA	1970-2015	1970-1994 X, 1995-2015 B	VA	1970-2015	1970-1994 X, 1995-2015 B
VA_P	1970-2015	1970-1994 X, 1995-2015 B	VA_P	1970-2015	1970-1994 X, 1995-2015 B
II	1970-2014	1970-1994 X, 1995-2014 B	II	1970-2015	1970-1994 X, 1995-2015 B
II_P	n.a.		II_P	1970-2015	1970-1994 X, 1995-2015 B
H_EMP	1970-2015	1970-1994 X, 1995-2015 B	H_EMP	1970-2015	1970-1994 X, 1995-2015 B
EMP	1970-2015	1970-1994 X, 1995-2015 B	LAB	1970-2015	1970-1994 X, 1995-2015 B
LAB	1970-2015	1970-1994 X, 1995-2015 B	LAB	1970-2015	1970-1994 X, 1995-2015 B
CAP	1970-2015	1970-1994 X, 1995-2015 B	CAP	1970-2015	1970-1994 X, 1995-2015 B
LAB_QI	1970-2015	1970-1994 X, 1995-2015 B	LAB_QI	1991-2015	1991-1994 X, 1995-2015 B
CAP_QI	1972-2015	1972-1996 X, 1997-2015 B	CAP_QI	1991-2015	1991-1994 X, 1995-2015 B
Overall		1972-2014	Overall		1991-2015
Spain			Italy		
Variable	Availability	Source	Variable	Availability	Source
GO	1970-2015	1970-1994 X, 1995-2015 B	GO	1991-2015	1991-1994 X, 1995-2015 B
GO_P	n.a.		GO_P	1991-2015	1991-1994 X, 1995-2015 B
VA	1970-2015	1970-1994 X, 1995-2015 B	VA	1970-2015	1970-1994 X, 1995-2015 B
VA_P	1970-2015	1970-1994 X, 1995-2015 B	VA_P	1970-2015	1970-1994 X, 1995-2015 B
II	1970-2015	1970-1994 X2, 1995-2015 B	II	1991-2015	1991-1994 X, 1995-2015 B
II_P	n.a.		II_P	1991-2015	1991-1994 X, 1995-2015 B
H_EMP	1970-2015	1970-1994 X, 1995-2015 B	H_EMP	1970-2015	1970-1994 X, 1995-2015 B
EMP	1970-2015	1970-1994 X, 1995-2015 B	EMP	1970-2015	1970-1994 X, 1995-2015 B
LAB	1970-2015	1970-1994 X, 1995-2015 B	LAB	1970-2015	1970-1994 X, 1995-2015 B
CAP	1970-2015	1970-1994 X, 1995-2015 B	CAP	1970-2015	1970-1994 X, 1995-2015 B
LAB_QI	1980-2015	1980-1994 X, 1995-2015 B	LAB_QI	1970-2015	1970-1994 X, 1995-2015 B
CAP_QI	1980-2015	1980-1994 X, 1995-2015 B	CAP_QI	1972-2014	1972-1994 X, 1995-2014 B
Overall		1980-2015	Overall		1991-2014

Note: In the source column, B stands for the baseline dataset, and X for one of the two extension datasets (2011 release for GO, GO_P, II and II_P, 2012 release for all other variables).

which are, according to the website, "*structured and built up in the same way as the data in the EU KLEMS database to increase comparability [..]. This harmonisation process includes input definitions, price concepts, aggregation procedures and comparable measures of inputs and productivity.*" In particular, the US data contains the exact same twelve growth accounting variables that we also used for European countries.

Regarding the industry classification, the US data of the April 2013 release have been converted into the NACE Rev. 1 classification. We stick to this classification to avoid making further conversions, and as for European countries, we limit the sample to the non-farm, non-mining market economy. We therefore exclude data for Agriculture, Hunting,

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Forestry and Fishing (AtB), Mining and Quarrying (C), Coke, Refined Petroleum and nuclear fuel (23), Real Estate activities (70), Public Administration and Defense (L), Education (M), Health and Social Work (N), Private Households with Employed Persons (P) and Extraterritorial Organizations and Bodies (Q). This leaves us with 21 industries, listed in Table A.3, which are roughly comparable to the 19 NACE Rev. 2 industries that we consider for European countries.

Table A.3: List of industries: United States

Industry name	NACE Rev. 1	Sector
Food, Beverages and Tobacco	15t16	Non-durable manufacturing
Textiles, Textile, Leather and Footwear	17t19	Non-durable manufacturing
Wood and Manufacturing of Wood and Cork	20	Non-durable manufacturing
Pulp, Paper, Printing and Publishing	21t22	Non-durable manufacturing
Chemicals and chemical products	24	Non-durable manufacturing
Rubber and plastics	25	Non-durable manufacturing
Other Non-Metallic Minerals	26	Non-durable manufacturing
Basic Metals and Fabricated Metal	27t28	Durable manufacturing
Machinery, NEC	29	Durable manufacturing
Electrical and Optical Equipment	30t33	Durable manufacturing
Transport Equipment	34t35	Durable manufacturing
Manufacturing NEC, Recycling	36t37	Durable manufacturing
Electricity, Gas and Water Supply	E	Non-manufacturing
Construction	F	Non-manufacturing
Wholesale and Retail Trade	G	Non-manufacturing
Hotels and Restaurants	H	Non-manufacturing
Transport and Storage	60t63	Non-manufacturing
Post and Telecommunciations	64	Non-manufacturing
Financial Intermediation	J	Non-manufacturing
Renting of manuf. and other business activities	71t74	Non-manufacturing
Other Community, Social and Personal Services	O	Non-manufacturing

3.A.2 Survey data on Capacity Utilization

Europe: Joint Harmonised EU Programme of Business and Consumer Surveys

Our European data on capacity utilization comes from the Joint Harmonised EU Programme of Business and Consumer Surveys, which can be accessed through the European

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Commission's website[22] and was downloaded in April 2018. Within this framework, the "industry" survey, which targets manufacturing firms, includes a quarterly question on capacity utilization (question 13 of the questionnaire), asking firms *"At what capacity is your company currently operating (as a percentage of full capacity)?"* The firm then has to fill out the blank in the following sentence, *"The company is currently operating at ___ % of full capacity"*. We obtain an annual measure of capacity utilization by taking a simple average of these quarterly measures.[23]

The survey provides data for 24 manufacturing industries, using the NACE Rev. 2 classification, for all EU member states. EU KLEMS also uses the NACE Rev. 2 classification, but considers a higher level of aggregation, with just 10 manufacturing industries. Therefore, we aggregate the survey data to this higher level using the average nominal value added of industries between 2008 and 2015, taken from the Eurostat Structural Business Statistics.

Industry availability: we drop industries with 2 or more gaps in their data.

United Kingdom Manufacturing: Quarterly data for 1994Q3-2017Q3, industries 12 and 33 excluded for missing data.

Construction: Quarterly data for 1994Q4-2017Q3.

Services: Quarterly data for 2011Q3-2017Q3, for industries 49, 50, 52, 53 (4/5 for H), 55, 56, (2/2 for I), 58, 62 (2/6 for J), 69, 70, 71, 73, 74, 75, 77, 78, 79, 80, 81, 82 (12/13 for M-N), 91, 92, 93 (3/7 for R-S). Data for industries 52, 56, 74, 82, 92 contains one missing observation, data for industry 58 contains two missing observations.

Germany Manufacturing: Quarterly data for 1991Q1-2017Q3. Industries 12, 30 and 33 are missing, industry 21 only becomes available from 2003Q4.

[22] See https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/business-and-consumer-surveys_en.

[23] At the industry level, firm responses are aggregated using employment and/or value added weights, depending on the country considered (weighting schemes are described in the country-specific metadata section of the Commission website).

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Construction: Quarterly data for 1991Q1-2017Q3. Industry 43 missing throughout.
Services: Quarterly data for 2011Q1-2017Q3, for industries 49, 52 (2/5 for H), 55, 56, (2/2 for I), 62 (1/6 for J), 69, 70, 71, 72, 73, 74, 77, 78, 79, 81, 82 (11/13 for M-N), (0/7 for R-S).

France Manufacturing: Quarterly data for 1991Q1-2017Q3. Industry 12 missing throughout.
Construction: Quarterly data for 1990Q1-2017Q3. Two missing observations in industries 41 and 43 in 1993Q3 and 1993Q4. Industry 42 only available from 2004Q1.
Services: Quarterly data for 2011Q4-2017Q3, for industries 49, 52, 53 (3/5 for H), 55, 56, (2/2 for I), 58, 59, 60, 61, 62, 63 (6/6 for J), 69, 70, 71, 73, 74, 77, 78, 79, 80, 81, 82 (11/13 for M-N), 95, 96 (2/7 for R-S).

Spain Manufacturing: Quarterly data for 1993Q1-2017Q3.
Construction: Quarterly data for 1993Q1-2017Q3.
Services: Quarterly data for 2011Q3-2017Q3, for all industries in the sample.

Italy Manufacturing: Quarterly data for 1990Q1-2017Q3, industry 12 excluded for missing data.
Construction: Quarterly data for 1990Q1-2017Q3.
Services: Quarterly data for all industries in the sample, with the exception of industry 94. Most industries have data for 2010Q1-2017Q3, except for 58, 60, 80 and 81 (2010Q3-2017Q3) and 51, 59, 75, 90, 91, 92, 93, 95 and 96 (2013Q3-2017Q3). Data for industry 61 contains one gap.
(Through aggregation, we get consistent time series for all of these countries for our 10 manufacturing industries, throughout).
There are 9 non-manufacturing industries. For two of them, Utilities (D-E) and Wholesale and Retail Trade (G), there is no survey data. For Financial and Insurance Activities (K),

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

there is survey data only for Spain. For Construction, most countries have data from a separate survey. For the five remaining industries as well, data is not always available, with the situation being summarized above.

Winsorizing outliers: all values above 100 set to 100, winsorize the lowest values to the 0.1% percentile (very few observations).

United States: Federal Reserve Board and Census Bureau

US capacity utilization data come from the Federal Reserve Board's monthly reports on Industrial Production and Capacity Utilization (G.17).[24] The data is constructed by the Federal Reserve on the basis of an underlying Census Bureau survey of manufacturing firms, the Census Bureau's Quarterly Survey of Plant Capacity (QSPC).

The QSPC is carried out at the plant level (and not at the firm level, as its European counterpart) and also measures capacity utilization somewhat differently. Plants are asked three questions. First, they should report the value of current production: "*Report the value of production based on estimated sales price(s) of what was produced during the quarter, not quarter sales*". Second, they should report their full production capacity, defined as "*the maximum level of production that this establishment could reasonably expect to attain under normal and realistic operating conditions fully utilizing the machinery and equipment in place*". In the detailed instruction that plant managers are given about how they should calculate this number, it is noteworthy that the Census suggests that "*if you have a reliable or accurate estimate of your plant's sustainable capacity utilization rate, divide your market value of production at actual operations [..] by your current rate of capacity utilization [to get full production capacity]*". Finally, firms are asked to report the ratio between current and full production, which is capacity utilization. Once they have done so, firms are asked "*Is this a reasonable estimate of your utilization rate for this quarter? Mark (X) yes or no. If no, please review your full production capability*

[24]The data can be downloaded at https://www.federalreserve.gov/releases/G17/Current/default.htm.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

estimate. If yes, continue with the next item."

For our purposes, we use the annual version of the Federal Reserve's database, which provides data for 17 manufacturing industries, as well as for Electric and Gas utilities, using the NAICS classification. We limit ourselves to the time period 1972-2010, for which data is available for all industries. In order to aggregate the data to the 12 manufacturing industries in our KLEMS data for the US, we use the average value added between 1972 and 2010, taken from the 2017 release of the World KLEMS dataset for the United States,[25] as aggregation weights for the case in which two or more NAICS industries correspond to one NACE Rev.1 industry.

3.A.3 Instruments

Oil prices

We use two series for crude oil prices: Brent for European countries, and West Texas Intermediate (WTI) for the United States. Monthly data on Brent prices are from the World Bank's commodity price database[26] and cover the period 1979-2018, while monthly data on WTI prices are taken from the FRED database of the Federal Reserve Bank of St. Louis and cover the period 1946-2018. In both databases, prices are expressed in US dollars per barril.

We aggregate prices to the quarterly level by taking simple average of monthly data, and then deflate these series and to real oil prices, using a quarterly CPI deflator from the OECD's Main Economic Indicators database. Note that we do not convert oil prices into national currencies, in order to not to mix up oil price and exchange rate shocks (see Blanchard and Galí (2007)).

[25]This release provides data for disaggregated NAICS industries, but only contains information on a very limited number of growth accounting variables, namely gross output, value added, and capital and labour compensation. This is why we do not work with this data in our main analysis.

[26]The database is available at http://www.worldbank.org/en/research/commodity-markets.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Monetary Policy shocks

For members of the European Monetary Union, we use monetary policy shocks as identified by Jarocinski and Karadi (2018) using ECB policy announcements. Using surprise movements in Eonia interest rate swaps, the authors identify monthly monetary policy shocks starting in March 1999. We aggregate these shocks to the annual level by taking the average of monthly values.

For the United States, we use the series of narratively identified monetary policy shocks from the seminal work of Romer and Romer (2004), as updated in Wieland and Yang (2016) and provided at an annual frequency in the latter paper.[27] For all countries, we use the shock in year $t-1$ as an instrument for changes in hours per worker between years $t-1$ and t.

Fiscal Policy shocks

For fiscal shocks, we mainly rely on a database on fiscal consolidation shocks compiled by Alesina et al. (2015), which identifies changes in taxes and government spending motivated by debt and deficit reduction concerns, and therefore arguably unrelated to productivity shocks. Their database, which builds on earlier efforts by Pescatori et al. (2011), is available at the annual level for all countries in our sample between 1978 and 2014. As usual, we use the shock in year $t-1$ as an instrument for changes in hours per worker between years $t-1$ and t.

For the United States, we also use a measure of exogeneous tax changes developed by Romer and Romer (2010) and available at the quarterly level for the period 1945-2007. We compute annual shocks as the sum of quarterly ones.

[27] Alternatively, we can use the measure provided by Gertler and Karadi (2015), which relies on surprise movements in interest rates after monetary policy announcements.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Economic Policy Uncertainty

Our measure of Economic Policy Uncertainy (EPU) was developed by Baker et al. (2016), and is regularly updated and made available at http://www.policyuncertainty.com, which also contains further methodological details. For European countries, the measure is a monthly index based on newspaper articles on policy uncertainty (articles containing the terms uncertain or uncertainty, economic or economy, and one or more policy–elevant terms, in the native language of the respective newspaper). The number of economic uncertainty articles is then normalized by a measure of the number of articles in the same newspaper and month, and the resulting newspaper-level monthly series is standardized to unit standard deviation prior to 2011. Finally, the country-level EPU series is obtained as the simple average of the series for the country's newspapers, and normalized to have a mean of 100 prior to 2011.[28]

In order to obtain an annual series, we take a simple average of monthly values. Then, our instrument for the change in inputs, capacity utilization or hours from year $t-1$ to year t is the log change in this index between years $t-2$ and $t-1$. The index is available since 1987 for France, 1993 for Germany, 1997 for Italy and the United Kingdom, and 2001 for Spain. If there is no available data for a country during a given period, we use the change in the European EPU series (which is the simple average of the series of for five European countries considered in our analysis).

For the United States, measurement is more sophisticated, considering not only newspaper articles, but also the number of federal tax code provisions set to expire in future years and disagreement among economic forecasters. The resulting aggregate measure is available from 1985 onwards.

[28]The newspapers used are Le Monde and Le Figaro for France, Handelsblatt and Frankfurter Allgemeine Zeitung for Germany, Corriere Della Sera and La Repubblica for Italy, and El Mundo and El Pais for Spain.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

3.B Robustness checks

3.B.1 Non-manufacturing sectors capacity utilization level

In this section, we use average level of capacity utilization in the manufacturing sector as a proxy for capacity utilization in the non-manufacturing sector for the entire sample. In contrast, the baseline specification uses industry-specific survey data for non-manufacturing when available. A.1 shows the updated results in 3.4.2 with the new specification.

Table A.1: Estimated β coefficients on survey-based capacity utilization

Average manufacturing capacity utilization as proxy for non-manufacturing capacity utilization

	United States			United Kingdom		
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Survey Cap	0.235**	0.274**	0.0776	0.150***	-0.0340	0.154***
	(0.0946)	(0.140)	(0.116)	(0.0419)	(0.0926)	(0.0569)
Observations	115	161	207	95	95	171
First-stage Fstat	9.603	11.67		35.50	7.613	

US: 1985-2010. Instrumental variables: Oil, Monetary(RR), Excess Bond Premium (GZ)
UK: 1994-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parentheses. Observations: Industry x year.
Average manufacturing capacity utilization as proxy for non-manufacturing capacity utilization

	Germany			France		
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Survey Cap	0.328***	0.476***	0.0850**	0.186***	0.125*	0.150***
	(0.0373)	(0.0702)	(0.0400)	(0.0507)	(0.0682)	(0.0463)
Observations	110	110	198	115	115	207
First-stage Fstat	37.62	16.22		43.51	31.40	

DE: 1991-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
FR: 1991-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parentheses. Observations: Industry x year.
Average manufacturing capacity utilization as proxy for non-manufacturing capacity utilization

	Spain			Italy		
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Survey Cap	0.190***	0.148***	0.152*	0.300***	0.370***	0.109***
	(0.0407)	(0.0569)	(0.0831)	(0.0303)	(0.0817)	(0.0379)
Observations	105	105	189	105	105	189
Creaig-Davis F-stat	13.10	13.51		44.98	16.15	

ES: 1993-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
IT: 1991-2014. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parentheses. Observations: Industry x year.
Average manufacturing capacity utilization as proxy for non-manufacturing capacity utilization

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

In this specification the value of capacity utilization is the same for every industry within the Non-Manufacturing group. Thus, we report the Cragg-Donald Wald F statistic of the first-stage regression considering only one observation by year for the Non-Manufacturing sector to avoid artificially inflating the value with repeated observations.

Corrected F-Statistic for Non-Manufacturing

	US	UK	Germany	France	Spain	Italy
Corrected Fstat	3.247	10.16	11.06	14.43	9.810	11.55

Cragg-Donald Wald F statistic with only one observation per year

3.B.2 No backcasted values for missing observations

In this section, we use do not backcast instrumental variables for those time periods when they are missing. In contrast, the baseline specification replace missing observations of the intrumental variables with sinthetic values constructed as the linear combination of the available instruments. Effectively, this specification reduces the time span to 1999-2015 for EZ countries and 1997-2015 for UK.A.2 and A.3 show the updated results in 3.4.1 and 3.4.2 with the new specification.

3.B.3 Not detrended survey data on capacity utilization

In this section, we use survey data on industry capacity utilization without any detrendeing procedure. In contrast, the baseline specification detrends the series with a Band-pass filter with frequencies between 2 and 16 years. A.4, A.1, A.2 and A.5 show the updated results in 3.4.2, 3.4.2, 3.4.3 and 3.4.4 with the new specification.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Table A.2: Estimated β coefficients on hours per worker (BFK methodology)

No backcasted values for missing observations

	United States			United Kingdom		
	(1) Durable Mfg.	(2) Non-Durable Mfg.	(3) Non Mfg.	(4) Durable Mfg.	(5) Non-Durable Mfg	(6) Non Mfg.
Hours/Emp.	0.636	1.352**	0.353	1.631*	0.141	-0.819
	(0.451)	(0.586)	(0.879)	(0.918)	(0.706)	(0.594)
Observations	115	161	207	85	85	153
First-stage Fstat	7.587	5.559	1.327	1.511	0.463	2.902

US: 1985-2010. Instrumental variables: Oil, Monetary(RR), Excess Bond Premium (GZ)
UK: 1994-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parentheses. Observations: Industry x year
No backcasted values for missing observations

	Germany			France		
	(1) Durable Mfg.	(2) Non-Durable Mfg.	(3) Non Mfg.	(4) Durable Mfg.	(5) Non-Durable Mfg	(6) Non Mfg.
Hours/Emp.	0.876***	0.824***	0.883**	0.702***	0.218	0.510
	(0.0757)	(0.123)	(0.385)	(0.176)	(0.241)	(0.372)
Observations	80	80	144	80	80	144
First-stage Fstat	65.18	44.91	27.43	31.90	14.62	7.726

DE: 1991-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
FR: 1991-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parentheses. Observations: Industry x year
No backcasted values for missing observations

	Spain			Italy		
	(1) Durable Mfg.	(2) Non-Durable Mfg.	(3) Non Mfg.	(4) Durable Mfg.	(5) Non-Durable Mfg	(6) Non Mfg.
Hours/Emp.	0.600	-0.626	-1.740	0.630***	0.649***	0.562
	(0.538)	(0.962)	(1.062)	(0.0713)	(0.154)	(0.398)
Observations	80	80	144	75	75	135
Creaig-Davis F-stat	2.629	0.742	3.391	43.37	20.94	4.572

ES: 1993-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
IT: 1991-2014. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parentheses. Observations: Industry x year
No backcasted values for missing observations

3.B.4 Different sector composition

In this section, we estimate the parameters on productivity of hours per employee and capacity utilization for four large sector. Construction and Utilities are estimated separately from the rest of Non-Manufacturing. In contrast, the baseline specification estimates the parameter for Durable and Non-durable Manufacturing and Non-Manufacturing. A.6 and A.7 show the updated results in 3.4.1 and 3.4.2 with the new specification.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Table A.3: Estimated β coefficients on survey-based capacity utilization

No backcasted values for missing observations

	United States			United Kingdom		
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Survey Cap	0.221**	0.252*	0.0772	0.166***	-0.0401	0.148***
	(0.0890)	(0.130)	(0.116)	(0.0405)	(0.103)	(0.0539)
Observations	115	161	207	85	85	153
First-stage Fstat	9.517	12.19	29.63	29.53	5.276	66.45

US: 1985-2010. Instrumental variables: Oil, Monetary(RR), Excess Bond Premium (GZ)
UK: 1994-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parentheses. Observations: Industry x year
No backcasted values for missing observations

	Germany			France		
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Survey Cap	0.314***	0.459***	0.195*	0.168***	0.112	0.114***
	(0.0375)	(0.0603)	(0.107)	(0.0502)	(0.0683)	(0.0341)
Observations	80	80	144	80	80	144
First-stage Fstat	46.86	23.14	53.88	39.15	26.13	133.7

DE: 1991-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
FR: 1991-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parentheses. Observations: Industry x year
No backcasted values for missing observations

	Spain			Italy		
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Survey Cap	0.190***	0.167***	0.233**	0.287***	0.355***	0.161**
	(0.0363)	(0.0567)	(0.106)	(0.0296)	(0.0828)	(0.0626)
Observations	80	80	144	75	75	135
Creaig-Davis F-stat	14.09	13.07	70.86	39.26	11.91	48.30

ES: 1993-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
IT: 1991-2014. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parentheses. Observations: Industry x year
No backcasted values for missing observations

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Table A.4: Estimated β coefficients on survey-based capacity utilization

Not detrended survey data for capacity utilization

	United States			United Kingdom		
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Survey Cap	0.178**	0.219*	0.0523	0.142***	-0.0645	0.139***
	(0.0839)	(0.115)	(0.109)	(0.0416)	(0.101)	(0.0534)
Observations	115	161	207	100	100	180
First-stage Fstat	10.54	12.58	36.24	35.42	6.223	82.76

US: 1985-2010. Instrumental variables: Oil, Monetary(RR), Excess Bond Premium (GZ)
UK: 1994-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parentheses.
Observations: Industry x year
Not detrended survey data for capacity utilization

	Germany			France		
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Survey Cap	0.297***	0.464***	0.197*	0.174***	0.120*	0.116***
	(0.0367)	(0.0660)	(0.106)	(0.0508)	(0.0658)	(0.0348)
Observations	120	120	216	120	120	216
First-stage Fstat	47.59	17.02	57.01	45.46	30.15	152.0

DE: 1991-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
FR: 1991-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parentheses.
Observations: Industry x year
Not detrended survey data for capacity utilization

	Spain			Italy		
	Durable Mfg.	Non-Durable Mfg.	Non Mfg.	Durable Mfg.	Non-Durable Mfg	Non Mfg.
Survey Cap	0.180***	0.153***	0.183*	0.285***	0.373***	0.169***
	(0.0338)	(0.0519)	(0.0968)	(0.0285)	(0.0843)	(0.0613)
Observations	110	110	198	115	115	207
First-stage F-stat	14.38	13.38	62.58	45.28	15.55	63.19

ES: 1993-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
IT: 1991-2014. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parentheses.
Observations: Industry x year
Not detrended survey data for capacity utilization

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

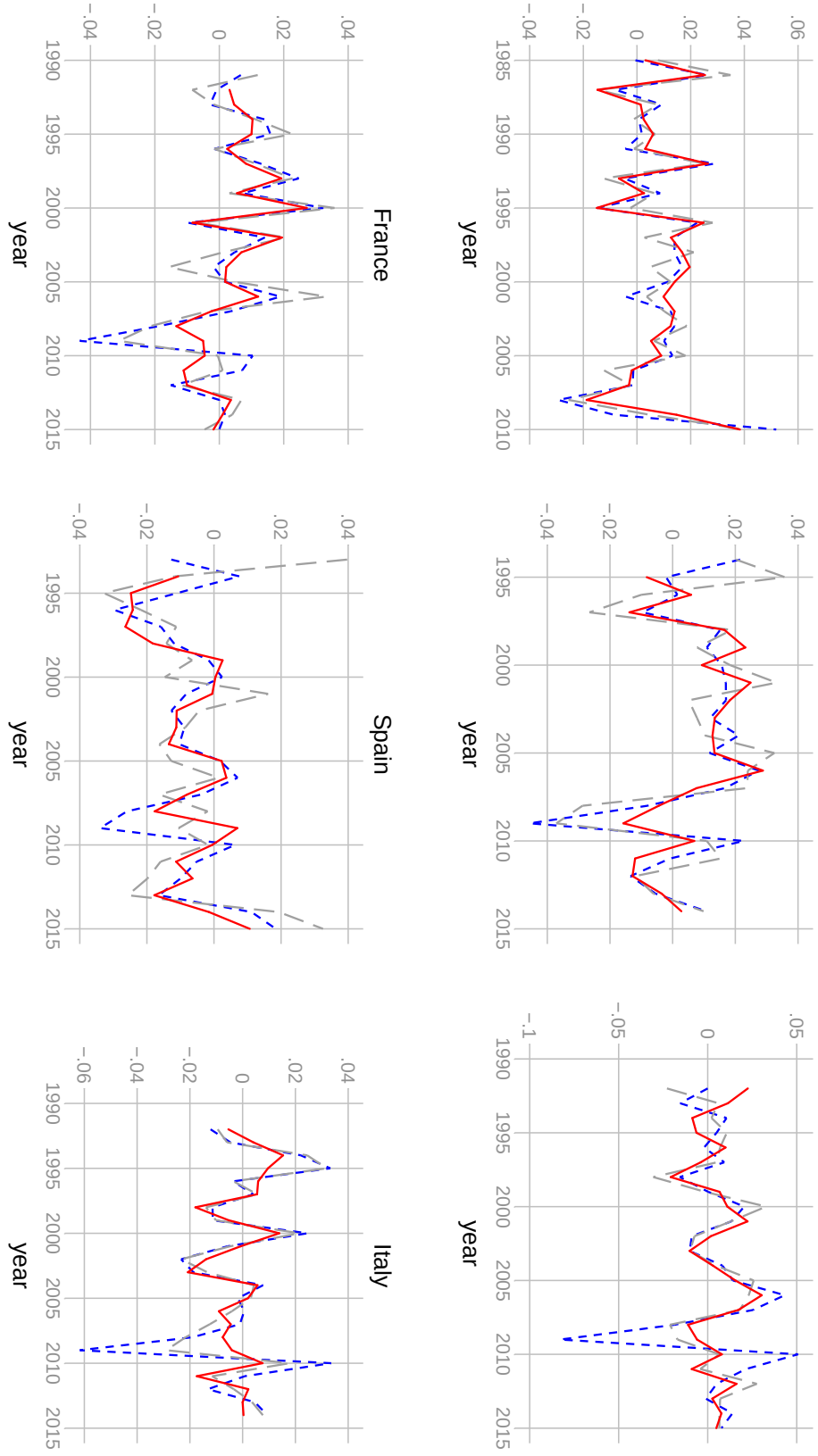


Figure A.1: Adjusted TFP series, growth rates

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

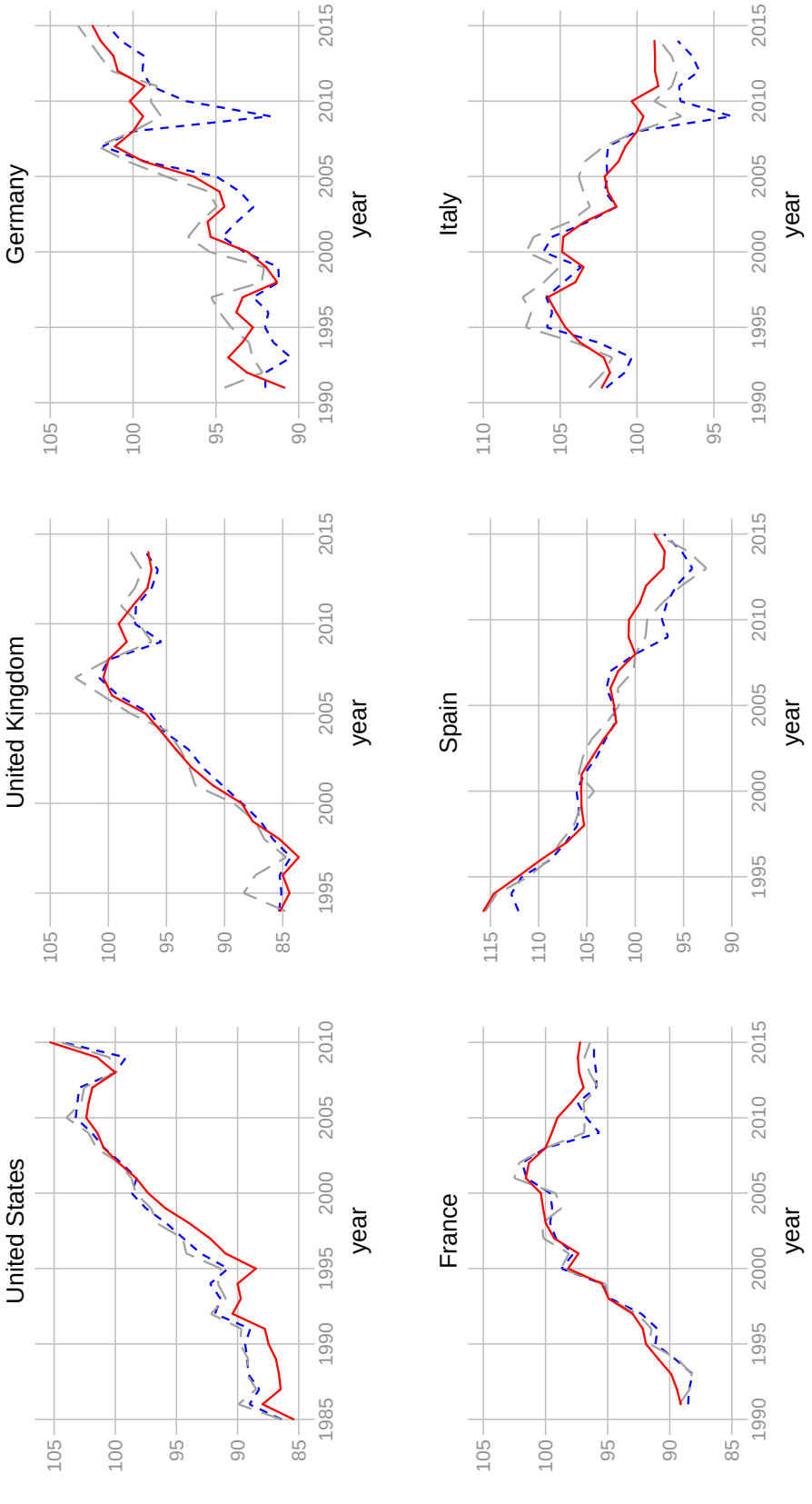


Figure A.2: Adjusted TFP series, levels

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Table A.5: Properties of the adjusted series: TFP Correlations

	United States			
	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.656	1		
BFK	0.439	0.891	1	
Survey Cap-adj.	0.367	0.889	0.896	1
	United Kingdom			
	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.821	1		
BFK	0.685	0.738	1	
Survey Cap-adj.	0.510	0.811	0.587	1
	Germany			
	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.934	1		
BFK	0.347	0.573	1	
Survey Cap-adj.	0.267	0.450	0.611	1
	France			
	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.821	1		
BFK	0.628	0.907	1	
Survey Cap-adj.	0.440	0.747	0.817	1
	Spain			
	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.481	1		
BFK	0.270	0.519	1	
Survey Cap-adj.	0.0280	0.538	0.614	1
	Italy			
	Value Added	EU KLEMS	BFK	Survey Cap-adj.
Value Added	1			
EU KLEMS	0.809	1		
BFK	0.634	0.906	1	
Survey Cap-adj.	0.295	0.591	0.777	1

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Table A.6: Estimated β coefficients on hours per worker (BFK methodology)

4 large sectors decomposition

	United States				United Kingdom			
	(1) Durable Mfg.	(2) Non-Durable Mfg.	(3) Cons. & Util.	(4) Non Mfg.	(5) Durable Mfg.	(6) Non-Durable Mfg	(7) Non Mfg.	(8) Cons. & Util.
Hours/Emp.	0.636	1.352**	1.498	0.155	1.401**	-0.0790	-1.291*	0.245
	(0.451)	(0.586)	(1.882)	(0.776)	(0.696)	(0.439)	(0.662)	(1.343)
Observations	115	161	46	161	105	105	42	147
First-stage Fstat	7.587	5.559	0.339	1.421	1.280	0.571	0.470	0.359

US: 1985-2010. Instrumental variables: Oil, Monetary(RR), Excess Bond Premium (GZ)

UK: 1994-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)

Robust standard errors in parentheses.Observations: Industry x year

4 large sectors decomposition

	Germany				France			
	(1) Durable Mfg.	(2) Non-Durable Mfg.	(3) Cons. & Util.	(4) Non Mfg.	(5) Durable Mfg.	(6) Non-Durable Mfg	(7) Cons. & Util.	(8) Non Mfg.
Hours/Emp.	0.750***	0.657***	-0.220	1.565***	0.700***	0.247	0.527	0.217
	(0.0924)	(0.140)	(0.450)	(0.400)	(0.173)	(0.225)	(0.536)	(0.375)
Observations	120	120	48	168	125	125	50	175
First-stage Fstat	70.66	45.95	11.71	16.21	43.36	18.95	2.989	7.909

DE: 1991-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)

FR: 1991-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)

Robust standard errors in parentheses.Observations: Industry x year

4 large sectors decomposition

	Spain				Italy			
	(1) Durable Mfg.	(2) Non-Durable Mfg.	(3) Cons. & Util.	(4) Non Mfg.	(5) Durable Mfg.	(6) Non-Durable Mfg	(7) Cons. & Util.	(8) Non Mfg.
Hours/Emp.	2.604*	-2.663	-0.0455	-1.891	0.660***	0.727***	0.0939	-0.279
	(1.362)	(3.879)	(1.474)	(1.298)	(0.0772)	(0.167)	(0.428)	(0.550)
Observations	115	115	46	161	115	115	46	161
Creaig-Davis F-stat	1.153	0.203	1.370	2.140	57.67	28.09	1.965	5.047

ES: 1993-2015. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)

IT: 1991-2014. Instrumental variables: Oil, Monetary, Excess Bond Premium (GZ)

Robust standard errors in parentheses.Observations: Industry x year

4 large sectors decomposition

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZALEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Table A.7: Estimated β coefficients on survey-based capacity utilization

4 large sectors decomposition

	United States				United Kingdom			
	(1) Durable Mfg.	(2) Non-Durable Mfg.	(3) Cons. & Util.	(4) Non Mfg.	(5) Durable Mfg.	(6) Non-Durable Mfg	(7) Cons. & Util.	(8) Non Mfg.
Survey Cap	0.221**	0.252*	0.349	0.0299	0.146***	-0.0574	0.315***	0.0979*
	(0.0890)	(0.130)	(0.369)	(0.115)	(0.0415)	(0.102)	(0.0998)	(0.0571)
Observations	115	161	46	161	100	100	40	140
First-stage Fstat	9.517	12.19	3.202	27.44	34.83	6.253	21.35	60.05

US: 1985-2010. Intrumental variables: Oil, Monetary(RR), Excess Bond Premium (GZ)
UK: 1994-2015. Intrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parenthesis.Observations: Industry x year
4 large sectors decomposition

	Germany				France			
	(1) Durable Mfg.	(2) Non-Durable Mfg.	(3) Cons. & Util.	(4) Non Mfg.	(5) Durable Mfg.	(6) Non-Durable Mfg	(7) Cons. & Util.	(8) Non Mfg.
Survey Cap	0.298***	0.464***	-0.0743	0.455***	0.175***	0.122*	0.0450	0.132***
	(0.0361)	(0.0665)	(0.0877)	(0.114)	(0.0506)	(0.0664)	(0.0988)	(0.0389)
Observations	120	120	48	168	120	120	48	168
First-stage Fstat	48.97	17.83	27.14	93.42	47.01	31.33	34.70	127.9

DE: 1991-2015. Intrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
FR: 1991-2015. Intrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parenthesis.Observations: Industry x year
4 large sectors decomposition

	Spain				Italy			
	(1) Durable Mfg.	(2) Non-Durable Mfg.	(3) Cons. & Util.	(4) Non Mfg.	(5) Durable Mfg.	(6) Non-Durable Mfg	(7) Cons. & Util.	(8) Non Mfg.
Survey Cap	0.181***	0.155***	0.109	0.220**	0.285***	0.374***	0.0599	0.227**
	(0.0371)	(0.0558)	(0.209)	(0.110)	(0.0281)	(0.0822)	(0.0490)	(0.0952)
Observations	110	110	44	154	115	115	46	161
Creaig-Davis F-stat	16.24	14.96	22.69	61.32	48.69	16.22	26.25	48.89

ES: 1993-2015. Intrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
IT: 1991-2014. Intrumental variables: Oil, Monetary, Excess Bond Premium (GZ)
Robust standard errors in parenthesis.Observations: Industry x year
4 large sectors decomposition

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Bibliography

Acemoglu, D. and D. Autor (2011). Skills, tasks and technologies: Implications for employment and earnings. In *Handbook of labor economics*, Volume 4, pp. 1043–1171. Elsevier.

Acemoglu, D., D. Autor, D. Dorn, G. H. Hanson, and B. Price (2016). Import competition and the great us employment sag of the 2000s. *Journal of Labor Economics 34*(S1), S141–S198.

Adao, R., C. Arkolakis, and F. Esposito (2019). Spatial linkages, global shocks, and local labor markets: Theory and evidence. Technical report, National Bureau of Economic Research.

Adao, R., M. Kolesár, and E. Morales (2019). Shift-share designs: Theory and inference. *The Quarterly Journal of Economics 134*(4), 1949–2010.

Adda, J. and Y. Fawaz (2019). Trade induced mortality. *L'Actualité Économique 95*(1), 1–25.

Aghion, P., A. Bergeaud, T. Boppart, P. J. Klenow, and H. Li (2017, November). Missing Growth from Creative Destruction. Working Paper 24023, National Bureau of Economic Research.

Albouy, D. (2016). What are cities worth? land rents, local productivity, and the total value of amenities. *Review of Economics and Statistics 98*(3), 477–487.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Alesina, A., C. Favero, and F. Giavazzi (2015). The output effect of fiscal consolidation plans. *Journal of International Economics 96*, S19 – S42. 37th Annual NBER International Seminar on Macroeconomics.

Autor, D. and D. Dorn (2013). The growth of low-skill service jobs and the polarization of the us labor market. *American Economic Review 103*(5), 1553–97.

Autor, D., D. Dorn, G. Hanson, and K. Majlesi (2016). Importing political polarization? *Massachusetts Institute of Technology Manuscript*.

Autor, D., D. Dorn, and G. H. Hanson (2013). The china syndrome: Local labor market effects of import competition in the united states. *American Economic Review 103*(6), 2121–68.

Baker, S. R., N. Bloom, and S. J. Davis (2016). Measuring Economic Policy Uncertainty. *The Quarterly Journal of Economics 131*(4), 1593–1636.

Bakker, J. D. (2018). International trade and regional inequality. Technical report, CEPREMAP.

Baqaee, D. R. and E. Farhi (2017, November). Productivity and Misallocation in General Equilibrium. NBER Working Papers 24007, National Bureau of Economic Research, Inc.

Basu, S. and J. G. Fernald (2001, January). Why Is Productivity Procyclical? Why Do We Care? In *New Developments in Productivity Analysis*, pp. 225–302. University of Chicago Press.

Basu, S., J. G. Fernald, and M. S. Kimball (2006, December). Are Technology Improvements Contractionary? *American Economic Review 96*(5), 1418–1448.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Beaudry, P., M. Doms, and E. Lewis (2006). Endogenous skill bias in technology adoption: City-level evidence from the it revolution. Technical report, National Bureau of Economic Research.

Bentolila, S., P. Cahuc, J. J. Dolado, and T. L. Barbanchon (2012, August). Two-Tier Labour Markets in the Great Recession: France Versus Spain. *Economic Journal 122*(562), 155–187.

Blanchard, O. J. and J. Galí (2007). The Macroeconomic Effects of Oil Price Shocks: Why are the 2000s so different from the 1970s? In *International Dimensions of Monetary Policy*, NBER Chapters, pp. 373–421. National Bureau of Economic Research, Inc.

Bloom, N., M. Draca, and J. Van Reenen (2016). Trade induced technical change? the impact of chinese imports on innovation, it and productivity. *The Review of Economic Studies 83*(1), 87–117.

Bloom, N., K. Handley, A. Kurman, and P. Luck (2019). The impact of chinese trade on us employment: The good, the bad, and the debatable. Technical report.

Borusyak, K., P. Hull, and X. Jaravel (2018). Quasi-experimental shift-share research designs. Technical report, National Bureau of Economic Research.

Boskin, M., E. R. Dulberger, R. J. Gordon, Z. Griliches, and D. Jorgenson (1996). Toward A More Accurate Measure Of The Cost Of Living. Technical report, Final Report to the Senate Finance Committee.

Bound, J. and H. J. Holzer (2000). Demand shifts, population adjustments, and labor market outcomes during the 1980s. *Journal of labor Economics 18*(1), 20–54.

Buera, F. J., J. P. Kaboski, and R. Rogerson (2015). Skill biased structural change. Technical report, National Bureau of Economic Research.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Burnside, C., M. Eichenbaum, and S. Rebelo (1995, April). Capital Utilization and Returns to Scale. In *NBER Macroeconomics Annual 1995, Volume 10*, NBER Chapters, pp. 67–124. National Bureau of Economic Research, Inc.

Burstein, A., E. Morales, and J. Vogel (2019). Changes in between-group inequality: computers, occupations, and international trade. *American Economic Journal: Macroeconomics 11*(2), 348–400.

Bustos, P., J. M. C. Vincenzi, J. Monras, and J. Ponticelli (2019). Structural transformation, industrial specialization, and endogenous growth. Technical report, National Bureau of Economic Research.

Caliendo, L., M. Dvorkin, and F. Parro (2019). Trade and labor market dynamics: General equilibrium analysis of the china trade shock. *Econometrica 87*(3), 741–835.

Cesa-Bianchi, A., G. Thwaites, and A. Vicondoa (2016). Monetary policy transmission in an open economy: new data and evidence from the united kingdom.

Christiano, L. J. and T. J. Fitzgerald (2003). The Band Pass Filter. *International Economic Review 44*(2), 435–465.

Colantone, I., R. Crinò, and L. Ogliari (2015). The hidden cost of globalization: Import competition and mental distress.

Colantone, I. and P. Stanig (2018). Global competition and brexit. *American political science review 112*(2), 201–218.

Combes, P.-P. and L. Gobillon (2015). The empirics of agglomeration economies. In *Handbook of regional and urban economics*, Volume 5, pp. 247–348. Elsevier.

Costello, D. M. (1993). A Cross-Country, Cross-Industry Comparison of Productivity Growth. *Journal of Political Economy 101*(2), 207–222.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Dix-Carneiro, R. and B. K. Kovak (2015). Trade liberalization and the skill premium: A local labor markets approach. *American Economic Review 105*(5), 551–57.

Dorn, D., G. Hanson, et al. (2017). When work disappears: manufacturing decline and the falling marriage-market value of men. Technical report, National Bureau of Economic Research.

Dorn, D., G. H. Hanson, G. Pisano, P. Shu, et al. (2016). Foreign competition and domestic innovation: Evidence from us patents. Technical report, National Bureau of Economic Research.

Eckert, F., S. Ganapati, C. Walsh, et al. (2019). Skilled tradable services: The transformation of us high-skill labor markets. Technical report.

Elvery, J. A. (2010). City size and skill intensity. *Regional Science and Urban Economics 40*(6), 367–379.

Farr, M. and L. Shatkin (2004). *O* NET dictionary of occupational titles*. Jist Publishing.

Feenstra, R. C., H. Ma, and Y. Xu (2017). Us exports and employment. Technical report, National Bureau of Economic Research.

Feler, L. and M. Z. Senses (2017). Trade shocks and the provision of local public goods. *American Economic Journal: Economic Policy 9*(4), 101–43.

Fernald, J. (2014a, October). Productivity and Potential Output Before, During, and After the Great Recession. In *NBER Macroeconomics Annual 2014, Volume 29*.

Fernald, J. G. (2014b). A quarterly, utilization-adjusted series on Total Factor Productivity. Working Paper Series 2012-19, Federal Reserve Bank of San Francisco.

Florida, R., C. Mellander, K. Stolarick, and A. Ross (2011). Cities, skills and wages. *Journal of Economic Geography 12*(2), 355–377.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Forslid, R. and G. I. Ottaviano (2003). An analytically solvable core-periphery model. *Journal of Economic Geography 3*(3), 229–240.

Gertler, M. and P. Karadi (2015, January). Monetary Policy Surprises, Credit Costs, and Economic Activity. *American Economic Journal: Macroeconomics* 7(1), 44–76.

Giannone, E. (2017). Skill-biased technical change and regional convergence. Technical report, Society for Economic Dynamics.

Gilchrist, S. and E. Zakrajšek (2012). Credit spreads and business cycle fluctuations. *American Economic Review 102*(4), 1692–1720.

Glaeser, E. L. and G. A. Ponzetto (2007). Did the death of distance hurt detroit and help new york? Technical report, National Bureau of Economic Research.

Glaeser, E. L. and A. Saiz (2003). The rise of the skilled city. Technical report, National Bureau of Economic Research.

Goldsmith-Pinkham, P., I. Sorkin, and H. Swift (2018). Bartik instruments: What, when, why, and how. Technical report, National Bureau of Economic Research.

Gordon, R. J. (2016). *The Rise and Fall of American Growth: The U.S. Standard of Living since the Civil War*. Princeton University Press.

Grossman, G. M. and E. Rossi-Hansberg (2008). Trading tasks: A simple theory of offshoring. *American Economic Review 98*(5), 1978–97.

Hall, R. E. (1988, October). The Relation between Price and Marginal Cost in U.S. Industry. *Journal of Political Economy 96*(5), 921–947.

Hornbeck, R. and E. Moretti (2018). Who benefits from productivity growth? direct and indirect effects of local tfp growth on wages, rents, and inequality. Technical report, National Bureau of Economic Research.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Hsieh, C.-T. and E. Moretti (2015). Housing constraints and spatial misallocation. Technical report, National Bureau of Economic Research.

Hulten, C. R. (1978). Growth Accounting with Intermediate Inputs. *The Review of Economic Studies 45*(3), 511–518.

Imbs, J. M. (1999). Technology, Growth and the Business Cycle. *Journal of Monetary Economics 44*(1), 65 – 80.

Jäger, K. (2017). EU KLEMS Growth and Productivity Accounts 2017 release - Description of Methodology and General Notes. Technical report, The Conference Board.

Jarocinski, M. and P. Karadi (2018, March). Deconstructing Monetary Policy Surprises - The Role of Information Shocks. CEPR Discussion Papers 12765, C.E.P.R. Discussion Papers.

Jorgenson, D. W., M. S. Ho, and J. D. Samuels (2012). A Prototype Industry-Level Production Account for the United States, 1947–2010.

Levchenko, A. A. and N. Pandalai-Nayar (2018). Technology and Non-Technology Shocks: Measurement and Implications for International Comovement. *mimeo*.

Malamud, O. and A. Wozniak (2012). The impact of college on migration evidence from the vietnam generation. *Journal of Human resources 47*(4), 913–950.

Monras, J. (2018). Economic shocks and internal migration.

Moretti, E. (2011). Local labor markets. In *Handbook of labor economics*, Volume 4, pp. 1237–1313. Elsevier.

Moretti, E. (2012). *The new geography of jobs*. Houghton Mifflin Harcourt.

Moretti, E. (2013). Real wage inequality. *American Economic Journal: Applied Economics 5*(1), 65–103.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Notowidigdo, M. J. (2011). The incidence of local labor demand shocks. Technical report, National Bureau of Economic Research.

Notowidigdo, M. J. (2019). The incidence of local labor demand shocks.

OECD (2001). *Measuring Productivity: OECD Manual*. OECD Statistics.

O'Mahony, M. and M. P. Timmer (2009, June). Output, Input and Productivity Measures at the Industry Level: The EU KLEMS Database. *Economic Journal 119*(538), F374–F403.

Pescatori, A., D. Leigh, J. Guajardo, and P. Devries (2011, June). A New Action-Based Dataset of Fiscal Consolidation. IMF Working Papers 11/128, International Monetary Fund.

Pierce, J. and E. Wisniewski (2018). Some Characteristics of the Decline in Manufacturing Capacity Utilization. *FEDS Notes Washington: Board of Governors of the Federal Reserve System*.

Pierce, J. R. and P. K. Schott (2016). The surprisingly swift decline of us manufacturing employment. *American Economic Review 106*(7), 1632–62.

Roback, J. (1982). Wages, rents, and the quality of life. *Journal of political Economy 90*(6), 1257–1278.

Rohlf, A. (2018). Did globalization help germany become cleaner? - the effect of increasing import/export exposure on local air pollution at the german county level. *mimeo*.

Romer, C. D. and D. H. Romer (2004, September). A New Measure of Monetary Shocks: Derivation and Implications. *American Economic Review 94*(4), 1055–1084.

Romer, C. D. and D. H. Romer (2010, June). The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks. *American Economic Review 100*(3), 763–801.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.

Rosen, S. (1979). Wage-based indexes of urban quality of life. *Current issues in urban economics*, 74–104.

Ruggles, S., M. Sobek, T. Alexander, C. A. Fitch, R. Goeken, P. K. Hall, M. King, and C. Ronnander (2016). Integrated public use microdata series: Version 4.0 [machine-readable database]. minneapolis, mn: Minnesota population center [producer and distributor], 2016.

Shapiro, M. D. (1989). Assessing the Federal Reserve's Measures of Capacity and Utilization. *Brookings Papers on Economic Activity 20*(1), 181–242.

Solow, R. M. (1957). Technical Change and the Aggregate Production Function. *The Review of Economics and Statistics 39*(3), 312–320.

Tolbert, C. M. and M. Sizer (1996). Us commuting zones and labor market areas.

Valero, A. and J. Van Reenen (2016). The economic impact of universities: Evidence from across the globe. Technical report, National Bureau of Economic Research.

Wieland, J. F. and M.-J. Yang (2016, March). Financial Dampening. NBER Working Papers 22141, National Bureau of Economic Research, Inc.

Wozniak, A. (2010). Are college graduates more responsive to distant labor market opportunities? *Journal of Human Resources 45*(4), 944–970.

Xu, Y., H. Ma, and R. C. Feenstra (2019). Magnification of the 'china shock'through the us housing market. Technical report, National Bureau of Economic Research.

Tesi di dottorato "Essays in International Economics, Regional Divergence, and Productivity"
di QUINTANA GONZÁLEZ JAVIER
discussa presso Università Commerciale Luigi Bocconi-Milano nell'anno 2020
La tesi è tutelata dalla normativa sul diritto d'autore (Legge 22 aprile 1941, n.633 e successive integrazioni e modifiche).
Sono comunque fatti salvi i diritti dell'università Commerciale Luigi Bocconi di riproduzione per scopi di ricerca e didattici, con citazione della fonte.