Three essays on labor market frictions, international trade, and uncertainty

Samil Oh

THREE ESSAYS ON LABOR MARKET FRICTIONS, INTERNATIONAL TRADE, AND UNCERTAINTY

A dissertation submitted in partial fulfillment of the requirements for the degree of

PhD in Business Administration
From ESSEC Business School

Presented and defended publicly the 28th of September 2018 by

Samil OH

JURY

Thepthida SOPRASEUTH, Co-Supervisor, Professor, Université de Cergy-Pontoise

Cristina TERRA, Co-Supervisor, Professor, ESSEC Business School

Aurélien EYQUEM, Referee, Professor, Université Lumière Lyon 2

Jinill KIM, Referee, Professor, Korea University

Lise PATUREAU, Professor, Université Paris-Daupine

Olivier CHARLOT, Professor, Université de Cergy-Pontoise

Université / / Paris Seine

Thèse de doctorat

pour l'obtention du titre de DOCTEUR EN SCIENCES ÉCONOMIQUES délivré par

l'Université de Cergy-Pontoise

École doctorale no 405 : Économie, Management, Mathématiques et Physique (EM2P) Théorie Économique, Modélisation et Applications (THEMA)
CNRS UMR 8184

THREE ESSAYS ON LABOR MARKET FRICTIONS, INTERNATIONAL TRADE, AND UNCERTAINTY

présentée et soutenue publiquement le 28 09 2018 par

Samil OH

JURY

Thepthida SOPRASEUTH, CoDirecteur de thèse, Professeur, Université de Cergy-Pontoise

Cristina TERRA, CoDirecteur de thèse, Professeur, ESSEC Business School

Aurélien EYQUEM, Rapporteur, Professeur, Université Lumière Lyon 2

Jinill KIM, Rapporteur, Professeur, Korea University

Lise PATUREAU, Professeur, Université Paris-Daupine

Olivier CHARLOT, Professeur, Université de Cergy-Pontoise

Acknowledgements

This dissertation concludes four years of hard work, dozens of pages of code, but above all a fantastic opportunity to meet and interact with bright and generous people at ESSEC, Université de Cergy-Pontoise, and more recently at ILO.

First and foremost, I express my gratitude to my one of a kind supervisor, Professor Thepthida Sopraseuth, for her guidance and support. She has been my advisor and mentor since my first year at ESSEC. With her patience, generosity, rigor and wisdom, she provided me with all the orientation, knowledge, talent and motivation I could ask for. Without her persistent help and encouragement, this thesis would not have been possible. I have been privileged and honored to have her as my advisor. I would also like to thank my co-supervisor, Professor Cristina Terra, for her supporting smiles and comments. Since the first year, Terra has been of great advice, always eager to help me with professional, academic, or personal advice.

My deep gratitude also goes to the members of my dissertation committee. I am particularly grateful to Professor Aurélien Eyquem and Professor Jinill Kim for accepting to be the referees of my thesis. I would also like to thank the members of the jury: Professor Lise Patureau and Professor Olivier Charlot.

I also thank François Langot for inviting me to join the research project, sponsored by the World Bank and ILO. I was lucky and honored to collaborate with him. I have learned a great deal from him on how to write a paper. I am deeply indebted to my co-author Rossana Merola (ILO) for her valuable inputs and offering me to join ILO.

I am also grateful to Lina Prevost, who has provided outstanding support in all administrative and organizational tasks since the beginning of this Ph.D. Special thanks to all my colleagues at ESSEC and Université de Cergy-Pontoise for their support and contribution into the completion of this thesis: Davide Romelli, Oana Peia, Nima Fazeli, Jérémie Juste, Tista Kundu, Joonsuk Kwon, Hyunwoo Shim, Yong June Yoon, Heesang Ryu, Xiao Jia, and Bastien Buchwalter. I wish you all an exciting and adventurous post-Ph.D. life, and I am looking forward for our paths to cross again. Although I only spent a few months at ILO, I also want to thank Francesco Carbonero, Muhammad Waleed, Daniel Samaan, and Ekkehard Ernst for making feel at home from the beginning.

Mira, my lifetime partner, the mother of my beautiful daughter, I thank you for accepting to take this long and exhausting journey with me. Your love and support helped me throughout. This journey belongs to you!

Contents

List of Tables

List of Figures

Introduction

The labor market is a central institution in any modern economy. This market allocates workers to jobs. If the labor market operates properly, workers will find employment at the right speed, and these jobs will be appropriate to their experience and skill. If the market does not function satisfactorily, willing workers will remain unemployed for too long, vacancies will stay unfilled, and many workers will occupy positions that are unsuited for them. Moreover, firms will not appear, grow, or close at the optimal rate.

At the same time, the labor market is characterized by pervasive regulation. Across nations, the labor market is subject to minimum wages, hiring and firing restrictions, compulsory collective bargaining and arbitrage, limitations on the number of hours, anti-discrimination clauses, curtailments on work by age and by gender, etc. Moreover, substantial differences in labor market flexibility persist even within groups of countries with similar income levels.

A recent and growing literature investigates the consequences of such heterogeneity in labor market institutions, studying how labor market rigidities affect the causes and consequences of policy changes, such as trade liberalization and market reforms. An important conclusion of these research is that the institutional features of local labor markets shape the pattern of comparative advantage across countries, contributing to the determination of long-run outcomes of regime changes. Thus far, however, few works have addressed the implications of labor market rigidities for trade-induced labor dynamics focusing on the informal sector, or the second moment shocks in an open economy setting. Important questions remain open for researchers and policymakers: How does labor market frictions interact with uncertainty in a small open economy? How do labor market frictions in formal and informal sectors affect the transition dynamics generated by trade integration? Are labor market frictions important for understanding the propagation of uncertainty shocks across countries? The purpose of this thesis is to address these questions, studying the role of labor market frictions and its interaction with international trade and uncertainty.

Chapter One The first chapter investigates the impact of uncertainty shocks in a small open economy with search and matching frictions and firm entry. Other existing works analyze the macroeconomic effect of uncertainty shocks using either search and matching models, or in an open economy setting. To the best of our knowledge, none has used firm entry model. In our paper, we combine all elements and show how they interact and magnify recessionary effects of uncertainty shocks.

We first develop our empirical analysis in the context of the Korean economy, as all dimensions of the model are relevant in this country. An increase in uncertainty lowers output, consumption, investment and job finding rate, while raising unemployment and job separations. We also supplement the existing empirical evidence by looking at firm dynamics, real exchange rate and current account behavior. Increased uncertainty generates current account surplus, real exchange rate depreciation and reduces the number of firms in the economy. In our theoretical framework, we illustrate new transmissions mechanism that are ignored in the literature. Economic mechanisms go beyond the simple addition of each feature. Search frictions, firm entry and the open economy dimension actually strongly interact to amplify the effects of uncertainty shocks and make the model consistent with the empirical evidence.

This paper is co-authored with Thepthida Sopreseuth (Université de Cergy-Pontoise (THEMA)). We thank Olivier Charlot, Lise Patureau, Lee Sang Seok and Cristina Terra for their comments as well as participants to T2M conference (Lisbon, 2017), Asian Meeting of the Econometric Society (Hong Kong, 2017), Society for Computational Economics (New York, 2017), KEA-APEA conference (Seoul, 2017).

Chapter Two The second chapter studies how tax reforms help ensure a fair globalization. Over the past decades, trade liberalization has led to significant trade expansion, with positive effects on the economic activity. However, trade liberalization has not always been associated with better working conditions and more equal income distribution. In this paper we develop a two-area model: a developed and an emerging country. The two areas differ according to the size of the informal sector, which is characterized by a more flexible labor market (i.e. rapid entry and exit and more flexible adjustment to change in demand) and lower productivity. Our analysis suggests that trade liberalization boosts economic activity and employment in both the formal and informal sector. However, this employment expansion is biased toward the informal sector, which is not subject to labor regulation and hence more flexible. Hence, trade liberalization leads to lower employment quality, as informal workers are not covered by the labor legislation (e.g. minimum wages) and social security, and receive lower wage.

In order to reduce the increasing incidence of informality by trade liberalization, both countries should introduce incentives to develop businesses in the formal economy. A budget-neutral tax reform switching the tax burden from payroll taxes paid by firms operating in the formal sector to a consumption tax may represent a strategy to support the formal sector. Moreover, these tax reforms succeed in mitigating the adverse effects of trade liberalization on employment quality. However, formalization comes at the cost of widening income inequality between formal and informal workers.

This paper is co-authored with François Langot (Le Mans University (Gains-TEPP & IRA), Paris School of Economics & Cepremap) and Rossana Merola (ILO). The work greatly benefited from guidance, encouragement and helpful comments by Stéphane Adjemian, Thomas Brand, Matteo Cacciatore, Ekkehard Ernst, Fabio Ghironi, Stefan Kühn,

Pierella Paci, Christian Viegelahn and members of the DYNARE team. It has been presented at the World Bank (2018) and Asian Meeting of the Econometric Society (Seoul, 2018).

Chapter Three The third chapter assesses the importance of labor market institutions in the transmission of uncertainty shocks to labor markets. Since the work by Bloom (2009), uncertainty about the future course of the economy has been identified as a possible driving force behind business cycle fluctuations. A number of recent papers have shown that an increase in uncertainty leads to a drop in economic activity: output, investment, consumption, and employment. However, most of the analysis studies the impact of uncertainty shocks in single-country analysis and cross-country evidence focusing on the labor market is still scarce.

Using country-specific VARs across OECD countries, I find that there is substantial cross-country heterogeneity in the responses of unemployment rates to uncertainty shocks. I also provide evidence that this heterogeneity can be attributed to differential employment protection legislation (EPL). Low EPL countries suffer more severe rises in unemployment compared to high EPL countries following uncertainty shocks. Stricter EPL mutes the reaction of unemployment, making it more costly to lay workers off. Moreover, the second moment shock reinforces this mechanism through the real options channel. Under irreversibility and uncertainty, firing costs come with a bigger cost. On the other hand, the role of other labor market characteristics is ambiguous.

Chapter 1

Firm Entry, Search and Marching Frictions in a Small Open Economy Faced with Uncertainty Shocks: The Case of Korea

1.1 Introduction

This paper investigates the impact of uncertainty shocks in a small open economy with search and matching frictions, endogenous job separation and firm entry. We combine these elements to highlight important transmission mechanisms that have not been analyzed in the existing work. We develop our analysis in the context of the Korean economy, as all dimensions of the model are relevant in this country: Korea is a globalized economy with heavily regulated labor and product markets, in which the job separation margin explains a large share of unemployment fluctuations.

We first provide original empirical evidence on the effects of fluctuating uncertainty on macroeconomic aggregates, labor market adjustments, firm dynamics, real exchange rate and current account. Using survey data, we compute the job finding and job separation rates. Following Shimer (2012)'s variance decomposition, unemployment inflows appears to be the main driver of unemployment cyclical behavior, which stresses the need for endogenous separation in the model. We then investigate the macroeconomic impact of time-varying volatility in a structural VAR. In doing so, we extend the literature along several dimensions. First, to our knowledge, we are the first to provide empirical evidence on labor market flows, firm dynamics *and* open-economy variables. Previous studies either investigate labor market flows or open-economy dimension. None look at firm dynamics. We look at all dimensions in Korean data. Secondly, the papers that analyze the effect of uncertainty shocks on the labor market (Leduc & Liu (2016), Guglielminetti (2016), Riegler (2015)) focus on US data. However, gross labor market flows are large in the US, suggesting that search and matching frictions may be too low to create large irreversibility. The macroeconomic effects of uncertainty may be larger in more regulated labor and product markets, such as in Korea. With the exception of Miyamoto (2016) on Japanese data, to our knowledge, there is no empirical study on labor market flows in other countries in uncertain times. We fill this gap. We find that an increase in uncertainty lowers output, consumption, investment and job finding rates, while raising job separations and unemployment. We also find that increased uncertainty generates current account surplus, real exchange rate depreciation and reduces the number of firms in the economy.

We next develop a small open economy with search and matching frictions, endogenous job separation and firm entry. Uncertainty shocks are defined as unexpected exogenous variations in the volatility of the technological process. We consider only this uncertainty shock in order to compare our results to the literature (that mainly focuses on the macroeconomic impact of this shock). The model predicts that an increase in uncertainty raises unemployment, job separation rates, and lowers output, consumption, investment, the number of firms and job finding rates. The economy is also characterized by a current account surplus and real exchange rate depreciation. These effects are consistent with the VAR evidence.

The economic mechanisms are the following. In the standard real business cycle (RBC) model, uncertainty creates a precautionary saving motive: Domestic households cut consumption spending to invest in physical capital, job creation, firm entry or Foreign bonds. In a search and matching model, a job match is an irreversible long-term employment relation, which creates an option-value channel. When uncertainty increases, the value of a job match declines as the option value of waiting increases. Under the benchmark calibration, the option-value channel dominates the precautionary motive effects such that the increase in uncertainty reduces vacancies. Firms also use the separation margin to lay off the least productive workers. Unemployment goes up, making it harder for unemployed workers to find jobs. The decline in employment drives the marginal product of capital downward, which triggers fall in capital investment. The real option channel also applies to firm entry. As firm entry is costly, the option value of waiting increases. The expected value of a firm falls, which drives firm entry down. The number of producers declines. At the aggregate level, the reduction in the number of firms is equivalent to a drop in the capital stock. This amplifies the initial fall in output. The recessionary effects of increased uncertainty make investment in capital, job creation and firms unattractive. Households are then attracted by foreign bonds, which creates a current account surplus. Real exchange rate depreciates in response to increased uncertainty because of the fall in domestic relative prices, induced by the reduction in the number of producers. Real exchange rate depreciation makes Foreign bonds attractive as an hedging device against domestic shocks.

Economic mechanisms go beyond the simple addition of each feature. Search frictions, firm entry and the open economy dimension actually strongly interact to amplify the effects of uncertainty shocks and make the model consistent with the empirical evidence. Several elements illustrate these interactions. First, in a search and matching model with firm entry, firm entry interacts with labor frictions as the number of competitors affect the firm's relative price, hence the marginal value of a match. In turn, as firm entry involves vacancy opening, labor market tightness affects firm entry costs (Cacciatore & Fiori (2016)). Secondly, firm entry affects relative prices, hence consumer price index. The real exchange rate is therefore responsive to changes in the competitive environment. Furthermore, real exchange rate depreciation makes Foreign bonds attractive as an insurance device against domestic shocks.

Households then strongly reduce consumption and investment in domestic smoothing tools (jobs, firms or capital), thereby amplifying the recession in uncertain times.

Our work relates to the literature that documents the relationship between uncertainty and the business cycle. Basu & Bundick (2017) argue that the fall in output, consumption, investment, and employment can be obtained after an uncertainty shock in a demand-driven economy, with price rigidity. In Basu & Bundick (2017)'s model, increased uncertainty leads to an endogenous rise in markups, which is crucial in driving down employment in uncertain times. In this paper, as heightened uncertainty lowers firm entry, markups also endogenously increase. With respect to Basu & Bundick (2017), we investigate the macroeconomic effects of uncertainty shocks on labor market flows in an open economy setting. Other existing works analyze the macroeconomic effect of uncertainty shocks using either search and matching models, or in an open economy setting. To the best of our knowledge, none has used firm entry model. In our paper, we combine all elements and show how they interact and magnify recessionary effects of uncertainty shocks.

With respect to the literature on uncertainty shock in an open economy setting (Fernandez-Villaverde et al. (2011), Fogli & Perri (2015), Kollmann (2016)), our originality lies in investigating the consequences of time-varying volatility on labor market adjustments and firm entry. All models, including our own, correctly predict that heightened uncertainty is associated with a current account surplus. However, Kollmann (2016)'s model predicts that heightened uncertainty leads to higher domestic consumption and real exchange rate appreciation, which is not consistent with Korean data. Fernandez-Villaverde et al. (2011) and Fogli & Perri (2015)'s models generate a large precautionary savings that entices domestic households to work more, which is also inconsistent with Korean data. With respect to the literature in a search and matching environment (Leduc & Liu (2016), Guglielminetti (2016), Miyamoto (2016)), we lay stress on the endogenous separation and study the interaction between search and matching frictions and firm entry in an open economy setting. In particular, with endogenous separation, job finding rate increases in uncertain times, which is not consistent with the data (Miyamoto (2016)). Schaal (2017)'s search model also predicts an increase in the job finding rate during the Great recession [1]. Riegler (2015)'s search and matching model correctly predicts a fall in the job finding rate in response to increased uncertainty. With respect to his paper, we investigate the impact of uncertainty in aggregate shocks, rather than idiosyncratic volatility shock. Furthermore, Riegler (2015) introduces

[1] Schaal (2017) also get sizable effects from idiosyncratic volatility shocks partly by assuming a negative correlation between the volatility shocks and the level of aggregate productivity. We do not follow this route.

costly job creation (in addition to the usual hiring cost) to obtain the desired fall in job finding rate after an increase in uncertainty. We do not follow this route. Finally, we take into account the feedback effect of firm dynamics on relative prices, hence real exchange rate, which in turn affects precautionary motives and investment. Schaal (2017) and Riegler (2015) propose interesting insight in labor market dynamics. However, they say nothing about consumption and investment dynamics. As pointed out by Basu & Bundick (2017), papers experience difficulty in generating business-cycle comovements among output, consumption, investment, and employment from changes in uncertainty. Our paper succeeds in doing so, in addition to generating data-consistent a fall in the number of firms, current account surplus and real exchange rate depreciation. Finally, we relate to the literature using search and matching models with firm dynamics. Cacciatore & Fiori (2016) and Cacciatore et al. (2016) focus on structural reforms. We extend this work by investigating the macroeconomic effects of uncertainty shocks.

The paper is organized as follows. We investigate the macroeconomic effects of uncertainty shocks in Korean data in Section 2. We develop a small open economy model with search and matching, endogenous separation and firm entry in Section 3. We explore the macroeconomic effects of uncertainty shocks in Section 4. Section 5 concludes.

1.2 Effects of uncertainty shocks: empirical evidence

1.2.1 Measuring uncertainty

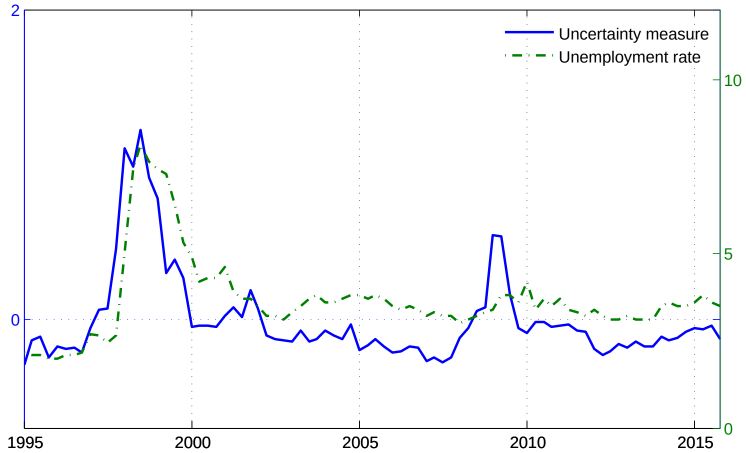
Our measure of uncertainty is forecast dispersion computed from the Korean economy forecasts. Periods when forecasters hold more diverse opinions are likely to reflect greater uncertainty. Survey-based measures of uncertainty have been commonly used in the empirical literature (Bachmann et al. (2013), Leduc & Liu (2016), Guglielminetti (2016) among others). Since January 1995, Consensus Economics has surveyed over prominent financial and economic forecasters for their estimates of a range of Korean macroeconomic variables, including GDP, inflation, unemployment and interest rates over a 2 year forecast horizon. Among them, we use the cross-sectional standard deviation of GDP forecasts.[2] The monthly

[2]To construct the series, we compute the average of cross-sectional standard deviations of GDP forecasts over a 2 year horizon. Bloom (2014) also checks that forecast dispersion provides a good proxy for perceived uncertainty. In the US Survey of Professional Forecasters, in 1992, forecasters provide probabilities for GDP growth (in percent) falling into ten different bins. Using the subjective uncertainty calculated using these probabilities, Bloom shows that disagreement across forecasters indeed captures changes in subjective

time series are seasonally adjusted using X-13-ARIMA-SEATS method and we quarterly average the series from 1995Q1 to 2015Q4.

Since we study the effects of a domestic uncertainty shock, however, our measure needs to be orthogonal to foreign uncertainty shocks. Therefore, we regress our forecast dispersion on US uncertainty measure[3] and use the residual from this regression as our uncertainty measure. Figure 1.1 displays our measure of uncertainty. In particular, our measure is positively associated with the unemployment rate. This counter-cyclical behavior is consistent with empirical findings on US data.

Figure 1.1: Uncertainty measure



Source: Authors's calculations and Statistics Korea. Uncertainty measure (the left y-axis). Unemployment rate (the right y-axis)

1.2.2 Measuring worker flows

As in Shimer (2012), we measure the probability that an employed worker becomes unemployed and the probability that an unemployed worker finds a job, using EAPS survey data, between 1995Q1 and 2015Q4 [4]. Job finding and employment exit probabilities are

uncertainty.

[3]As US uncertainty indicator, we use a measure of disagreement drawn by the Survey of Professional Forecasters (SPF) administered by the Philadelphia FED. Professional forecasters are asked to disclose their best predictions about several macroeconomics indicators at different horizons. The Philadelphia FED itself computes a measure of forecast dispersion, which consists of the difference between the 75th and the 25th percentiles of the forecasts. We use this measure computed for the forecast on nominal GDP.

[4]See Appendix 1.5 for a full description of the microdata and the methodology.

reported in Figure 1.6 in Appendix 1.5. The job finding probability falls in recession, while employment exit probability rises in economic slumps. These cyclical features are also found in other OECD countries (Elsby et al. (2008), Shimer (2012)). The salient stylized fact in Korean data lies in the leading role of job separations in unemployment fluctuations. Based on Shimer (2012)'s variance decomposition, exit from employment accounts for nearly 80% of unemployment fluctuations (versus an upper bound of 50%-60% on US and French data (Fujita & Ramey (2009), Hairault et al. (2015)).[5] As a result, the model developed in this paper includes endogenous separation.

1.2.3 VAR evidence

The structural VAR consists of six time-series; in the following order, a measure of uncertainty, one of the labor market variables (the unemployment rate, the job finding rate or the job separation rate), the number of firms [6], real GDP (or one of GDP components such as real consumption or real private investment), a measure related to the open economy dimension (current account, as percent of GDP, or real exchange rate defined as the relative price of US consumption basket with respect to the Korean one[7]) and US real GDP. We include US output to ensure the identified shock is not correlated with any foreign shock. It is estimated with 2 lags according to Akaike's information criterion. All quarterly variables are in log (except a measure of uncertainty and current account), seasonally adjusted, and HP-filtered with smoothing parameter 1600. The sample ranges from 1995Q1 to 2015Q4.

As in Basu & Bundick (2017) and Leduc & Liu (2016), we assume that uncertainty does not respond to the state of the economy on impact, but labor variables, real domestic GDP, and current account are allowed to react instantaneously to uncertainty. As in Leduc & Liu (2016), our identification strategy exploits the fact that, when answering questions at time t about their expectations, survey participants do not have complete information about the time t realizations of variables in our VAR model because the macroeconomic data have not yet been made public. Thus, the measure of uncertainty comes first in the Cholesky ordering.

Figure 1.2 plots the effects of the relevant variables to one-standard deviation shock to

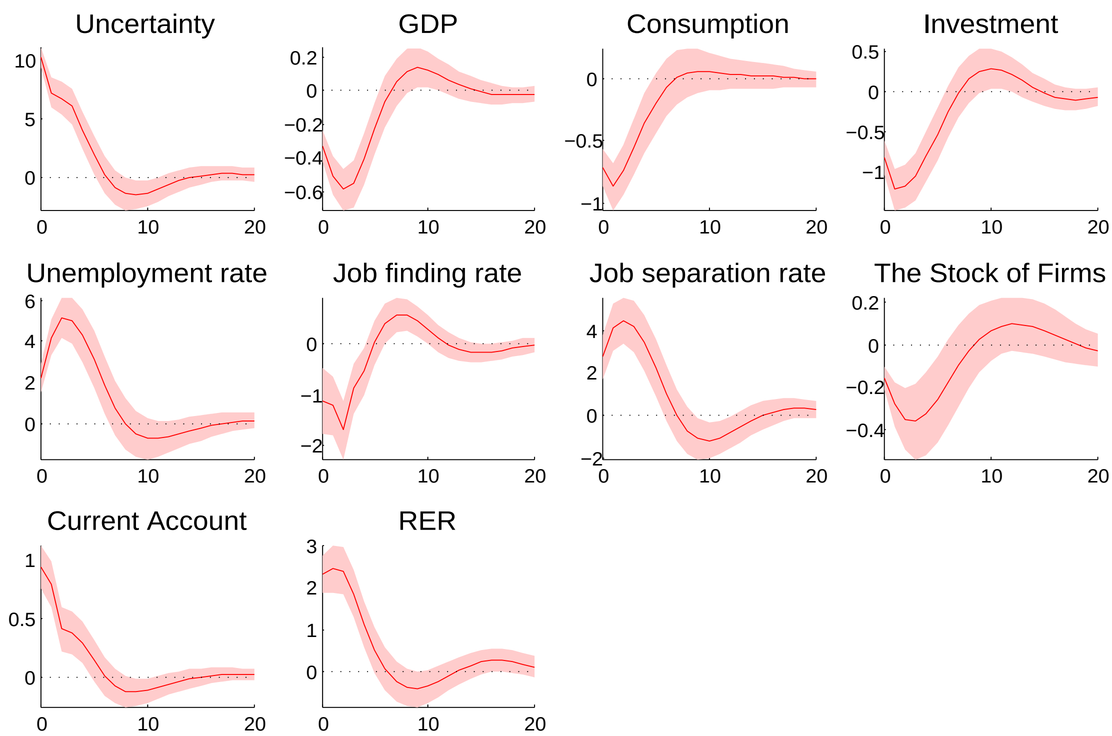
[5]See Appendix 1.5 for details on the computation of Shimer (2012)'s variance decomposition.

[6]Korean firm data are available on a semi-annual basis. Thus, semi-annual stock of firms is turned into quarterly data using spline. Furthermore, for want of data, we could not include vacancies in the VAR.

[7]In the model as in the data, real exchange rate is the US CPI expressed in South Korean wons relative to Korean CPI. An increase in the real exchange rate captures a depreciation of the Korean currency.

uncertainty with the 68% confidence bands. The responses of all macroeconomic variables appear statistically significant. First of all, a surge in uncertainty reduces output, consumption, and investment. Specifically, an increase in uncertainty produces a peak decline in output of about 0.6 percent, which falls within the range found in the literature (0.2 percent in Basu & Bundick (2017), 2.5 percent in Bloom et al. (2012)). The peak decline in investment is twice larger as the decline in output, as in US data (Basu & Bundick (2017)).

Figure 1.2: Structual VAR : The effects of one-standard deviation increase in uncertainty



Note: Quarterly data. 68% confidence band. The units of the horizontal axes are quarters. The units of the vertical axes are % change. Example : following a 1 standard deviation shock, the maximum fall in investment is -1.5%. Current account is % of GDP, IRF is then in percentage points.

Heightened uncertainty lowers GDP, consumption and investment, as well as the job finding rate while job separation increases. Both effects on the job finding and separation rates contribute to an increase in unemployment. In particular, a one-standard-deviation increase in uncertainty leads to a peak increase of unemployment rate of about 5.1 percent relative to the sample average. The negative effects of higher uncertainty on labor variables are in line with the recent empirical studies on US flows (Leduc & Liu (2016), Riegler (2015) and Guglielminetti (2016)). The number of firms significantly drops following an uncertainty shock. Increased uncertainty is also associated with current account surplus. This is consistent with the empirical result that heightened uncertainty reduces domestic absorption (consumption and investment fall, Fogli & Perri (2015), Fernandez-Villaverde et al. (2011)). Korean real exchange depreciates on impact. This is also consistent with current account surplus as real depreciation makes imports more expensive and sustains exports. In Appendix 1.5, we also show that the results are robust to alternative identification, volatility measure, and specification.

1.3 Small open economy with labor market frictions, endogenous job separation and firm entry

In this section, we develop a small open economy with labor market frictions, endogenous job separation and firm entry as in Cacciatore & Fiori (2016) and Cacciatore et al. (2016). Foreign variables are denoted with a superscript star. The subscript d refers to quantities and prices of a country's own goods consumed domestically. x refers to quantities and prices of exports.

1.3.1 Household's preference

The economy is populated by a unit mass of households, where each household is an extended family. In each family, some members are employed, others are employed. This assumption is made to avoid heterogeneity across households, as in Andolfatto (1996). The representative household maximizes the expected intertemporal utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma_c}}{1-\sigma_c} \right]$$

where $\beta \in (0,1)$ is the discount factor, and $\sigma_c > 0$ risk aversion. C_t represents consumption of market and home-produced goods: $C_t = C_t^M + (1 - L_t)h_p$, where C_t^M is consumption of market goods, h_p is home production, and L_t is the number of employed workers. The aggregate market-consumption basket C_t^M is a CES aggregate of domestic ($C_{d,t}$) and foreign

$(C^*_{x,t})$ goods with elasticity of substitution $\phi > 0$:

$$C_t^M = \left((1-\gamma)^{\frac{1}{\phi}} C_{d,t}^{\frac{\phi-1}{\phi}} + \gamma^{\frac{1}{\phi}} (C^*_{x,t})^{\frac{\phi-1}{\phi}}\right)^{\frac{\phi}{\phi-1}}$$

with $0 < \gamma < 1$ the share of foreign goods in the consumption basket and ϕ the elasticity of substitution between Home and Foreign goods. The corresponding composite price index is:

$$P_t = \left((1-\gamma) P_{d,t}^{1-\phi} + \gamma(\varepsilon_t P^*_{x,t})^{1-\phi}\right)^{\frac{1}{\phi-1}}$$

with ε_t the nominal exchange rate. The domestic consumption basket $C_{d,t}$ is defined over a set Ω_t of available consumption goods. As in Bilbiie et al. (2012), we assume that $C_{d,t}$ and $C^*_{x,t}$ take a translog form as in Feenstra (2003) such that the elasticity of substitution across varieties ω in the subset $C_{d,t}$ increases with the number of available goods in the economy. The price index associated with translog preferences is

$$\begin{aligned} \ln P_{d,t} &= \frac{1}{2\sigma}\left(\frac{1}{N_t} - \frac{1}{\tilde{N}_t}\right) + \frac{1}{N_t}\int_{\omega \subset \Omega_{d,t}} \ln p_{d,t}(\omega) d\omega \\ &\quad + \frac{\sigma}{2N_t}\int_{\omega \subset \Omega_{d,t}} \int_{\omega' \subset \Omega_{d,t}} \ln p_{d,t}(\omega)\left(\ln p_{d,t}(\omega) - \ln p_{d,t}(\omega')\right) d\omega d\omega' \end{aligned}$$

with $\sigma > 0$ the price elasticity of demand on an individual good, $p_{d,t}(\omega)$ the price of a variety ω produced and sold at Home, N_t the total number of Home producers (the mass of Ω_t), and $\tilde{N}_t$ the maximum number of varieties (the mass of Ω). In a small open economy setting, P^*_t and $P^*_{x,t}$ are exogenous.

1.3.2 Production

Producer of variety ω. There is a continuum of monopolistically competitive firms, each producing a different variety ω. As in Bilbiie et al. (2012), a firm is a producer of one product. The number of firms is endogenous, because of firm entry. Upon entry, firms pay a sunk entry cost $f_{E,t}$. Exit is exogenous, based on death shock $0 < \delta < 1$. Production uses labor and capital. Within each firm, there is a continuum of jobs, each job is executed by one worker. Capital is perfectly mobile across firms and jobs as in Den Haan & Watson (2000) and Cacciatore & Fiori (2016).

A filled job i at firm ω produces $Z_t z_{it} k^{\alpha}_{i\omega t}$ with Z_t aggregate productivity, z_{it} match-specific productivity, $k_{i\omega t}$ stock of capital allocated to the job. Within each firm, jobs with identical productivity z_{it} produce the same amount of output. As a result, i be can ignored. Each job is characterized by its match-specific productivity z_t. z_t is a per-period i.i.d. draw from a time-invariant distribution with c.d.f. $G(z)$, positive support, and density $g(z)$. When solving the model, we assume that $G(z)$ is lognormal with log-scale μ_z and shape σ_z. Total output for producer ω is

$$y_{\omega t} = Z_t l_{\omega t} \frac{1}{[1 - G(z^c_{\omega t})]} \int_{z^c_{\omega t}}^{\infty} k^{\alpha}_{\omega t}(z) z g(z) dz$$

$z^c_{\omega t}$ endogenous threshold below which jobs that draw $z_t < z^c_{\omega t}$ are not profitable. As in Leduc & Liu (2016), the aggregate TFP shock Z_t follows the stochastic process

$$\ln Z_t = \rho_z \ln Z_{t-1} + \sigma_{zt} \epsilon^z_t \tag{1.1}$$

with $0 < \rho_Z < 1$. ϵ^z_t is an i.i.d.innovation to the technology shock and is a standard normal process, with mean zero and unit variance. The time-varying standard deviation of the innovation σ_{zt} captures technology uncertainty shock. σ_{zt} follows the stochastic process

$$\ln \sigma_{zt} = (1 - \rho_{\sigma_z}) \ln \sigma_z + \rho_{\sigma_z} \ln \sigma_{z,t-1} + \sigma_{\sigma_z} \epsilon^{\sigma_z}_t \tag{1.2}$$

with $0 < \rho_{\sigma_z} < 1$. $\epsilon^{\sigma_z}_t$ is an i.i.d.innovation to the technology uncertainty shock and is a standard normal process, with mean zero and unit variance. σ_{zt} and σ_{σ_z} respectively controls the degree of mean volatility and stochastic volatility in TFP. Firms sells at home and abroad. The demand faced by producer ω is

$$y_{\omega t} = y_{d,t}(\omega) + y_{x,t}(\omega)$$

with

$$y_{d,t}(\omega) = (1 - \gamma)\sigma \ln \left(\frac{\bar{p}_{d,t}}{p_{d,t}(\omega)} \right) \frac{P_{d,t}}{p_{d,t}(\omega)} \left(\frac{P_{d,t}}{P_t} \right)^{-\phi} Y^C_t$$

$$y_{x,t}(\omega) = \gamma\sigma \ln \left(\frac{\bar{p}_{x,t}}{p_{x,t}(\omega)} \right) \frac{P_{x,t}}{p_{x,t}(\omega)} \left(\frac{P_{x,t}}{\varepsilon_t P^*_t} \right)^{-\phi} Y^{C*}_t$$

where Y^C and Y^{C*}_t denote aggregate demand at Home and abroad. Notice that P^*_t expressed in Foreign currency, while P_x and $p_{x,t}(\omega)$ are in Home currency. The maximum prices that a domestic producer can charge is lower when faced with a larger number of competitors N_t

$$\ln \bar{p}_{d,t} = \frac{1}{\sigma N_t} + \frac{1}{N_t}\int_{\omega \subset \Omega_{d,t}} \ln p_{d,t}(\omega) d\omega$$
$$\ln \bar{p}_{x,t} = \frac{1}{\sigma N_t} + \frac{1}{N_t}\int_{\omega \subset \Omega_{x,t}} \ln p_{x,t}(\omega) d\omega$$

Search and matching frictions Labor markets are characterized by search and matching frictions. Hirings are subject to costs of posting vacancy κ. The number of matched workers M_t are such that

$$M_t = \chi U_t^{\varepsilon} V_t^{1-\varepsilon}$$

with $\chi > 0$, $0 < \varepsilon < 1$, U_t the total number of unemployed workers in the economy and V_t the aggregate number of vacancies. The probability of filling a vacancy is $q_t = \frac{M_t}{V_t}$ and labor market tightness is $\theta_t = \frac{V_t}{U_t}$. Firms select capital after observing aggregate and idiosyncratic shocks. Let $v_{\omega t}$ denote the vacancies posted by producer ω. Total capital stock for firm ω is $k_{\omega t} = l_{\omega t}\tilde{k}_{\omega t}$ where

$$\tilde{k}_{\omega t} = \frac{1}{\left[1 - G\left(z_{\omega t}^c\right)\right]}\int_{z_{\omega t}^c}^{\infty} k_{\omega t}^{\alpha}(z) g(z) dz$$

The inflow of new workers and the outflow of workers due to separations jointly determine the evolution of firm level employment.

$$l_{\omega t} = \left(1 - \lambda_{\omega t}\right)\left(l_{\omega t-1} + q_{t-1} v_{\omega t-1}\right)$$

where $\lambda_{\omega t} = \lambda_t^x + \left(1 - \lambda_t^x\right) G\left(z_{\omega t}^c\right)$ denotes total separations within the firm ω. λ_t^x is the fraction of jobs that are exogenously separated in each firm.

Profit maximization Producer ω's production function can be written as

$$y_{\omega t} = Z_t \tilde{z}_{\omega t} k_{\omega t}^{\alpha} l_{\omega t}^{1-\alpha}$$

with $k_{\omega t} = l_{\omega t}\tilde{k}_{\omega t}$, $\tilde{z}_{\omega t} = \frac{1}{[1-G(z_{\omega t}^c)]}\left[\int_{z_{\omega t}^c}^{\infty} z^{\frac{1}{1-\alpha}} g(z) dz\right]^{1-\alpha}$ and $\tilde{k}_{\omega t} = \frac{1}{[1-G(z_{\omega t}^c)]}\int_{z_{\omega t}^c}^{\infty} k_{\omega t}^{\alpha}(z) g(z) dz$. Let $\rho_{\omega t} = \frac{p_{\omega t}}{P_t}$ denote the relative price of good ω with respect to the consumer price index. $\rho_{x\omega t} = \frac{p_{xt}}{P_t}$ as p_{xt} is the export price, expressed in Home consumption units. The firm per-period profit (in units of consumption) is

$$d_{\omega t} = \rho_{d\omega t} y_{d,t}(\omega) + \rho_{x\omega t} y_{x,t}(\omega) - \tilde{w}_{\omega t} l_{\omega t} - r_t k_{\omega t} - \left(1 - \lambda_t^x\right) G\left(z_{\omega t}^c\right)\left(l_{\omega t-1} + q_{t-1} v_{\omega t-1}\right) F - \kappa v_{\omega t}$$

where $\tilde{w}_{\omega t} = \frac{1}{[1-G(z^c_{\omega t})]}\int_{z^c_{\omega t}}^{\infty} w_{\omega t}(z)g(z)dz$ is the average wage paid by the firm. When terminating a job, each job incurs a real cost F. Firing costs are not a transfer to workers, they refer to pure administrative losses. The firm's program is

$$Max \quad \Pi_t = E_t\left[\sum_{s=t}^{\infty}\beta^t\left(1-\delta\right)^{s-t}\frac{\lambda_{t+s}}{\lambda_t}d_{\omega s}\right]$$

subject to

$$\begin{aligned}
l_{\omega t} &= \left(1-\lambda_{\omega t}\right)\left(l_{\omega t-1}+q_{t-1}v_{\omega t-1}\right) \qquad (\psi_{\omega t})\\
y_{\omega t} &= y_{x,t}(\omega)+y_{d,t}(\omega) = Z_t l_{\omega t}\frac{1}{\left[1-G\left(z^c_{\omega t}\right)\right]}\int_{z^c_{\omega t}}^{\infty} k^{\alpha}_{\omega t}(z)zg(z)dz \qquad (\varphi_{\omega t})\\
y_{\omega t} &= y_{x,t}(\omega)+y_{d,t}(\omega) = \sigma\ln\left(\frac{\bar{p}_{d,t}}{p_{d,t}(\omega)}\right)\frac{P_{d,t}}{p_{d,t}(\omega)}\left(\frac{P_{d,t}}{P_t}\right)^{-\phi}\left[(1-\gamma)Y^C_t + Q^{\phi}_t\gamma Y^{C*}_t\right] \qquad (\mu_{\omega t})\\
y_{x,t}(\omega) &= \gamma\sigma\ln\left(\frac{\bar{p}_{x,t}}{p_{x,t}(\omega)}\right)\frac{P_x}{p_{x,t}(\omega)}\left(\frac{P_{x,t}}{\varepsilon_t P^*_t}\right)^{-\phi}Y^{C*}_t \qquad (\mu_{x\omega t})\\
y_{d,t}(\omega) &= (1-\gamma)\sigma\ln\left(\frac{\bar{p}_{d,t}}{p_{d,t}(\omega)}\right)\frac{P_{d,t}}{p_{d,t}(\omega)}\left(\frac{P_{d,t}}{P_t}\right)^{-\phi}Y^C_t \qquad (\mu_{d\omega t})
\end{aligned}$$

with the real exchange rate $Q_t \equiv \frac{\varepsilon_t P^*_t}{P_t}$. The Lagrange multiplier $\varphi_{\omega t}$ captures the marginal cost of a job. The FOC with respect to $k_{\omega t}$ equate the marginal productivity of capital to capital rental rate r_t.

Job creation Using the FOCs with respect to $v_{\omega t}$ and $l_{\omega t}$, we obtain the following job creation condition:

$$\frac{\kappa}{q_t} = \beta\left(1-\delta\right)\left(1-\lambda^x\right)E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\left(\begin{array}{c}\left(1-G\left(z^c_{\omega t+1}\right)\right)\left(\frac{y_{\omega t+1}}{l_{\omega t+1}}\varphi_{\omega t+1}\left(1-\alpha\right)-\tilde{w}_{\omega t+1}+\frac{\kappa}{q_{t+1}}\right)\\ -G\left(z^c_{\omega t+1}\right)F\end{array}\right)\right] \tag{1.3}$$

The firm determines the optimal number of vacancies such that the cost of vacancy posting (κ incurred during an average number of periods of $\frac{1}{q_t}$) equal the expected return of a filled vacancy (which includes, if the job is not destroyed, future labor productivity and vacancy costs saved on next period's job, net of wage cost, and, for lost jobs, firing costs).

Job destruction The job destruction equation defines a productivity threshold $z_{\omega t}^{c}$ below which a job is destroyed

$$(1-\alpha)\,\varphi_{\omega t}\frac{y_{\omega t}}{l_{\omega t}}\left[\frac{z_{\omega t}^{c}}{\tilde{z}_{t}}\right]^{\frac{1}{1-\alpha}}-w_{\omega t}\left(z_{\omega t}^{c}\right)+\frac{\kappa}{q_{t}}=-F \tag{1.4}$$

The job destruction equation states that, at productivity level $z_{\omega t}^{c}$, the firm's outside option (firing the worker, thereby incurring the firing cost F) equals its profit (marginal product, net of labor costs) in addition to the recruitment costs the firm saves by keeping the worker.

Price setting The relative price of a variety ω is $\rho_{d\omega t}=\frac{p_{d\omega t}}{P_t}$ and $\rho_{x\omega t}=\frac{p_{x\omega t}}{P_t}$. Price setting is such that

$$\rho_{d\omega t}=\rho_{x\omega t}=\mu_{\omega t}\varphi_{\omega t} \tag{1.5}$$

Let $\theta_{\omega t}=\frac{-\partial ln y_{\omega t}}{\partial ln p_{\omega t}}$ denote the price elasticity of total demand for variety ω. Then the firm's mark up over marginal cost $\mu_{\omega t}=\frac{\theta_{\omega t}}{\theta_{\omega t}-1}$.

Wage setting

The wage is the solution of the Nash bargaining process that splits the surplus of the match between the firm and the worker as in most of the labor search literature. At the symmetric equilibrium, all firms ω behave similarly. The average wage is then

$$\tilde{w}_t=(b+h_p)(1-\eta)+\eta\left[\begin{array}{c}(1-\alpha)\,\varphi_t\frac{y_t}{l_t}+\kappa\theta_t\\ +\Big(1-(1-\delta)(1-\lambda^x)(1-s_t)\,\beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\right]\Big)\,F\end{array}\right]$$

with $s_t=\frac{M_t}{U_t}$ the job finding rate and η the worker's bargaining power. The wage is a weighted sum of the worker's outside option and the value of the match for the firm, which includes the expected marginal product of labor, the search costs saved by the firms because she kept the worker within the firm. Firing costs have two opposing effects on the current wage. On the one hand, the firm saves today the firing costs, which increases the current wage. On the other hand, the firm will pay future firing costs, in case of job separation in the next period, which lowers the current wage.

Firm entry

As in Cacciatore & Fiori (2016), prior to entry, firms pay a sunk entry cost

$$f_{Et} = f_{Rt} + f_{Tt} + \kappa v_t^e \tag{1.6}$$

The first two terms represent, respectively, the costs in terms of goods and services imposed by regulatory and administrative barriers to market entry (f_{Rt}) and technological requirements for business creation (f_{Tt}) such as research and development ($R\&D$), nonresidential structures, etc. $f_{Rt} + f_{Tt}$ are paid in terms of the final good Y_t. Upon entry, new entrants choose the same amount of labor as incumbent. They then post v_t^e vacancies such that $v_t^e = \frac{l_t + q_t v_t}{q_t}$. Prospective entrants compute their expected post-entry value, such that is the present discounted value of their expected profit stream

$$e_t = E_t \left[\sum_{s=t}^{\infty} \beta^t (1-\delta)^{s-t} \frac{\lambda_{t+s}}{\lambda_t} d_s \right] \tag{1.7}$$

The free entry condition is $e_t = f_{Et}$. As in Bilbiie et al. (2012), we introduce a one-period time-to-build lag. New and incumbent firms can be hit by a death shock with probability $\delta \in (0,1)$ at the end of the period. The law of motion is given by

$$N_t = (1-\delta)(N_{t-1} + N_{Et-1})$$

Upon exit, the firm's workers join the unemployment pool.

1.3.3 Household budget constraint

Household accumulates physical capital and rent it to firms. Investment consists of domestic and foreign goods, in the same fashion as the consumption basket. Capital accumulation obeys a standard law of motion:

$$K_{t+1} = (1-\delta_K)K_t + I_t \left[1 - \frac{\nu}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right] \tag{1.8}$$

with scale parameter $\nu > 0$ and $0 < \delta_K < 1$ capital depreciation rate. On the international financial market, households have access to foreign-currency risk-free bonds. Let us define $b_t^* = \frac{B_t^*}{P_t^*}$ real holdings of Foreign-currency bonds (in units of Foreign consumption). We assume a quadratic cost of adjusting Foreign bond holding, as in Benigno (2009). In addition, households hold shares in a mutual fund of firms. As in Ghironi & Melitz (2005), household savings are made available to prospective entrants to cover their entry costs through the mutual fund. x_t denotes the share in the mutual fund held by the household at the beginning of period t. The representative household receives each period, $N_t d_t$, the total profit of all firms that produce in that period (in units of consumption). Each period t, the household buys x_{t+1} shares in a mutual fund of $N_t + N_{Et}$ firms. Household's budget constraint (in units of consumption basket) is

$$\begin{aligned} & C_t + b_t + Q_t b_t^* + \frac{\xi}{2} Q_t \left(b_t^*\right)^2 + \left(N_t + N_{E,t}\right) e_t x_{t+1} + I_t \\ = \; & r_t K_t + \mathcal{W}_t + Q_t b_{t-1}^* \left(1 + i^*\right) + N_t x_t \left(d_t + e_t\right) + \left(1 + i_{t-1}\right) \frac{P_{t-1}}{P_t} b_{t-1} \\ & + \left(b + h_p\right)\left(1 - L_t\right) + \Pi_t + T_t \quad (\lambda_t) \end{aligned}$$

where T_t are lump-sum transfers, $\xi > 0$ the scale parameter on adjustment costs on Foreign bond holding. This is a small open economy. As a result, Foreign variables are considered as exogenous. In addition, as we focus on technological shocks, Foreign variables are assumed to be constant. λ_t is the Lagrange multiplier associated with the budget constraint. The first-order condition on Foreign holding is

$$1 + \xi b_t^* = \beta (1 + i^*) E_t \left[\frac{\lambda_{t+1}}{\lambda_t} \frac{Q_{t+1}}{Q_t} \right] \tag{1.9}$$

Choice of investment in firm entry is such that

$$e_t = \beta (1 - \delta) E_t \left[\frac{\lambda_{t+1}}{\lambda_t} (d_{t+1} + e_{t+1}) \right] \tag{1.10}$$

Household's choice on capital is such that

$$\zeta_t^K = \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} \left(\varphi_{t+1} \alpha \frac{Y_{t+1}}{K_{t+1}} \right) + \zeta_{t+1}^K (1 - \delta) \right] \tag{1.11}$$

$$\zeta_t^K \left[1 - \frac{\nu}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 - \nu \frac{I_t}{I_{t-1}} \left(\frac{I_t}{I_{t-1}} - 1 \right) \right] + \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} \zeta_{t+1}^K \left(\frac{I_{t+1}}{I_t} \right)^2 \nu \left(\frac{I_{t+1}}{I_t} - 1 \right) \right] = 1 \tag{1.12}$$

with ζ_t^K is the multiplier associated with equation (1.8) and captures the shadow price of capital.

1.3.4 Equilibrium

In the symmetric equilibrium, the elasticity of substitution across varieties is $\theta_t = 1 + \sigma N_t$ and the mark-up

$$\mu_t = 1 + \frac{1}{\sigma N_t} = \frac{\theta_t}{\theta_t - 1} \tag{1.13}$$

As the number of producers N_t increases, the mark up decreases. As a result, the relative price

$$\rho_t = \exp\left[-\frac{1}{2}\frac{\tilde{N}_t - N_t}{\sigma \tilde{N}_t N_t}\right] \tag{1.14}$$

declines if N_t falls. Total employment is $L_t = N_t l_t$, the law of motion of employment is $L_t = (1-\lambda_t)(1-\delta)\left[L_{t-1} + q_{t-1}V_{t-1}\right]$ while the mass of unemployed workers is $U_t = 1 - L_t$. Total vacancies are $V_t = (N_t + N_{E,t})\, v_t + N_{E,t}\frac{l_t}{q_t}$ while aggregate capital is $K_t = N_t k_t$. Total output for all producing firms in terms of consumption units is $Y_t = \rho_t Z_t \tilde{z}_t K_t^{\alpha} L_t^{1-\alpha}$.[8] As pointed out by Ghironi & Melitz (2005), the number of firms behaves very much like a capital stock. Aggregate variables are directly affected by changes in the number of producers. Firm entry then potentially provides a potent magnification mechanism to uncertainty shocks. Current account dynamics is given by

$$Q_t b_t^* - Q_t b_{t-1}^* = Q_t b_{t-1}^* i^* + \rho_t N_t y_t - Y_t^C \tag{1.15}$$

with

$$Y^C = C^M + N_{E,t}\left(f_{Rt} + f_{Tt}\right) + \kappa V_t + I_t + F L_t \frac{G\left(z_t^c\right)}{\left[1 - G\left(z_t^c\right)\right]} + \frac{\xi}{2} Q_t \left(b_t^*\right)^2$$

Notice, in equation (1.15), that Home resources are scaled by the number of producers N_t and the relative price ρ_t (that comoves with N_t, equation (1.14)). A fall in the number of producers N_t then reduces Home aggregate production through these two channels.

[8] Because of the love for variety, measures in units of consumption are not data-consistent. The aggregate price index in the model takes into account changes in the number of available products, which is not the case in CPI data. Ghironi & Melitz (2005) suggest to solve this problem by deflating all variables using an average price index. When we assess the model's fit with the data, we make sure to consider data-consistent variables.

1.4 Effects of uncertainty shocks

1.4.1 Solution method and calibration

Solution method Uncertainty shocks, which are the second-moment shocks in our model only enter the model's policy functions independently from the level shocks at third order. Hence, the model is solved using a third-order approximation around the deterministic steady state. We then simulate the model and compute moments of endogenous variables using pruning[9]. The Dynare is used for that purpose (Adjemian et al. (2014)).

As argued in Fernandez-Villaverde et al. (2011), higher order approximation moves the economy away from its deterministic steady state. This implies responses as deviations of the deterministic steady state are not informative. To overcome this problem, we simulate the model for 4000 periods conditioning on future shocks by setting them to 0 and consider the values reached after the simulation as the "stochastic steady state"[10]. All IRFs are then computed as deviations from the stochastic steady state.

Calibration We calibrate the model at a quarterly frequency and choose parameter values from the literature to match features of the Korean economy. However, when data is not available for Korea, we use standard values in the literature. The benchmark calibration is summarized in Table 1.1 . We choose standard values for all the parameters that are conventional in the literature: the discount factor β, risk aversion σ_C, the capital share in the Cobb-Douglas production function α, and the capital depreciation rate δ_K ($\beta = 0.99$, $\sigma_C = 1$, $\alpha = 0.33$, and $\delta_K = 0.025$). Moreover, we set workers' bargaining power parameter η to 0.6 following Petrongolo & Pissarides (2001). Using Hosios (1990) condition, we set also the elasticity of matches to unemployment ε to 0.6. Adjustment costs on capital are set such that the model matches the relative volatility of investment (leading to $\nu = 0.5$).

Concerning the parameters related to the product market, we set regulation entry cost f_R following the procedure described in Ebell & Haefke (2009). Djankov et al. (2002)'s assessment of entry costs in Korea amounts to 27% of annual GDP per capita. We then infer the entry costs in terms of months of lost output. We add this measure to Pissarides

[9] To ensure stable sample paths, pruning discards higher order terms when iteratively computing simulations of the solution. At third order, Dynare 4.4.3 uses the pruning algorithm of Andreasen et al. (2013)

[10] Born & Pfeifer (2014) use the term EMAS (the ergodic mean in the absence of shocks). It is the point of the state space where, in absence of shocks in that period, agents would choose to remain although they are taking future volatility into account.

(2001)' index of entry costs (converted in the same unit of months of lost output).[11]

We set the technological entry cost f_T such that aggregate R&D expenditures are 1.7 percent of GDP as in Cacciatore & Fiori (2016). In order to get the calibrated value of f_T, we convert the empirical target in terms of quarterly output per capita. The calibrated value is a lower bound for the Korean economy as Korea is characterized by the largest growth in R&D expenditures over the recent years (OECD (2015b)).

To pin down the firm exit rate δ, we target the portion of worker separation due to firm exit equal to 26 percent, within the range of estimates reported by Haltiwanger et al. (2006). We set the price elasticity of demand on an individual good, σ, such that the steady state markup is 10 percent, a benchmark value in the literature.

We now turn to the parameters that are specific to the search and matching framework. Unemployment benefit b, are equal to 61 percent of the steady state wage (OECD, Benefits and Wages Database, Korea)[12]. We choose the exogenous separation rate, λ^x, so that the percentage of jobs counted as destroyed in a given year that fail to reappear in the following year is 71 percent as in Cacciatore & Fiori (2016). We set home production, h_p, the matching efficiency parameter, χ, and firing costs, F, to match the total quarterly separation rate, λ, the unemployment rate, U, and the probability of filling a vacancy, q. We set $U = 11.2$, $q = 0.6$, and $\lambda = 0.027$, in line with the estimates in Appendix 1.5. The resulting firing costs and home production appear to be, respectively, 3 percent of average wage and 31 percent of average wage, at the steady state. For the lognormal scale and shape parameters, μ_z and σ_z, we normalize μ_z to zero, and choose σ_z such that the model reproduces the variability of the job separation rate. Hiring costs as a fraction of steady-state average wage is $\frac{\kappa}{w} = 0.10$, close to the estimates by Abowd & Kramarz (1997) on French data. We consider France as a heavily regulated labor market, as in Korea.

As for the open economy dimension, as in Cacciatore et al. (2016), elasticity of substitution between domestic and foreign goods ϕ is 3.8, and adjustment costs on Foreign bonds $\xi = 0.0025$. The share of imports in total consumption γ is set to 0.3, which is consistent with OECD data on Korean imports. Foreign interest rate i^* is pinned down by the Euler equation on Foreign bonds.

[11] Korea does not appear in Pissarides (2001)' sample. However, according to Nicoletti & Scarpetta (2003)'s index of product market regulation, Korea's level of product market regulation is similar to Italy, Portugal and Spain. These countries appear in Pissarides (2001)' sample. We consider the Italian measure as a proxy for Korea. The implied regulation cost amount to 3.28 quarters of firm-level steady state output. Korea indeed ranks high in the OECD PMR index and in Djankov et al. (2002)'s listing of heavily regulated markets.

[12] We consider net replacement rates during the initial phase of unemployment

We calibrate the parameters in the first-moment shock. We set the persistence parameter to $\rho_z = 0.9$ and choose the average standard deviation, σ_z, to match the absolute standard deviation of GDP in the data. When it comes to the parameters in the second-moment shock, we set the standard deviation of the uncertainty shock to $\sigma_{\sigma z} = 0.17$ and the persistence parameter to $\rho_{\sigma z} = 0.70$, based on our VAR estimation from section 1.2. We check in Appendix 1.5 that the moments predicted by the model provides a satisfactory match of the data.

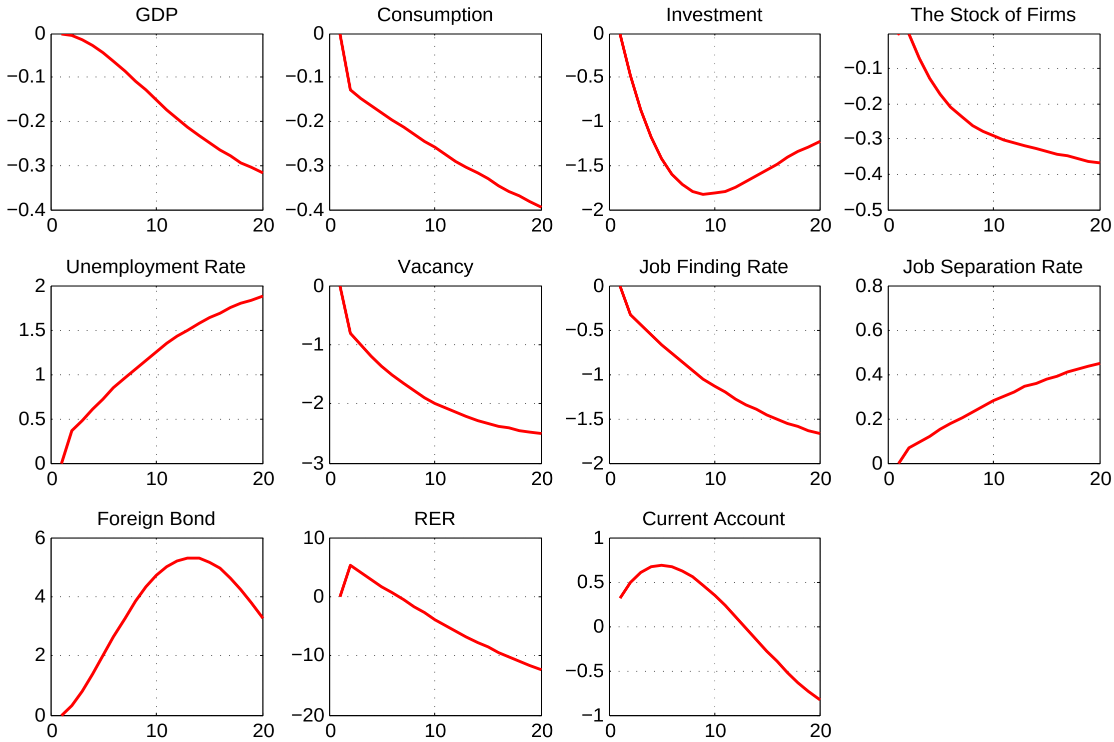
Table 1.1: Calibration

Parameter	Description	Value
β	Discount factor	0.99
σ_C	Risk aversion	1
α	Capital share	0.33
δ_K	Capital depreciation rate	0.025
σ	Variety elasticity	13.5
δ	Plant exit	0.007
f_R	Regulation entry cost	7.9
f_T	Technology entry cost	7.8
v	Investment adjustment costs	0.5
λ	Total quarterly separation rate	0.027
b/w	Unemployment benefit replacement ratio	0.61
F	Firing costs	0.0483
ε	Matching function elasticity	0.6
η	Worker's bargaining power	0.6
χ	Matching efficiency	0.32
κ	Vacancy cost	0.0966
σ_z	Lognormal shape	0.08
ρ_z	TFP, persistence	0.9
σ_z	TFP, standard deviation	0.0105
$\rho_{\sigma z}$	TFP uncertainty, persistence	0.70
$\sigma_{\sigma z}$	TFP uncertainty	0.17

1.4.2 Impulse response functions

Figure 1.3 displays the impulse responses of macroeconomic variables to a one-standard deviation increase in technology uncertainty shock.

Figure 1.3: Impulse responses of macroeconomic variables to a one-standard deviation technology uncertainty shock



The units of the vertical axes are % change from the stochastic steady state. Example: following a 1 standard deviation shock, the maximum fall in investment is -1.7%. Vacancy is aggregate vacancy. RER: real exchange rate Q. Job finding rate is $s_t = \frac{M_t}{U_t}$. Job separation is $\lambda_t^x + G(z_t^c)(1-\lambda_t^x) + \delta(1-\lambda_t^x)(1-G(z_t^c))$ total separation rate, including separations due to firm exit. Current account as % of GDP.

Mechanisms at work

Precautionary savings. As in the standard RBC model, uncertainty creates a precautionary saving motive: domestic households want to consume less and save more in order to insure themselves against future shocks. Since marginal utility is convex, the stochastic discount rate ($\beta\frac{\lambda_{t+1}}{\lambda_t}$) goes up following an uncertainty shock as in Fernandez-Villaverde et al. (2011), which raises the value of investing in job creation (equation (1.3)), firms entry (equation (1.10)), foreign bonds (equation (1.9)) and physical capital (equation (1.11)).

Real option value. Uncertainty also makes economic agents cautious about decisions like employment, which adjustment costs can make expensive to reverse. Thus, it gives rise to a contractionary real option-value effect. In our model, real options apply to key decisions: hirings, firing and firm entry.

As for hirings, unlike in a standard RBC model, employment cannot adjust each period due to search and matching frictions. Vacancy posting decisions are based on the expected value of a filled vacancy (equation (1.3)), which is determined by the stochastic discount rate times the expected surplus of a match. On the one hand, the stochastic discount rate increases, which raises the expected value of a filled vacancy. The present value of a job match goes up. On the other hand, a job match is an irreversible long-term employment relation. Therefore, the expected volatility of the economy affects the expected value of a filled vacancy (right hand-side of equation (1.3)), thereby introducing a real option effect. When uncertainty hits the economy, the option value of waiting rises, causing a drop in φ the marginal value of a match to the firm. The real-option effect dominates the precautionary savings effect. Hence, faced with a lower expected return on the match, firms post fewer vacancies.

Separations are also subject to an option value. As productivity can quickly revert, firms become more reluctant to separate from their workforce, all the more so as they pay firing costs. This could lead to less separations. However, conflicting forces are at work. As firms post lower vacancies, q the probability of filling a vacancy increases, thereby lowering the average hiring costs $\frac{\kappa}{q_t}$. This creates incentives to destroy more matches as rehiring is less costly. The combined effect on separations is ambiguous. In the benchmark calibration, job destruction rises. As a result, the decline in vacancy posting and the increase in separations push unemployment upward, making it harder for unemployed workers to find jobs. The decline in total employment drives the marginal product of capital downwards, which triggers a fall in capital investment. The interaction between capital and endogenous separation makes the propagation of the shock stronger, as in Den Haan & Watson (2000).

Let us have a look at firm dynamics. As firm entry entails sunk costs (equation (1.6)), real option channel also applies to firm entry. With higher uncertainty, e the expected value of a firm falls, which drives firm entry down. The number of producers eventually declines, raising mark-up (equation (1.13)).

Interaction between search frictions and firm entry Firm dynamics have an impact on job creation and separation decisions, and vice versa. First, firm entry condition (equation (1.6)) depends on labor market conditions. With lower vacancies and higher unemployment, labor market tightness declines, which drives firm entry cost down. Nonetheless, the number of firms still falls in response to higher uncertainty due to the option value channel. Secondly, firm entry also affects job creation and job destruction (in equations (1.3) and (1.4)) as φ, the marginal cost of a job, depends on the number of competitors. The fall in the number of firms N drives the relative price ρ downward (equation (1.14)) and raises the mark-up. The price-setting (equation (1.5)) implies that the real marginal benefit of a match φ goes down. Hence, the fall in the stock of firms amplifies the initial decline in vacancy posting, making expected future profits less. At the same time, it reinforces job destruction as existing matches become less valuable to the firm. Finally, with a reduced stock of firms, the total number of vacancy posting falls, making labor market tightness even lower. Overall, firm dynamics amplifies the deterioration in labor market conditions.

Open economy dimension and interaction with firm dynamics. We lay stress, in the previous paragraphs, on the fall of the Home relative price ρ. This effect drives consumer price index down, thereby generating a real exchange rate depreciation (Q rises). This is consistent with the empirical findings in section 1.2.

In addition, a rise in uncertainty induces households to save more and consume less. In the standard RBC closed economy model, this precautionary savings motive translates into higher investment, which is counterfactual. In our model, the domestic household has several investment opportunities to smooth consumption: jobs, capital, firms or foreign bonds. As pointed out in the previous paragraphs, the value of domestic physical capital, jobs, and firms fall. Households are then enticed to invest in Foreign bonds whose returns i^* are not affected by the local uncertainty shock. The rise in uncertainty generates a current account surplus. To further understand the current account dynamics, let us rewrite equation (1.9) as

$$1 + \xi b_t^* = \beta(1+i^*) \left[E_t \left(\frac{\lambda_{t+1}}{\lambda_t} \right) E_t \left(\frac{Q_{t+1}}{Q_t} \right) + cov \left(\frac{\lambda_{t+1}}{\lambda_t}, \frac{Q_{t+1}}{Q_t} \right) \right] \qquad (1.16)$$

It is clear from equation (1.16) that the rise in $\beta\frac{\lambda_{t+1}}{\lambda_t}$ entices households to buy more Foreign bonds. The real exchange rate depreciation (rise in Q driven by relative prices and firm dynamics) amplifies this urge to invest in Foreign bonds. The covariance between changes in the discount rate and real exchange rate is also positive. In other words, consumers use foreign bonds to smooth consumption, all the more so as the Home currency depreciates (foreign currency appreciates in real terms). As the foreign bond is denominated in foreign currency, it provides an interesting hedging device against the fall in Home consumption purchasing power if Foreign currency appreciates when Home consumption falls.

In the description of the economic mechanisms we just provided, we lay stress on the link between the magnitude of real exchange rate depreciation and the current account surplus. As changes in the real exchange rate stem from firm dynamics (through changes in relative price ρ), the model display a strong interaction between the open economy dimension and firm dynamics.

Understanding the respective role of search and matching, open economy and firm entry

In order to provide further understanding of the respective role of search and matching, open economy and firm entry in the model, we display the response of the economy to a technology uncertainty shock in 3 different models. We start with the simple model with search and matching frictions and endogenous separations (no firm entry, closed economy) and analyze the effects of endogenous separation. We extend then this simple model along one dimension: either firm entry (a model with search and matching frictions in an closed economy, with firm entry) or the open economy dimension (a model with search and matching frictions in an open economy, no firm entry).[13] Table 1.2 summarizes our findings and contribution to the literature. Results of existing works are either incomplete or inconsistent with respect to Korean data. With search and matching frictions and endogenous separations (row 3. of Table 1.2), the model predicts an increase in investment and job finding rate. Firm entry

[13]Each model is not an extreme calibration of the full model. We actually wrote separate models. In all models, all parameter values are kept at their benchmark values reported in Table 1.1, except the parameters whose value is derived at the steady state (home production, matching efficiency and firing costs) that are computed to match the same empirical targets: Unemployment, vacancy filling rate and total quarterly separation rate.

(row 4. of Table 1.2) helps the model predict a fall in investment and job finding rate, which is consistent with empirical evidence. The stock of firms also falls, as in the data. The addition of the open economy dimension (row 5.) does not solve the counterfactual rise in the job finding rate but helps the model predict a fall in investment. Moreover, the behavior of open-economy variables match the data. The following subsections describe the economic mechanisms and underline the interaction between search and matching, open economy and firm entry.

Table 1.2: Responses of macroeconomic variables to increased uncertainty

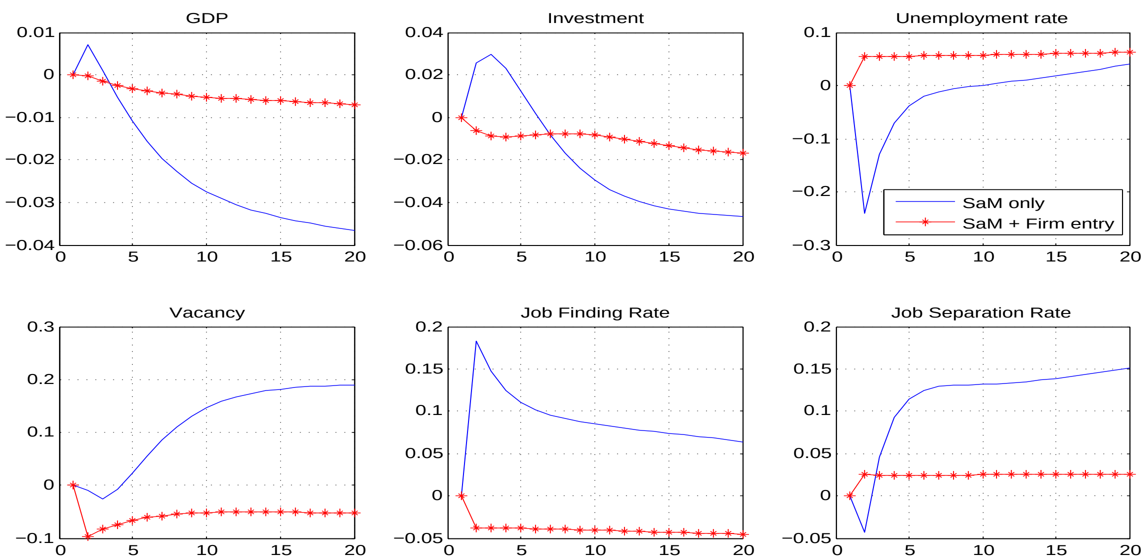
		C	I	E	U	JFR	JSR	N	CA	RER
1.	Korean Data	-	-		+	-	+	-	+	+
Our paper										
2.	Benchmark	-	-	-	+	-	+	-	+	+
3.	SaM only (endo. sep.)	-	+*			+*				
4.	SaM + Firm entry (closed economy)		-			-		-		
5.	SaM + open economy (no firm entry)		-			+*			+	+
Neo Keynesian model (sticky p.)										
6.	Basu & Bundick (2017)	-	-	-						
Search and matching (closed economy)										
7.	Leduc & Liu (2016) , sticky p., exo. sep.	-			+					
8.	Guglielminetti (2016), flex. p., exo. sep.	-	-		+	-				
9.	Miyamoto (2016), flex. p., endo. sep.	-			+	+*	+			
Open economy (no search and matching)										
10.	Kollmann (2016)	+*							+	-*
11.	Fogli & Perri (2015)	-	+*	+*					+	
12.	Fernandez-Villaverde et al. (2011)	-	-	+*					+	

C consumption, I investment, E employment, U unemployment, JFR Job Finding Rate, JSR Job Separation Rate, N number of firms, CA Current Account, RER Real Exchange Rate (+ means depreciation of national currency)
Following an increase in uncertainty, based on IRFs displayed in paper. "+": IRF displays an increase in the short-run. "-": based on IRFs displayed in paper, IRF displays a decrease in the short-run.
* : counterfactual IRF. Example: displays a "+", should be "-" to be consistent with the data. Or vice versa.
"sticky p.": sticky price; "flex. p": flexible price. "exo. sep." / "endo. sep.": exogenous / endogenous job separation.
Leduc & Liu (2016) develop a model without capital, hence without investment.

Search and matching with endogenous separation. With respect to Leduc & Liu (2016), our model includes endogenous separation and capital. Figure 1.4 shows that the addition of job separation and capital (SaM only) actually moves the model further away from the data. Indeed, the model predicts an counterfactual *increase* in investment and job finding rate (row 3. of Table 1.2). Due to real option value, job creation and destruction both decrease. The combined effect lowers unemployment, making it easier to find jobs. The increase in employment leads to a rise in investment. Endogenous separation seems to be the key to the counterfactual results. With exogenous separation, lower vacancy would increase unemployment, leading to lower investment. Guglielminetti (2016) uses a search and matching model with exogenous separation and capital. Absent endogenous separation, she finds that the model is able to replicate the contemporaneous drop in output, consumption and investment and the negative impact on the labor market.

Firm entry. To illustrate the link between search frictions and firm dynamics, we add firm dynamics shutting off the open economy dimension (row 4. of Table 1.2). Figure 1.4 shows that the introduction of firm entry (SaM + Firm entry) generates a fall in job finding rate and investment, which is consistent with the data. As the option value channel also affects firm entry decision, the number of producers N_t goes down in uncertain times, which increases mark up (μ equation (1.13)) and reduce relative prices (ρ equation (1.14)). This means that the marginal gain from a match φ falls (equation (1.5)). Therefore, firms post less vacancies and separate from more matches. Unemployed workers face a lower probability of finding a job. Investment falls as the decrease in employment reduce the marginal product of capital.

Figure 1.4: Impulse responses to a one-standard deviation increase in technology uncertainty shock



'SaM only' closed economy, no firm entry. 'SaM + Firm entry' closed economy, firm entry. The units of the vertical axes are % change from stochastic steady state. Example : Following a one-standard deviation shock in uncertainty, jog finding rate peaks at 0.17% in the model 'SaM only'.

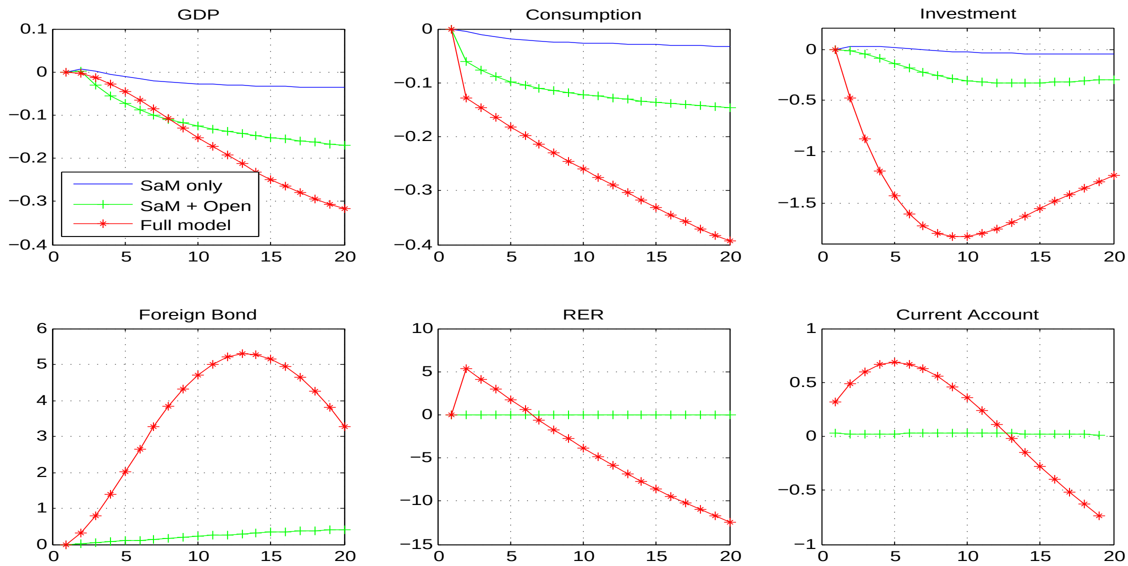
Adding the open economy dimension. In a closed economy, the precautionary savings motive entices households to invest more, which is counterfactual. In an open economy, foreign assets provide an more interesting investment opportunity to build up a buffer stock against future shocks, as the return on Foreign assets i^* is exogenous (row 5. of Table 1.2). To highlight the interaction between search frictions and open economy dimension, we open the economy shutting off firm dynamics. In Figure 1.5, with open economy dimension (SaM + Open), the Home country runs a current account surplus and the fall in consumption is larger than in a closed economy setting. In a nutshell, the open economy dimension allows the model to generate a larger fall in consumption and a drop (rather than an increase) in investment. The latter further reduces the marginal product of labor, thereby leading to larger recessionary macroeconomic effects of the uncertainty shock.

Furthermore, firm entry and open economy dimension interact with each other. The fall in the stock of firms, that are associated with real options channel, reinforces the real exchange rate depreciation, thereby inducing more capital outflows (equation (1.16)). In Figure 1.5, with open economy and firm entry (the full model), real exchange rate depreciates more, leading to larger foreign bond holding and current account surplus. This outcome is consistent with larger reduction in consumption and investment. Moreover, comparing Figures 1.4 and 1.5 shows that a larger fall in GDP is obtained under the full model because of the interaction with the open economy dimension. [14]

Kollmann (2016) also finds that, following an unexpected rise in output volatility, Home net foreign assets increase, which is consistent with our IRFs. However, in Kollmann (2016)'s 2-country model, under complete financial markets, the international risk sharing implies that the rise in Home output volatility triggers a wealth transfer from the rest of the world to the Home country, such that Home consumption rises, and the Home real exchange rate appreciates. These features are counterfactual on Korea data. Fogli & Perri (2015) show that, in a standard one-good 2-country RBC model, faced with increased domestic uncertainty, hence increased risk on domestic investment opportunities, agents buy more foreign assets. Our results show that these mechanisms are also at work in our model. However, in Fogli & Perri (2015)'s setting, as well as in Fernandez-Villaverde et al. (2011), the precautionary savings motive entices households to work more, which is counterfactual. Our model correctly predicts a fall in employment.

[14] The decline in output is persistent. It is also the case in Fernandez-Villaverde et al. (2011), Fogli & Perri (2015) and Kollmann (2016) as households gradually build-up a buffer stock of Foreign assets. Figure 1.4 suggest that firm dynamics also adds to the persistence of GDP response to increased uncertainty.

Figure 1.5: Impulse responses to a one-standard deviation increase in uncertainty shock



'SaM only': closed economy, no firm entry. 'SaM + Open': open economy, no firm entry. 'Full model' : benchmark model. The units of the vertical axes are % change from stochastic steady state. Example : Following a one-standard deviation shock in uncertainty, the maximum fall in investment is -1.7% in the Full model.

1.5 Conclusion

Using a VAR model, we show that an increase in uncertainty lowers output, consumption, investment and job finding rates, while raising job separations and unemployment. We also supplement the existing empirical evidence by looking at firm dynamics, real exchange rate and current account behavior. We find that increased uncertainty generates real exchange rate depreciation, current account surplus and reduces the stock of firms in the economy.

We then investigate the impact of uncertainty shocks in a small open economy with search and matching frictions, endogenous job separation and firm entry to illustrate new transmission mechanism. Basu & Bundick (2017) points out that papers experience difficulty in generating business-cycle co-movements among output, consumption, investment, and employment from changes in uncertainty. Our paper succeeds in doing so, in addition to generating data-consistent a fall in the number of firms, current account surplus and real exchange rate depreciation. The key mechanisms are real options channel and precautionary saving motive. The real options channel affects labor adjustment as well as firm entry. Precautionary saving motive gives rise to capital outflow and real exchange rate depreciation.

The interaction of these channels in an open economy setting leads to sizable macroeconomic effects of heightened uncertainty, and helps reproduce data-consistent results.

Appendix

A Data

A.1 Measuring worker flows

A.1.1 Economically Active Population Survey

We employ the Economically Active Population Survey (EAPS) conducted by Statistics Korea. It is cross-sectional monthly household survey, and the sample size consists of approximately 33,000 households per period (about 70,000 adult individuals). The main goal of EAPS is to reveal the characteristics of that population with regards to the labor market. In particular, based upon the main activities indicated for the reference week, Statistics Korea classifies respondents as follows: those working or absent from work as employed, those looking for work as unemployed, and all others as inactive. Among inactive, those who worked for the money more than 1 hour or worked more than 18 hours as non-paid family worker are classified as employed and those who searched for job during last 4 weeks are classified as unemployed.

A.1.2 Measuring transition rates

We use EAPS from January 1986 through December 2015 to construct the series of worker flows.[15] According to survey design, each household remains in the sample for 36 months, and 1/36 of total households is renewed each month.[16] EAPS's rotation scheme allows us to match individuals across two consecutive months, and obtain gross flows across labor market states.[17] Note that our analysis focuses on monthly transitions between employment (E) and unemployment (U), and never consider transition from and to inactivity (I). To calculate the transition rates, we first consider the gross flow N_t^{AB} of workers that transit from the state A to the state B over the month. Let $n_t^{EU}(n_t^{UE})$ denote the share of employed (unemployed) workers in period t-1 who are unemployed (employed) in period t:

$$n_t^{EU} = \frac{N_t^{EU}}{N_t^{EE} + N_t^{EU}}$$

[15]The EAPS has been in existence since 1963, but microdata in which information on individual characteristics is available have been collected since 1986.

[16]The survey was redesigned in 2005. Prior to 2005, EAPS maintained a fixed sample over 5 years.

[17]We match individuals by household ID, person ID, sex, and date of birth for the 1986-2004 period. Since 2005, however, Statistics Korea has not provided household ID and person ID. Thus, we use sex, date of birth, relation with the head of household, and level of education for the 2005-2015 period.

$$n_t^{UE} = \frac{N_t^{UE}}{N_t^{EE} + N_t^{EU}}$$

Then, we seasonally adjust the series using X-13-ARIMA-SEATS method, and corrects the time aggregation bias. We then compute quarterly averages of the monthly transition rates, as in Shimer (2012). Figure 1.6 displays the job finding (f_t) and separation (s_t) rates in Korea. The correlation of the corresponding steady-state unemployment $u = \frac{s_t}{s_t+f_t}$ with actual unemployment rate is very high (0.96), which tends to validate our method for measuring worker flows.

A.1.3 Contribution of the transition rates to unemployment

We next consider the cyclicality of the job finding and separation rates following Shimer (2012). If the economy were in steady state at some date t, the unemployment rate would be determined by the job finding and separation rates, $\frac{s_t}{s_t+f_t}$. In quarterly-averaged data, the correlation between this steady state measure and actual unemployment is 0.96. We use this strong relationship to calculate the contribution of changes in each of the two transition rates to fluctuations in unemployment rate.

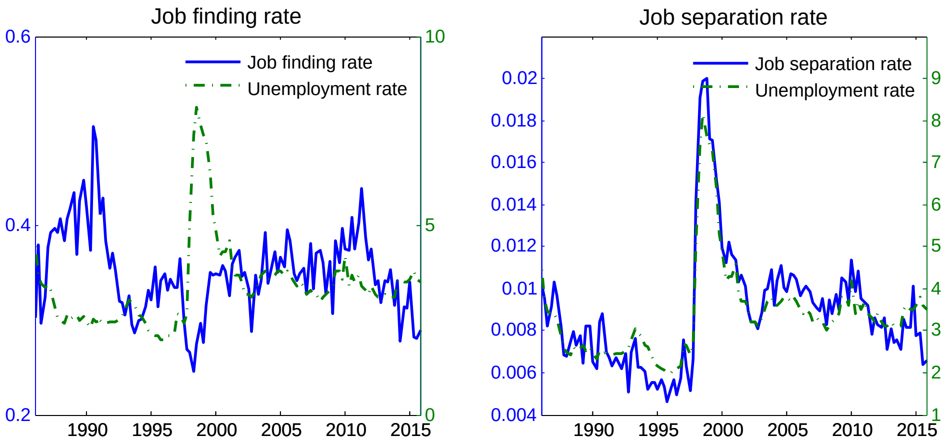
Let $\bar{f}$ and $\bar{s}$ denote the average values of f_t and s_t during the sample period and compute the hypothetical unemployment rates $\frac{\bar{s}}{\bar{s}+f_t}$ and $\frac{s_t}{s_t+\bar{f}}$ as measures of the contribution of fluctuations in the job finding and separation rates to overall fluctuation in the unemployment rate. Figure 1.7 shows the contribution of fluctuations in the job finding and separation rates to the fluctuations in the unemployment rate. This exercise finds that the separation rate contributes much more to accounting for the fluctuation in the unemployment in Korea.

In order to quantify this, Shimer (2012) looks at the comovement of detrended data. Therefore, we use the Hodrick-Prescott filter for detrending with a smoothing parameter of 1600. Over the sample periods, the correlation of the cyclical components of unemployment and $\frac{\bar{s}}{\bar{s}+f_t}$ is 0.209, while the correlation of unemployment and $\frac{s_t}{s_t+\bar{f}}$ is 0.796. It shows that the job separation rate is the main driver of the fluctuation in the unemployment rate. These findings are consistent with Kim & Lee (2014) who show that inflows into unemployment contributes substantially to unemployment fluctuations in Korea.

A.2 A first look at the data

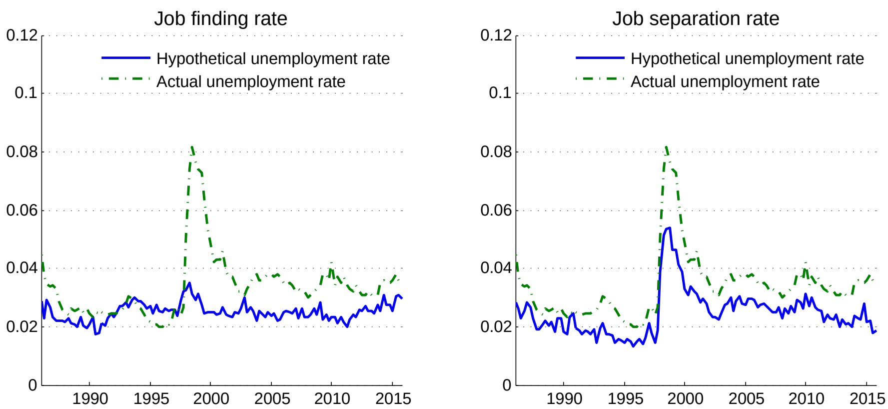
Figure 1.8 displays our measure of uncertainty along with workers' flows and current account as % of GDP. Visual inspection suggests that increased uncertainty tends to be associated

Figure 1.6: The job finding and separation rates



Source: Authors's calculations and Statistics Korea. Job finding and separation rates (the left y-axis). Unemployment rate (the right y-axis)

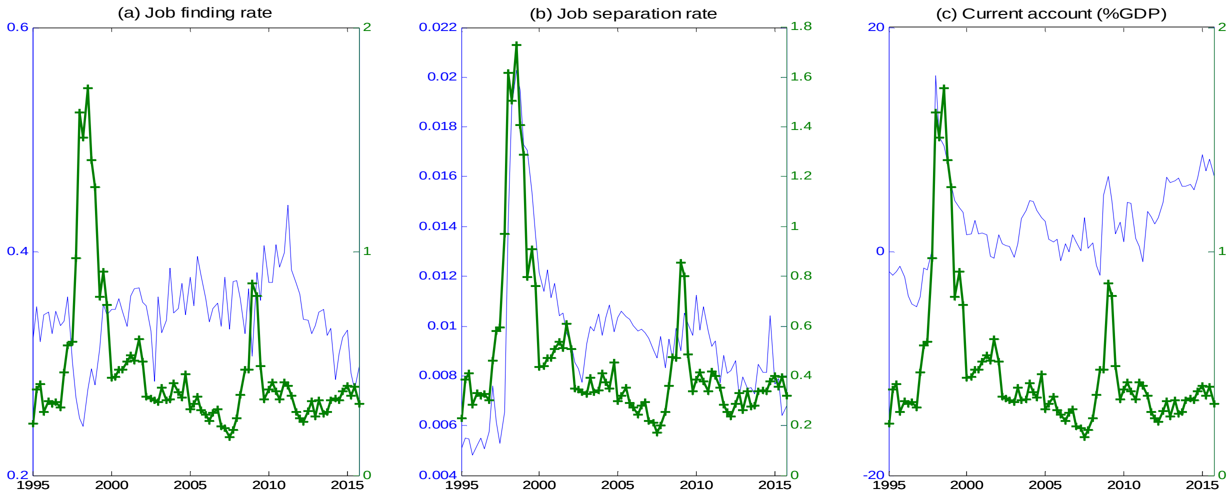
Figure 1.7: Contribution of fluctuations in the job finding and separation rates to the fluctuations in the unemployment rate



Source: Authors' calculations and Statistics Korea. "Hypothetical unemployment rate" in left panel : steady state unemployment predicted by time-varying job finding rate, separation rate constant. "Hypothetical unemployment rate" in right panel : steady state unemployment predicted by time-varying separation rate, job finding rate constant.

with lower job finding rate, higher separation and increases in current account. The correlation of the uncertainty measure with unemployment outflows, inflows and current account as % of GDP are respectively -0.52, 0.72 and 0.49. In section 1.2, we go beyond the descriptive statistics using a structural VAR to identify the causal effect of uncertainty on macroeconomic dynamics.

Figure 1.8: Job finding rate, separation rate, current account and uncertainty index



Source : Authors' calculations and Statistics Korea. See Appendix 3.5. Solid line: the time series mentioned in the title of the graph. "+" line: Uncertainty measure

A.3 Structural VAR : Robustness checks

This section shows that the impulse response function in Figure 1.2 is robust to alternative identification, volatility measure, and specification. Our assumptions to identify uncertainty shocks imply that uncertainty does not respond to macroeconomic shocks in the impact period. To check the extent to which this assumption may affect our results, uncertainty is placed last in our vector. Uncertainty may reflect the forecasters' perceptions of bad economic times rather than an uncertain future. To control for potential effects from changes in consumer sentiment, we estimate a five-variable VAR that includes a consumer sentiment index as an additional variable. Our uncertainty measure is constructed to take a value 1 for each quarter that uncertainty exceeds the threshold and a 0 otherwise. This indicator function is used to ensure identification comes only from these large, and arguably exogenous, uncertainty shocks rather than the smaller ongoing fluctuations. The outcome of all robustness checks are reported in Figure 1.9. In all cases, the responses are comparable to the baseline.

A.4 Macroeconomic data

The data coverage is 1986Q1-2015Q4.

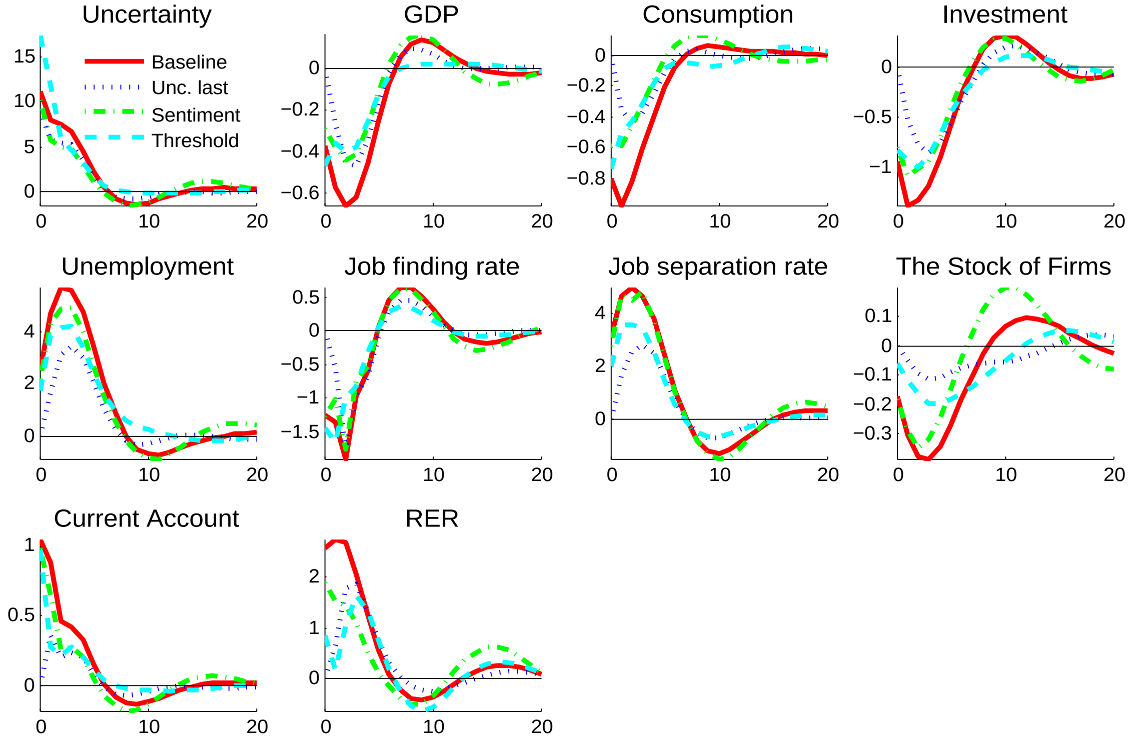
- Output: real gross domestic product, seasonally adjusted, 2010 reference year, Statistics Korea.
- Consumption: private consumption expenditure, seasonally adjusted, 2010 reference year, Statistics Korea.
- Investment: the sum of gross capital formation and changes in inventories, seasonally adjusted, 2010 reference year, Statistics Korea.
- Unemployment rate: official unemployment rate, job-search for 4 weeks standard, seasonally adjusted, Statistics Korea.
- Number of firms: the number of corporations in operation as of end of the relevant period, semi-annual frequency from 1995H1 to 2014H2, National Tax Statistics. We use a spline to transform semi-annual data into quarterly data.
- Current account as a % of GDP: seasonally adjusted, OECD Dataset.
- US GDP: real gross domestic product, billions of chained 2009 dollars, quarterly, seasonally adjusted annual rate, FRED

B Business cycle statistics: Model versus data

Finally, we check that the model provides a good fit of the data, with respect to business cycle statistics. Table 1.3 displays the simulated moments and the moments computed from Korean data from 1986Q4 to 2015Q4. All quarterly data are seasonally adjusted, logged, and HP-filtered with smoothing parameter 1600. See Appendix 1.5 for a description of data sources. As mentioned in the calibration section, some of the model's parameters were chosen to make the model match output volatility, investment and job separation relative volatility. The model is simulated with technological shocks (equations (1.1) and (1.2)).

With respect to labor market variables, the model is able to produce volatile job finding and separations rates. In particular, separation are more volatile than job findings, which is

Figure 1.9: The effects of one-standard deviation shock to uncertainty: robustness checks



Baseline: baseline VAR. Unc. last: uncertainty placed last in the otherwise baseline VAR. Sentiment: consumer sentiment index placed on top of the baseline VAR to control for potential effects from movement in consumers' perception of bad economic times. Threshold: uncertainty measure constructed to take a value 1 for each quarter that uncertainty exceeds the threshold and a 0 otherwise.

Table 1.3: Business cycle statistics: Model versus data

	Volatility		Cyclicality	
	(1) Data	(2) Model	(3) Data	(4) Model
Y (i)	2.07	2.07	1 (iii)	1
C (ii)	1.44	0.59	0.86	0.75
I	2.42	2.20	0.83	0.90
JSR	8.74	8.78	-0.73	-0.68
JFR	4.13	3.77	0.48	0.76
U	8.44	9.70	-0.81	-0.77
V	8.54 (iv)	8.73	0.9 (iv)	0.35
corr(U,V)			-0.80 (iv)	-56.4

(i). Output std. in %, in columns (1) and (2).

(ii). For all variables except output, std. relative to output, in columns (1) and (2)

(iii). Correlation with output in columns (3) and (4)

(iv). For want of Korean data, US value

a specific feature of the Korean economy. The model's predicted volatility of unemployment and vacancies is consistent with the data. For vacancies, there is no available data on Korean vacancies, we then report the business cycle statistics on US data.

Consumption is more volatile than output in Korean data. It is a well-known feature in emerging economies (Aguiar & Gopinath (2007) among others). The model fails to capture this feature. Capturing the high consumption volatility is beyond the scope of the paper. Furthermore, the high consumption volatility is not a robust stylized fact in Korean data. From 1980Q1 to 1995Q4, the relative volatility of consumption was 0.67. The relative consumption volatility prevailing during this period is closer to the model's predicted consumption volatility.

Finally, the model predicts a negative correlation between unemployment and vacancies. This is an interesting feature as a positive correlation between unemployment and vacancies is a well-known feature of Mortensen & Pissarides (1994)'s model with endogenous destruction. Indeed, with the separation margin, firms can quickly adjust the employment level, which is preferred by the firm as hiring is costly and takes time. Following a positive TFP shock, firm can increase employment by keeping more workers, even less productive ones, rather than waiting for new workers to arrive from the matching market. Vacancies can go down, so does unemployment, thereby generating a positive correlation between unemployment and vacancies. With firm entry, unemployment and vacancies can display a negative correlation in spite of endogenous separation. Indeed, as firm entry falls, with the decline in the number of firms actually result in a fall in aggregate vacancies.

Chapter 2

How Can Taxes Help Ensure a Fair Globalization?

2.1 Introduction

Over the past decades, trade liberalization has led to a significant trade expansion. By 2007, global trade had reached more than 60 percent of world GDP, compared with less than 30 percent in the mid-1980s (Bacchetta & Bustamante (2009)). Despite its uncontroversial expansionary effects on global growth, trade expansion has not always been translated into more equal incomes and better working conditions. Rising concerns on the distributional effects of trade emphasized the fall in wages for unskilled and low-income workers, as well as the rise in informal and less protected forms of employment.

Our contribution to the literature is two-fold. First, we assess the impact of trade openness on informality and inequality. Second, we investigate whether taxation may correct any possible negative effect that trade liberalization may have on labor quality and income distribution. Our analysis is based on a Dynamic Stochastic General Equilibrium (DSGE) model with two asymmetric countries: a developed and a developing country. The originality of our approach is to extend the Melitz (2003)'s model by introducing search and matching frictions as in Helpman et al. (2010), but in a dynamic framework, following Cacciatore & Ghironi (2014). In order to provide a credible impact of tax reforms, we also depart from the representative agent model by introduce hand-to-mouth agents as in Gali, Lopez-Salido and Valles (2007). A calibrated version of this model is the parsimonious way to quantify the transitional dynamics of labor reallocation induced by the world trade liberalization, as well as the redistributive effect of tax reforms.

The empirical literature provides mixed evidence on the distributional effects of trade liberalization. On the one side, trade liberalization is deemed to have boosted the demand of skilled workers and hence triggered an increase in the relative wage of skilled to unskilled workers, the so-called skill premium. As a consequence, income inequality has widened (see Epifani & Gancia (2006), Matsuyama (2007), Verhoogen (2008), Goldberg & Pavcnik (2007) and the literature mentioned herein). On the other side, other studies find that trade liberalization reduces the skill premium and hence inequality especially in middle and low-income countries (see McCaig (2011) for Vietnam, Zhang & Wan (2006) for China, Amiti & Cameron (2012) for Indonesia, Robertson (2004) for Mexico, Gonzaga et al. (2006) for Brazil, Kumar and Mishra (2008) for India).

To address raising inequality, tax policies can play a major role in redistributing income and making the post-tax income distribution less unequal. Efficient tax systems are important tools in addressing rising inequality and informality and restoring robust economic growth. Indeed, a targeted and well-balanced tax code is an essential element in making further progress in achieving the Sustainable Development Goals by providing a stable funding base for high-quality public services for all and effective transfers targeted to those most in need. However, using tax policies to address income inequality in an open economy faces particular challenges. In achieving a more equitable distribution of income, governments should prefer those tax instruments which, at the same time, reduce the incidence of informality. The high incidence of informality is an issue of concern especially in developing countries, that already have high informality rates to begin with and are characterized by poor working conditions.[1] On average, more than 50 percent of the labor force in developing countries is informal. In many Latin American countries informal employment exceeds 50 percent of total urban labor force (Gasparini & Tornarolli (2007)). Estimates for Sub-Saharan Africa and Asia are even higher (Jütting et al. (2008)). Nevertheless, informality is a matter of concern also in advanced economies, although to a lesser extent. During the late 20th century there was a general increase in the informal economy in many countries around the world, including OECD countries (see Schneider & Enste (2000)). Heintz & Pollin (2003), for example, show that within a data set of 23 countries, 19 showed increases in informality. Similarly, ILO data from 2002 show that self-employment increased in all developing regions, and world-wide increased from about one quarter to one third of non-agricultural employment during the period 1980-2000 (ILO, 2013).

Trade liberalization is deemed to have further increased the incidence of informality. In developing countries, job creation resulting from trade liberalization has mainly taken place in the informal economy. In some regions (e.g. Latin American countries), the increase in informality took place concomitantly, or in the aftermath of, major trade reforms in different countries of the region, which drastically cut tariff and non-tariff barriers, and opened markets to foreign competition. Indeed, there is a long standing concern about the labor market consequences of trade liberalization. One major concern in developing countries is that it could induce substantial reallocation of workers from the formal to the informal sector (Goldberg & Pavcnik (2003)). The empirical literature provides mixed evidence on the effects of trade liberalization on informality. Some papers find little or no effect of trade liberalization on informality (e.g. Goldberg & Pavcnik (2003), Menezes-Filho & Muendler (2011), Bosch et al. (2012)), whereas some others (e.g. Kovak (2013) , Dix-Carneiro & Kovak (2017)) find significant effects of trade liberalization on informality and wages. The lack of a clear consensus motivates the need to further investigate the effects of trade liberalization on

[1] For an overview on job quality in emerging economies, see OECD (2015a).

informality. If trade liberalization causes labor informality to increase, this could constitute a potentially large welfare loss from it. In this context, it would be crucial to identify policy strategies which may curb informality and reduce the incidence of low-quality jobs.

These structural changes, induced by a growing trade, as well as the need to fight rising inequalities through tax reforms ask for a structural approach. Thus, we develop a two-country DSGE model with a developed and a developing country (asymmetric equilibrium). These two countries differ according to the size of the informal sector in the intermediate-good sector. The informal sector is characterized by a more flexible labor market (i.e. rapid entry and exit and more flexible adjustment to change in demand) and lower productivity. In this respect our paper relates to the recent theoretical literature embedding the informal sector in DSGE models (e.g. Conesa et al. (2002), Busato & Chiarini (2004), Orsi et al. (2014), Pappa et al. (2015), Dellas et al. (2017)). Within this strand of literature, very few works enrich DSGE models with both informality and a fully-fledged labor market with search and matching frictions. The few exceptions, to the best of our knowledge, are Cook & Nosaka (2006), Zenou (2008), Satchi & Temple (2009), Batini et al. (2011), Bosch & Esteban-Pretel (2015) and Anand & Khera (2016). However, most of the aforementioned theoretical works focus on the role of regulation and none of them analyzes the effect of taxation on informality from both a developed and a developing country perspective.

The novelty of our paper is to focus on the interactions between the choices to participate at the international trade (Melitz (2003)) and the induced labor reallocations between formal and informal activities. Starting from the Melitz (2003)'s model where search and matching frictions are introduced on the labor market as in Helpman et al. (2010), our original contribution is to propose a dynamic two-country model where asymmetric areas, a developed and an emerging country, are characterized by different incidence of informality. We model informality as in Charlot et al. (2015). Our model closely follows Cacciatore & Ghironi (2014). However, Cacciatore & Ghironi (2014) focus on developed economies where representative agent can be employed in only one sector, the presence of informality being not considered. In order to fully capture the impact of trade liberalization and tax reform in emerging economies, it seems to be crucial to model the interplay between the formal and informal sector. Therefore, our main contribution is that we embed the informal sector, as we do believe that the analysis of labor market dynamics can not be limited to the sole formal sector, given the high incidence of informality especially in developing and emerging countries. Furthermore, in order to assess whether a fiscal reform can enable transition to formalization, we add taxation as well as hand-to-mouth agents in the model, which is not embedded in Cacciatore & Ghironi (2014).

Our work is related to the emerging literature analyzing the impact of taxation on informality. Empirical evidence points out that reducing taxation on formal businesses eases the migration of entrepreneurs from the informal to the formal sector, where productivity is higher, with positive effect on output and economic efficiency (see Slonimczyk (2011) for Russia and Araujo & Rodrigues (2016) for Brazil). Higher tax rates among firm-owners induce not only substantial movements to the informal sector, but also under-reporting of taxable earnings and income shifting to tax-favored business forms, which may ultimately lead to inefficient allocation or resources (see Waseem (2018) for an analysis of the Pakistani tax reform introduced in 2009). If informality is voluntary, lower taxation rates should reduce firms' incentives to enter the informal sector. However, even if informality is involuntary, lower tax rates could reduce informality by encouraging formal sector firms to expand employment and create more formal jobs. This strand of the literature suggests that the best approach to reduce the size of the informal sector is using taxation to reduce the costs of being formal and create the right incentives for companies and workers intending to switch to the formal sector.

Our analysis highlights a number of interesting results. We show that trade expansion resulting from a permanent fall in export costs raises GDP growth rate in both developed and emerging countries. However, trade expansion and higher levels of economic activity do not necessarily imply higher employment quality and better working conditions. In fact, the adjustment on the labor market is crucial in the evaluation of the effects of trade liberalization. We show that trade liberalization boosts economic activity and employment in both the formal and informal sector. However, this employment expansion is biased toward the informal sector, which is not subject to labor regulation and hence is more flexible. We show that it is possible to correct this bias in favor of the informal sector by reducing payroll taxes paid in the formal sector. An increase of the consumption tax could be a relevant strategy to finance the payroll tax cuts. However, formalization comes at the cost of widening income inequality between formal and informal workers.

The rest of the paper is structured as follows. In Section 2 we describe the model while in Section 3 we discuss the calibration. We analyze the impact of trade liberalization in Section 4. The impact of a budget-neutral tax reform is discussed in Section 5. Finally, Section 6 concludes. Some technical aspects are reported in the Appendix.

2.2 Model

We develop a two-country model, calibrated on a developed and an emerging country. The two economies are modeled exactly symmetrically, so that the following description in this Section holds for both economies. Variables appearing with an asterisk refer to the modeled foreign economy.

There are four actors in each country: households, firms producing intermediate goods, firms producing final goods and the government. The model features heterogeneous households: Ricardian and non-Ricardian. Ricardian households hold bonds but do not supply labor, whereas non-Ricardian households do not have access to financial markets to finance their consumption needs. Therefore, they may decide to either supply labor in the formal sector, or supply labor in the informal sector or be unemployed. Labor is hence supplied only by non-Ricardian households to intermediate good producers. Intermediate good producers operate in a perfect competitive market and hire labor – either on the formal or informal market – to produce intermediate goods which are sold to final good producers. Final good producers combine intermediate goods into a final good which is sold on a monopolistically-competitive market. Finally, to provide public goods and unemployment benefits, the government collects taxes paid on consumption by all households as well as payroll taxes paid only by employees and employers (i.e. intermediate good producers) operating in the formal sector.

For the sake of simplicity, the model does not feature nominal price rigidities and goods are produced using only labor without capital.

2.2.1 Households

There are two types of households in the economy: Ricardian and non-Ricardian. Ricardian households (indexed by a) do not work, hold assets and have access to international financial markets. Non-Ricardian households supply labor, but have no access to financial markets. Non-Ricardian households can work in the formal sector (indexed by F), work in the informal sector (indexed by I) or being unemployed (indexed by u).

For all agents, the consumption basket C_t aggregates Home and Foreign consumption in a Dixit-Stiglitz form:

$$C_t = \left[\int_0^1 C_t(i)^{\frac{\phi-1}{\phi}} di \right]^{\frac{\phi}{\phi-1}} \tag{2.1}$$

where $\phi > 1$ is the symmetric elasticity of substitution across goods. The corresponding consumption-based price index, P_t, is given by:

$$P_t = \left[\int_0^1 P_t(i)^{1-\phi} di\right]^{\frac{1}{1-\phi}} \tag{2.2}$$

Ricardian agents smooth their consumption, C_{at}, over time and thus maximize the life-time utility function $E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_{at})^{1-\gamma_c}}{1-\gamma_c}\right]$, where γ is the risk aversion parameter and β is the discount factor. Utility maximization is subject to the following budget constraint:

$$\begin{aligned} & A_{t+1} + S_t A^*_{t+1} + P_t \frac{\psi}{2}\left(\frac{A_{t+1}}{P_t}\right)^2 + S_t P^*_t \frac{\psi}{2}\left(\frac{A^*_{t+1}}{P^*_t}\right)^2 + (1+\tau^c_t) P_t C_{at} \\ = \;& (1+i^N_t)A_t + (1+i^{*N}_t)A^*_t S_t + P_t(T^A_t + T^i_t + T^f_t) \end{aligned}$$

Ricardian agents hold domestic assets A_t (denominated in domestic currency) on which they receive the nominal interest rate i^N_t and foreign assets A^*_{t+1} (denominated in foreign currency) on which they receive the interest rate i^{*N}_t. Assets are subject to quadratic adjustment costs, measured by the parameter ψ . These costs are paid to financial intermediaries whose only function is to collect these transaction fees and rebate the revenue to households in lump-sum fashion in equilibrium. Ricardian households pay a consumption tax τ^c_t on their consumption C^a_t. S_t is the nominal exchange rate. Moreover, T^A_t is a lump-sum rebate of costs of adjusting asset holdings from the intermediaries to which it is paid and T^i_t and T^f_t are a lump-sum rebate of profits from intermediate and final goods production.[2][3]

If we denote $\frac{A_{t+1}}{P_t} = a_{t+1}$ and $\frac{A^*_{t+1}}{P^*_t} = a^*_{t+1}$, we can re-write the budget constraint in real terms:

$$\begin{aligned} & a_{t+1} + Q_t a^*_{t+1} + \frac{\psi}{2}(a_{t+1})^2 + Q_t \frac{\psi}{2}\left(a^*_{t+1}\right)^2 + (1+\tau^c_t) C_{at} \\ = \;& \frac{(1+i^N_t)}{1+\pi_t} a_t + \frac{(1+i^{*N}_t)}{1+\pi^*_t} Q_t a^*_t + T^A_t + T^i_t + T^f_t \end{aligned}$$

where π_t is the inflation rate and $1+\pi_t = \frac{P_t}{P_{t-1}}$. The term $Q_t = S_t P^*_t / P_t$ stands for the real exchange rate. If we define the domestic and foreign gross real interest rates as $1+i_t = \frac{(1+i^N_t)}{1+\pi_t}$

[2] We assume that Ricardian households are firms' owners.

[3] The definition of this set of lump-sum rebate of costs and profits is the same as in Cacciatore and Ghironi (2015) and hence we refer to their paper for a complete derivation of these variables. The only difference in our model concerns the lump-sum rebate of profits from intermediate goods, which is defined as: $T^i_t = P_t\left(\phi_t Z_{Ft} l_{Ft} - \frac{w_{Ft}}{P_t} l_{Ft} - \frac{w_{It}}{P_t} l_{It} - \kappa_F V_{Ft} - \kappa_I V_{It}\right)$.

and $1+i_t^* = \frac{(1+i_t^{*N})}{1+\pi_t^*}$, we can re-write the budget constraint as:

$$a_{t+1}+Q_t a_{t+1}^* + \frac{\psi}{2}\left(a_{t+1}\right)^2 + \frac{\psi}{2}Q_t\left(a_{t+1}^*\right)^2 + (1+\tau_t^c)C_{at} = (1+i_t)a_t + (1+i_t^*)a_t^* Q_t + T_t^A + T_t^i + T_t^f \tag{2.3}$$

where i_t and i_t^* are respectively the real interest rates on domestic and foreign assets.

The Euler equations for domestic and foreign asset holding are respectively:

$$(1+\psi a_{t+1}) = (1+i_{t+1})\beta E_t\left(\frac{C_{at+1}^{-\gamma_c}}{C_{at}^{-\gamma_c}}\frac{1+\tau_t^c}{1+\tau_{t+1}^c}\right) \tag{2.4}$$

$$(1+\psi a_{t+1}^*) = (1+i_{t+1}^*)\beta E_t\left(\frac{C_{at+1}^{-\gamma_c}}{C_{at}^{-\gamma_c}}\frac{Q_{t+1}}{Q_t}\frac{1+\tau_t^c}{1+\tau_{t+1}^c}\right) \tag{2.5}$$

On the other hand, non-Ricardian households do not have access to financial markets and hence they can finance their consumption needs either though labor income (w_{Ft} if they supply labor to the formal sector and w_{It} if they supply labor to the informal sector) or through unemployment benefits (b_t) if they do not work.

The following equations define non-Ricardian agents' consumption depending on whether they work in the formal sector, or they work in the informal sector, or they are unemployed:

$$C_{Ft} = \frac{(1-\tau_{Ft}^w)}{(1+\tau_t^c)}w_{Ft}\ \ l_{Ft} \tag{2.6}$$

$$C_{It} = \frac{w_{It}}{(1+\tau_t^c)}l_{It} \tag{2.7}$$

$$C_{ut} = \frac{b_t}{(1+\tau_t^c)}(1-l_t) \tag{2.8}$$

The payroll tax on employees, τ_{Ft}^w, is borne only by non-Ricardian agents employed in the formal sector. Total labor supply, l_t, is the sum of labor supplied by non-Ricardian households in the formal and informal sector, i.e. $l_t = l_{Ft} + l_{It}$. In equilibrium, aggregate unemployment is given by:

$$U_t = 1 - l_{Ft} - l_{It} \tag{2.9}$$

Total consumption C_t is defined as the weighted sum of consumption of Ricardian households (C_{at}) and non-Ricardian households working in the formal sector (C_{Ft}), in the informal sector (C_{It}) or unemployed (C_{ut}):

$$C_t = \omega C_{at} + (1-\omega)(C_{Ft} + C_{It} + C_{ut}) \tag{2.10}$$

where ω is the share of Ricardian households.

2.2.2 Production

There are two vertically integrated production sectors. In the upstream, in both the formal and the informal sector, intermediate goods are produced in perfect competition using only labor. Intermediate goods are then sold to final good producers. In the downstream, each sector i is populated by a representative monopolistically competitive multi-product firm, which uses intermediate goods as inputs to produce differentiated varieties. In equilibrium, some of these varieties are exported while others are sold only on the domestic market.

Intermediate goods

We assume a unit mass of intermediate good producers, which operate both in the formal and informal sector. Both sectors are subject to search and matching frictions as in the Diamond-Mortensen-Pissarides framework. Unemployed agents search for a job in both sectors and search efforts are endogenous. Wages are set though an individual bargaining process.

We assume a constant-return-to-scale matching technology in each sector j, for $j = F, I$, where F and I refer respectively to the formal and the informal sector. The matching technology converts aggregate unemployed workers, U_t, and aggregate vacancies, V_t, into aggregate matches, M_t. The matching rate in each j sector is:

$$M_{jt} = \chi_j (e_{jt} U_t)^{1-\varepsilon} V_{jt}^{\varepsilon} \tag{2.11}$$

where U_t is the total number of unemployed workers and V_t is the number of vacancies. The parameters χ and ϵ measure respectively the matching efficiency and the matching function elasticity, with $\chi > 0$ and $0 < \epsilon < 1$. Let e_{jt} denote search efforts for the job type j when agents are unemployed.

The job filling rate, q_t, is:

$$q_{jt} = \frac{M_{jt}}{V_{jt}} = \chi_j \left(\frac{e_{jt} U_t}{V_{jt}} \right)^{1-\epsilon} \tag{2.12}$$

The job finding rate, ι is:

$$\iota_{jt} = \frac{M_{jt}}{U_t} = \chi_j \left(\frac{V_{jt}}{e_{jt} U_t} \right)^{\epsilon} e_{jt} \tag{2.13}$$

As in Krause and Lubik (2007), we assume that newly created matches become productive only in the next period. The law of motion of employment, l_{jt}, is:

$$l_{jt} = (1 - \lambda_j) l_{jt-1} + q_{jt-1} v_{jt-1} \tag{2.14}$$

where $\lambda_j \in (0, 1)$ is the exogenous separation rate and v_{jt} is the number of vacancies posted by the firm in period t. In equilibrium $v_{jt} = V_{jt}$.

Firms, both in the formal and informal sector, hire labor l_t to produce an intermediate good y_{jt} according to the following technology :

$$y_{jt}^{Int} = Z_{jt} l_{jt} \quad \forall \;\; j = F, I \tag{2.15}$$

where Z_{jt} is an exogenous technology term which follows an autoregressive process AR(1):

$$\log Z_{jt} = \phi^{Z1} \log Z_{jt-1} + \phi^{Z2} \log Z^{*}_{jt-1} + \epsilon^{Z}_{jt}. \tag{2.16}$$

In both sectors $j = F, I$, intermediate firms choose the number of vacancies, v_{jt}, and employment, l_{jt}, to maximize the discount value of their profits:

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{u_{C,t}}{u_{C,0}} \left(\varphi_t Z_{jt} l_{jt} - w_{jt} l_{jt} (1 + \tau^{f}_{jt}) - \kappa_j v_{jt} \right) \tag{2.17}$$

subject to the law of motion for labor: $l_{jt} = (1 - \lambda_j) l_{jt-1} + q_{jt-1} v_{jt-1}$. where φ_t is the real price at which intermediate goods producers sell their goods to final good producers and it is expressed in units of consumption[4]; w_{Ft} is the wage paid to workers in the formal sector (l_{Ft}), while w_{It} is the wage paid to workers in the informal sector (l_{It}). In both sectors, intermediate good producers incur a cost of κ_j units of consumption per vacancy posted v_{jt}. The term τ^{f}_{jt} represents a payroll tax on employers. These taxes are paid only by firms operating in the formal sector. Hence $\tau^{f}_{Ft} > 0$, whereas $\tau^{f}_{It} = 0$.

The first order conditions (hereafter, FOCs) on v_{jt} and l_{jt} in the formal and informal

[4]Firms are owned by households and $u_{C,t}$ is the marginal utility of consumption. This ensures that first order conditions are measured in the same units.

sector are respectively:

$$\frac{\kappa_j}{q_{jt}} = E_t\left[\beta_{t,t+1}\mu_{jt+1}\right] \tag{2.18}$$

$$\mu_{jt} = \varphi_{jt}Z_{jt} - w_{jt}(1+\tau^f_{jt}) + E_t\left[\beta_{t,t+1}(1-\lambda_j)\mu_{jt+1}\right] \tag{2.19}$$

where μ_{jt} is the Lagrangian multiplier for labor adjustment and measures the current value of an additional worker. Combining both FOCs leads to the job creation conditions in both sectors:

$$\frac{\kappa_F}{q_{Ft}} = E_t\left\{\beta_{t,t+1}\left[(1-\lambda_F)\frac{\kappa_F}{q_{Ft+1}} + \varphi_{t+1}Z_{Ft+1} - w_{Ft+1}(1+\tau^f_{Ft+1})\right]\right\} \tag{2.20}$$

$$\frac{\kappa_I}{q_{It}} = E_t\left\{\beta_{t,t+1}\left[(1-\lambda_I)\frac{\kappa_I}{q_{It+1}} + \varphi_{t+1}Z_{It+1} - w_{It+1}\right]\right\} \tag{2.21}$$

where $\beta_{t,t+1} \equiv \beta\frac{u_{C,t+1}}{u_{C,t}}$ is the one period ahead stochastic discount factor.

For both the formal and the informal sector, the job creation conditions state that, in equilibrium, the vacancy creation cost incurred by the firm per current match is equal to the expected discounted value of the vacancy creation cost per future match, further discounted by the probability of current match survival $1-\lambda$, plus the profits from the match at time t. Profits from the match take into account the future marginal revenue product from the match and its wage cost.

Wages Nominal wages are set through an individual Nash bargaining process. In each t period and in both sectors $J = F, I$, the real value of an existing, productive match for a producer, J_t, is the sum of the marginal product of the match ($\varphi_t Z_{jt}$) and the expected discounted continuation value of the match ($E_t\beta_{t,t+1}(1-\lambda_j)J_{jt+1}$), net of the wage bill:

$$J_{jt} = \varphi_t Z_{jt} - w_{jt}(1+\tau^f_{jt}) + E_t\beta_{t,t+1}(1-\lambda_j)J_{jt+1} \tag{2.22}$$

The worker's value of being matched, in both the formal and informal sector, is given by the sum of real wage received and the expected discounted future value of being matched by the firm:

$$W_{jt} = \frac{(1-\tau^w_{jt})}{(1+\tau^c_t)}w_{jt} + E_t\{\beta_{t,t+1}[(1-\lambda_j)W_{jt+1} + \lambda_j U_{u,t+1}]\} \tag{2.23}$$

The expected future value of being matched by the firm (the last term on the r.h.s) is a weighted average of probability $1-\lambda$ that the match will survive or the probability λ that the worker will become unemployed.

The value of being unemployed is defined as:

$$U_t = \frac{b_t}{(1+\tau_t^c)} - \vartheta \frac{e_{Ft}^{1+\varrho}}{1+\varrho} - \vartheta \frac{e_{It}^{1+\varrho}}{1+\varrho} + E_t\{\beta_{t,t+1}[\iota_{Ft} W_{Ft+1} + \iota_{It} W_{It+1} + (1-\iota_{Ft}-\iota_{It}) U_{u,t+1}]\} \quad (2.24)$$

where $\vartheta \frac{e_{jt}^{1+\varrho}}{1+\varrho}$ is a convex search cost and ϱ is the elasticity of disutility of searching. Therefore, the value of being unemployed is the sum of unemployment benefits[5] – net of search costs – and the expected discounted future value of future states, where ι_{Ft} and ι_{It} are the probability of becoming employed respectively in the formal or informal sector.

We define worker's surplus $H_{jt} \equiv W_{jt} - U_t$. The worker surplus in the formal and informal sector is given by:

$$H_{Ft} = \frac{(1-\tau_{jt}^w)}{(1+\tau_t^c)} w_{jt} - \left(\frac{b_t}{(1+\tau_t^c)} - \vartheta \frac{e_{Ft}^{1+\varrho}}{1+\varrho} - \vartheta \frac{e_{It}^{1+\varrho}}{1+\varrho} \right) + (1-\lambda_F-\iota_{Ft}-\iota_{It}) E_t(\beta_{t,t+1} H_{Ft+1}) \quad (2.25)$$

$$H_{It} = \frac{w_{It}}{(1+\tau_t^c)} - \left(\frac{b_t}{(1+\tau_t^c)} - \vartheta \frac{e_{Ft}^{1+\varrho}}{1+\varrho} - \vartheta \frac{e_{It}^{1+\varrho}}{1+\varrho} \right) + (1-\lambda_I-\iota_{Ft}-\iota_{It}) E_t(\beta_{t,t+1} H_{It+1}) \quad (2.26)$$

Nash bargaining maximizes the joint surplus $J_{jt}^{\eta} H_{jt}^{1-\eta}$ with respect to w_{jt}, where H_{jt} and J_{jt} stand for surpluses respectively for workers and firms and the parameter η measures the bargaining power of firms. The FOC implies:

$$\eta H_{jt} \frac{\partial J_{jt}}{\partial w_{jt}} + (1-\eta) J_{jt} \frac{\partial H_{jt}}{\partial w_{jt}} = 0 \quad (2.27)$$

where $\frac{\partial J_{jt}}{\partial w_{jt}} = -(1+\tau_{jt}^f)$ and $\frac{\partial H_{jt}}{\partial w_{jt}} = \frac{1-\tau_{jt}^w}{1+\tau_t^c}$. Hence, the sharing rule can be rewritten in the following form:

$$(1+\tau_{jt}^f)\eta H_{jt} = \frac{1-\tau_{jt}^w}{1+\tau_t^c}(1-\eta) J_{jt} \quad (2.28)$$

The bargained wage satisfies the following condition, respectively in the formal and informal

[5]We assume that the informal sector does not allow the worker to be eligible for the unemployment benefits. Given that we have a representative unemployed worker, we set an average unemployment benefits, $b_t = l_{Ft}/(l_{Ft}+l_{It}) b W_{Ft}$, where the parameter b is the replacement rate and measures benefit generosity by comparing unemployment benefits received when not working to wages earned when employed.

sector:

$$
\begin{aligned}
w_{Ft} =& \frac{\eta}{1-\tau^w_{Ft}}\left[\frac{b_t}{(1+\tau^c_t)} - \vartheta\frac{e_{Ft}^{1+\varrho}}{1+\varrho} - \vartheta\frac{e_{It}^{1+\varrho}}{1+\varrho}\right] \\
&+ \frac{1-\eta}{1+\tau^f_{Ft}}\left\{\varphi_t Z_{Ft} + E_t\left[\beta_{t,t+1}J_{Ft+1}\left((1-\lambda_F) - (1-\lambda_F-\iota_{Ft})\frac{1+\tau^f_{Ft}}{1+\tau^f_{Ft+1}}\frac{1-\tau^w_{Ft+1}}{1-\tau^w_{Ft}}\right)\right]\right\}
\end{aligned}
\tag{2.29}
$$

$$
w_{It} = \eta\left[\frac{b_t}{(1+\tau^c_t)} - \vartheta\frac{e_{Ft}^{1+\varrho}}{1+\varrho} - \vartheta\frac{e_{It}^{1+\varrho}}{1+\varrho}\right] + (1-\eta)\left[\varphi_t Z_{It} + \iota_{It}E_t\left(\beta_{t,t+1}J_{It+1}\right)\right] \tag{2.30}
$$

Wages are a linear combination – determined by the bargaining power parameter η – of worker's outside option and the marginal revenue product generated by the worker plus the expected discounted continuation value of the match to the firm. For high values of η, the bargaining power of firms is higher and the portion of the net marginal revenue product and continuation value to the firm appropriated by workers as wage payments is smaller, hence the outside option becomes more relevant.

Optimal search intensities are given by $\partial U_t/\partial e_{jt} = 0$, which yields:

$$
\vartheta e_{jt}^{\varrho} = \frac{\partial \iota_{jt}}{\partial e_{jt}} E_t(\beta_{t,t+1}H_{jt+1}) \tag{2.31}
$$

$$
\vartheta e_{Ft}^{\varrho} = \left(\frac{1-\eta}{\eta}\right)\chi_F\left(\frac{V_{Ft}}{e_{Ft}U_t}\right)^{\epsilon}\left(\frac{1-\tau^w_{t+1}}{(1+\tau^f_{t+1})(1+\tau^c_{t+1})}\right)\frac{\kappa_F}{q_{Ft}} \tag{2.32}
$$

$$
\vartheta e_{It}^{\varrho} = \left(\frac{1-\eta}{\eta}\right)\chi_I\left(\frac{V_{It}}{e_{It}U_t}\right)^{\epsilon}\left(\frac{1}{1+\tau^c_{t+1}}\right)\frac{\kappa_I}{q_{It}} \tag{2.33}
$$

This set of equations shows that search efforts are increasing in market tightness (V_{jt}/U_{jt}) and decreasing in taxes. We define the tax wedge as $TW_{Ft} = \frac{1-\tau^w_{t+1}}{(1+\tau^f_{t+1})(1+\tau^c_{t+1})}$ in the formal sector and $TW_{It} = \left(\frac{1}{1+\tau^c_{t+1}}\right)$ in the informal sector. Equations above show that the higher the tax wedge, the lower the search effort. However, the tax wedge is not symmetrical between sectors and hence the incentive to search for an informal job are reduced only by an increase in the consumption tax, τ^c_t, but they are not affected by changes in payroll taxes, τ^f_t and τ^w_t .

Final goods

In this subsection variables denoted by the letter d refer to a country's own goods consumed or produced domestically, whereas x refers to quantities and prices of exports.

Producer i is a multi-product firm that produces a set of differentiated product varieties, indexed by ω, $y(\omega, i)$, which is defined over a continuum Ω:

$$Y_t(i) = \left(\int_{\omega \in \Omega}^{\infty} y_t(\omega, i)^{\frac{\theta-1}{\theta}} d\omega \right)^{\frac{\theta}{\theta-1}} \tag{2.34}$$

where $\theta > 1$ is the symmetric elasticity of substitution across varieties. To save notation, from now on, we omit the index i, since consumption-producing sectors are symmetric in the economy.

We define P_t^y, the cost of the product bundle Y_t:

$$P_t^y = \left(\int_{\omega \in \Omega}^{\infty} p_t^y(\omega)^{1-\theta} d\omega \right)^{\frac{1}{1-\theta}} \tag{2.35}$$

where $p_t^y(\omega)$ is the nominal marginal cost of producing variety ω.

To create a new variety ω, each retailer needs to create a new plant, facing a sunk investment, $f_{e,t}$, denominated in units of intermediate input. Each plant produces using different technologies indexed by relative productivity $z(\omega)$, which is drawn from a common distribution $G(z)$ with support on $[z_{min}, \infty)$. For the sake of simplicity, from now on we omit ω. This relative productivity level remains fixed thereafter. Productivity level of foreign plants are drawn from an identical distribution. Each plant uses intermediate inputs to produce its differentiated product variety, facing the real marginal cost:

$$\varphi_{z,t} \equiv \frac{p_t^y(z)}{P_T} = \frac{\varphi_t}{z} \tag{2.36}$$

The number of products created and commercialized by each retailer is endogenous. At each point in time, only a subset of varieties $\Omega_t \subset \Omega$ is actually available to consumers. Therefore, at time t, each Home retailer commercializes $N_{d,t}$ varieties and creates $N_{e,t}$ new products that will be available for sale at time $t+1$. New and incumbent plants can be hit by a "death" shock with probability $\delta \in (0, 1)$ at the end of each period. The law of motion for the stock of producing plants is:

$$N_{d,t+1} = (1-\delta)(N_{d,t} + N_{e,t}) \tag{2.37}$$

where δ is the firm's exit rate. When serving the foreign market, each retailer faces per-unit iceberg trade costs, $\tau_t > 1$, as well as fixed export costs, $f_{x,t}$ paid for each exported product and denominated in units of intermediate input. We define total fixed costs $\bar{f}_{x,t} = f_{x,t}N_{x,t}$, where $N_{x,t}$ denotes the number of product varieties exported abroad. If fixed export costs are absent ($\bar{f}_{x,t} = 0$), each producer would find it optimal to sell all its product varieties both domestically and abroad. Fixed export costs imply that only varieties produced by plants with sufficiently high productivity (above a cutoff level $z_{x,t}$, determined below) are exportable.

We define two special "average" productivity levels (weighted by relative output shares): an average $\widetilde{z}_d$ for all producing plants and an average $\widetilde{z}_{x,t}$ for all exporting plants:

$$\widetilde{z}_d = \left(\int_{z_{min}}^{\infty} z^{\theta-1} dG(z)\right)^{\frac{1}{\theta-1}} \qquad \widetilde{z}_{x,t} = \left[\frac{1}{1-G(z_{x,t})}\right]\left(\int_{z_{x,t}}^{\infty} z^{\theta-1} dG(z)\right)^{\frac{1}{\theta-1}}$$

We assume that $G(\cdot)$ is Pareto with shape parameter $k_p > \theta - 1$.[6] As a result, $\widetilde{z}_d = \kappa^{\frac{1}{\theta-1}} z_{min}$ and $\widetilde{z}_{x,t} = \kappa^{\frac{1}{\theta-1}} z_{x,t}$, where $\kappa = k_p/[k_p - (\theta-1)]$. The share of exporting plants is given by:

$$N_{x,t} = [1 - G(z_{x,t})]N_{d,t} = \left(\frac{z_{min}}{\widetilde{z}_{x,t}}\right)^{-k_p} \kappa^{\frac{k_p}{\theta-1}} N_{d,t} \tag{2.38}$$

The real costs of producing the bundles $Y_{d,t}$ and $Y_{x,t}$ are respectively:

$$\frac{P^y_{d,t}}{P_t} = N_{d,t}^{\frac{1}{1-\theta}} \frac{\varphi_t}{\widetilde{z}_d}, \qquad \frac{P^y_{x,t}}{P_t} = N_{x,t}^{\frac{1}{1-\theta}} \frac{\varphi_t}{\widetilde{z}_{x,t}} \tag{2.39}$$

The final producer determines $N_{d,t+1}$ and the productivity cutoff $z_{x,t}$ to minimize the present discount value of costs:

$$\sum_{s=t}^{\infty} \beta_{t,s} \left[\frac{P^y_{d,s}}{P_s} Y_{d,s} + \tau_s \frac{P^y_{x,s}}{P_s} Y_{x,s} + \left(\frac{N_{s+1}}{1-\delta} - N_s\right) f_{e,s}\varphi_s + N_{x,s} f_{x,s}\varphi_s\right] \tag{2.40}$$

[6] Hence, $G(x) = \left(\frac{z}{z_{min}}\right)^{-k_p}$.

subject to (2.38), (2.39), and $\widetilde{z}_{x,t} = \kappa^{\frac{1}{\theta-1}} z_{x,t}$.

The FOC with respect to $z_{x,t}$ yields:

$$\tau_t \frac{P^y_{x,t}}{P_t} \frac{Y_{x,t}}{N_{x,t}} = \frac{(\theta-1)k_p}{k_p-(\theta-1)} f_{x,t}\varphi_t \tag{2.41}$$

In equilibrium, the marginal revenue from adding a variety with productivity $z_{x,t}$ to the export bundle has to be equal to the fixed cost. Thus, varieties produced by plants with productivity below $z_{x,t}$ are distributed only in the domestic market. The composition of the traded bundle is endogenous and the set of exported products fluctuates over time with changes in the profitability of export.

The FOC with respect to $N_{d,t+1}$ determines product creation:

$$\varphi_t f_{e,t} = (1-\delta)\beta_{t,t+1} \left[\begin{array}{l} \varphi_{t+1}\left(f_{e,t+1} - \frac{N_{x,t+1}}{N_{d,t+1}} f_{x,t+1}\right) \\ +\frac{1}{\theta-1}\left(\frac{P^y_{d,t+1}}{P_{t+1}}\frac{Y_{d,t+1}}{N_{d,t+1}} + \tau_{t+1}\frac{P^y_{x,t+1}}{P_{t+1}}\frac{Y_{x,t+1}}{N_{x,t+1}}\frac{N_{x,t+1}}{N_{d,t+1}}\right) \end{array} \right] \tag{2.42}$$

In equilibrium, the cost of producing an additional variety, $\varphi_t f_{e,t}$, must be equal to its expected benefit, which includes expected savings on future sunk investment costs augmented by the marginal revenue from commercializing the variety, net of fixed export costs, if it is exported.

Domestic and export prices Let $P_{d,t}$ and $P_{x,t}$ be the price of the product bundle $Y_{d,t}$ and $Y_{x,t}$. Each final producer faces the following domestic and foreign demand for its product bundles:

$$Y_{d,t} = \left(\frac{P_{d,t}}{P_t}\right)^{-\phi} Y^C_t, \qquad Y_{x,t} = \left(\frac{P_{x,t}}{P^*_t}\right)^{-\phi} Y^{C*}_t \tag{2.43}$$

where Y^C_t and Y^{C*}_t stand for aggregate demands of the consumption basket in the domestic and foreign country. The elasticity of substitution across sectoral bundles for the aggregate demand, $\phi > 1$, is equal to the elasticity of substitution for the consumption basket, although aggregate demand in each country includes sources other than consumption. This assumption ensures that the consumption price index for the the consumption aggregator is also the price index for aggregate demand of the basket.

We assume producer currency pricing (PCP): final producers set the price of the product bundle, $P_{d,t}$, and the the price of the export bundle, $P^h_{x,t}$, in their own domestic currency, letting the price in the foreign market move with the nominal exchange rate, that is: $P_{x,t} =$

$\tau P^h_{x,t}/S_t$. Because of fixed export costs, the composition of domestic and export bundles is different, and hence producers face different marginal costs of producing these bundles. Therefore final producers set two different prices for the Home and Foreign markets. The optimal price for domestic sales and exported sales satisfies respectively:

$$\frac{P_{d,t}}{P_t} = \frac{\phi}{\phi-1}\frac{P^y_{d,t}}{P_t}, \qquad \frac{P^h_{x,t}}{P_t} = \frac{\tau_t}{Q_t}\frac{\phi}{\phi-1}\frac{P^y_{x,t}}{P_t} \tag{2.44}$$

where $Q_t = S_t P^*_t / P_t$ is the real exchange rate.

We define the average price of a domestic variety, $\tilde{\rho}_{d,t} \equiv N_{d,t}^{\frac{1}{\theta-1}}(P_{d,t}/P_t)$ and the average price of an exported variety, $\tilde{\rho}_{x,t} \equiv N_{x,t}^{\frac{1}{\theta-1}}(P_{x,t}/P^*_t)$. Combining the equations (2.39) and (2.44), we obtain the average price of a domestic and an exported variety, respectively defined as:

$$\tilde{\rho}_{d,t} = \frac{\phi}{\phi-1}\frac{\varphi_t}{\tilde{z}_d}, \qquad \tilde{\rho}_{x,t} = \frac{\phi}{\phi-1}\frac{\tau_t}{Q_t}\frac{\varphi_t}{\tilde{z}_{x,t}} \tag{2.45}$$

Finally, the average output of, respectively, a domestic and exported variety are defined as:

$$\tilde{y}_{d,t} = \tilde{\rho}_{d,t}^{-\phi} N_{d,t}^{\frac{\theta-\phi}{1-\theta}} Y^C_t, \qquad \tilde{y}_{x,t} = \tilde{\rho}_{x,t}^{-\phi} N_{x,t}^{\frac{\theta-\phi}{1-\theta}} Y^{C*}_t \tag{2.46}$$

2.2.3 Government

In each period, we assume that government spending and unemployment benefits are funded by taxation on consumption and wage income:

$$G_t = \tau^c_t \left[\omega C^a_t + (1-\omega)(C^F_t + C^I_t + C^u_t)\right] + (\tau^w_t + \tau^f_t) w^F_t l_{Ft} - b_t U_t \tag{2.47}$$

2.2.4 Closing conditions

Aggregate demand is the sum of private and public consumption and is defined as:

$$Y^C_t = \omega C_{at} + (1-\omega)(C_{Ft} + C_Z It + C_{ut}) + \kappa_F V_{Ft} + \kappa_I V_{It} + G_t \tag{2.48}$$

We assume that he cost of opening new vacancies are socially shared.

Assets are in zero net supply, which implies the equilibrium condition:

$$a_{t+1} + a^*_{t+1} = 0 \tag{2.49}$$

Net foreign assets are determined by:

$$(a_{t+1} - a_t) + Q_t(a^*_{t+1} - a^*_t) = i_t a_t + Q_t i^*_t a^*_t + \left(Q_t N_{x,t} \tilde{\rho}_{x,t} \tilde{y}_{x,t} - N^*_{x,t} \tilde{\rho}^*_{x,t} \tilde{y}^*_{x,t}\right) \tag{2.50}$$

where the last term in brackets represents the trade balance: $TB_t = Q_t N_{x,t} \tilde{\rho}_{x,t} \tilde{y}_{x,t} - N^*_{x,t} \tilde{\rho}^*_{x,t} \tilde{y}^*_{x,t}$.

2.3 Calibration

We calibrate the model using quarterly data from the U.S. and Brazilian economy. We believe that Brazil is an illustrative example of an emerging countries which, starting form high level of informality in the late 1990s, has adopted a set of policy initiative to facilitate the move to formality. A first program, called SIMPLES, was launched in 1996 and was followed by a second one, the SUPERSIMPLES program, in 2006. Since, in Brazil there is a strong correlation between size of company and prevalence of informality, these programs aimed at reducing the costs of formalization through a reduction of tax rates and tax regulations for Brazilian micro firms with no more than five paid employees. Since the SUPERSIMPLES came into force in July 2007, some 9 million businesses have joined this system of taxation.[7]

In this section we discuss the calibration strategy. Broadly speaking, we choose some parameter values from the literature, while other parameters are set so to match macroeconomic series observed for the United States and Brazil. We assume that the two countries are asymmetric, hence some parameters describing labor and goods markets may differ across countries. Table 2.1 summarizes the asymmetric calibration.

We set the discount factor β to 0.99, implying that the annual real interest rate is 4 percent. The value of the risk aversion parameter, γ_c, is equal to 2. Following Bernard et al. (2003), we set the elasticity of substitution across product varieties, θ, equal to 3.8. Following Ghironi & Melitz (2005), we set the elasticity of substitution across Home and Foreign goods, ϕ, equal to θ, and the dispersion of firm productivity k_p equal to 3.4. We normalize z_{min} to 1. We set iceberg trade costs τ equal to 1.7, following the estimates of trade costs reported by Anderson & van Wincoop (2003). We calibrate the fixed export costs f_x so that the shares of exporting plants in the developed and emerging country are respectively equal to 21 percent and 18 percent, consistently with data reported in Bernard

[7]See ILO (2015) for a discussion and an evaluation of some programs launched in emerging countries to move to formalization.

et al. (2003) for the United States and in the World Bank Enterprise Survey for Brazil.[8] To ensure steady-state determinacy stationarity of net foreign assets, we set the parameter ψ measuring asset adjustment costs equal to 0.0025 as in Ghironi & Melitz (2005). Following Ebell & Haefke (2009), we set entry costs, f_e, so that regulation costs amount to 5.2 months of per capita output. To pin down the firm exit rate δ, we target the portion of worker separation due to firm exit equal to 30 percent in the United States and to 37 percent in Brazil: these values fall within the range of estimates reported by Haltiwanger et al. (2006). Empirical evidence indicates that informal firms are less productive than formal ones.

Regarding the parameters specific to the search and matching framework, the gross replacement rate for unemployment benefits b in the formal sector is set to 13 percent for the United States and 15.2 percent for Brazil. The parameter measuring firms' bargaining power, η, is equal to 0.4, as estimated by Flinn (2006). The elasticity of the matching function ε is equal to 0.4, so that it falls within the range of estimates reported by Petrongolo & Pissarides (2008) and the Hosios condition holds. We set the costs of vacancy posting (κ_F and κ_I), matching efficiency (χ_F and χ_I) and exogenous separation rate (λ_F and λ_I) in the formal and informal sectors so to match the underlying structure of the two countries, with the values of steady-state ratios summarized in Table 2.1. We choose a calibration based on the long-run averages (1992-2017) from ILO data. Steady-state unemployment rates are respectively 6 percent and 8.7 percent in the United States and Brazil, while the ratio of informal employment to total employment is respectively 7 percent and 30 percent in the United States and Brazil.[9] This calibration yields an informal wage gap (i.e. difference between wages for formal and informal workers) equal to 66 percent in the United States and 11 percent in Brazil. This latter value is very close to estimates in Bargain & Kwenda (2014) and Bargain & Magejo (2010) who conclude that earning differentials driven by the informal wage penalties are quite modest in Brazil and remain below 10 percent all along the distribution. Labor market regulations and high employer costs attached to formal employment in Brazil may simultaneously explain the large extent of informal work and the relatively modest informal wage gap. Firms tend to recoup high employers' payroll taxes paid to hire formal workers, which could partly explain low informal wage gaps. In Brazil informal wage penalties may only partly be related to the firm size effect, since many informal workers are to be found in large formal firms.

[8] As a *caveat*, we point out that the World Bank Enterprise Survey covers only firms of the formal private sector with five or more employees. Hence informal and micro firms are excluded from the sample.

[9] We use vulnerable employment as a proxy for informal employment.

Finally, we set the initial value of tax rates at their respective steady-state levels. The United States employs a retail sales tax rather than a value added tax (VAT) as the principal consumption tax. The retail sales tax in the United States is not a federal, but it is a tax imposed at the state and local government levels. The total tax rate ranges between 0 percent (e.g. in Delaware, Oregon, New Hampshire, Montana) and 13.5 percent (in Alabama). We decide to set τ^c for the United States at the average rate, 7.8 percent. Brazil operates a multiple rate system with ICMS (Imposto de Circulação de Mercadorias e Serviços) tax levied at a state level. The standard state rate of ICMS is 17 percent (18 percent in São Paulo, Minas Gerais and Paraná and 19 percent in Rio de Janeiro). Therefore, for Brazil we set τ^c equal to 17 percent. The personal income tax rate ranges between 0 percent and 37 percent in the United States and between 0 percent and 27.5 percent in Brazil. We choose the average value of the personal income tax rate and we set τ^w equal to 18 percent for the USA and 14 percent for Brazil. In the United States, the social security tax rate in 12.4 percent (6.2 percent on employees and 6.2 percent on employers). On top, there is a tax of 2.9 percent (half imposed on employer and half withheld from the employee's pay) of all wages for Medicare. In Brazil, the employer's contribution is determined at the rate of approximately 20 percent of salary to be paid to the National Institute of Social Security (Instituto Nacional do Seguro Nacional, INSS). On top, the FGTS is the Fundo de Garantia por Tempo de Serviço which is the Employee Indemnity Guarantee Fund and an employee compulsory fund. All Companies are obligated to deposit the FGTS contribution into their employers account. The tax corresponds to an 8 percent rate on top of the gross salary. Since in our model we consider only the share of payroll taxes paid by employers, we set the steady-state payroll tax rate, τ^f equal to 7.65 percent for the US and 28 percent for Brazil.

Table 2.1: Calibration

Targets and parameters	Notation	Developed	Emerging	Source
Calibration targets				
Formal employment	$l_F/(l_F + l_I)$	93%	70%	ILO, Trends Econometric Models
Informal employment	$l_I/(l_F + l_I)$	7%	30%	ILO, Trends Econometric Models
Unemployment rate	U	6%	8.7%	ILO, Trends Econometric Models
Share of exporting firms	N_x/N_d	21%	18%	World Bank and Bernard et al. (2003)
Final good Market				
Sunk entry costs	f_e	0.4	0.4	Ebell and Haefke (2009)
Fixed export costs	f_x	0.0062	0.0090	Calibration targets
Iceberg trade costs	τ	1.7	1.7	Anderson and van Wincoop (2004)
Pareto shape	κ_p	3.4	3.4	Ghironi and Melitz (2005)
Plant exit	δ	0.026	0.026	Haltiwanger et al. (2008)
Elasticity of substitution	$\theta = \phi$	3.8	3.8	Bernard et al. (2003)
Taxation				
Consumption tax	τ^c	7.8%	17%	
Income tax	τ_F^w (τ_I^w)	18% (0%)	14% (0%)	
Payroll tax	τ_F^f (τ_I^f)	7.65% (0%)	28% (0%)	
Labor market				
Bargaining power	η	0.4	0.4	Flinn (2006)
Matching function elasticity	ε	0.4	0.4	Petrongolo and Pissarides (2006)
Vacancy costs, formal	κ_F	2.5	2.5	Calibration targets
Vacancy costs, informal	κ_I	1.5	1.5	Calibration targets
Matching efficiency, formal	χ_F	0.30	0.28	Calibration targets
Matching efficiency, informal	χ_I	0.35	0.38	Calibration targets
Separation rate, formal	λ_F	0.032	0.055	Calibration targets
Separation rate, informal	λ_I	0.27	0.15	
Disutility of search, scale	ϑ	2	2	
Disutility of search, elasticity	ϱ	1.3	1.3	
Unemployment benefits, formal	b	13	15.2	Aleksynska and Schindler (2011)
Other parameters				
Risk aversion	γ_c	2	2	
Discount factor	β	0.99	0.99	
Bond adjustment cost	ψ	0.0025	0.0025	Ghironi and Melitz (2005)

2.4 The impact of trade liberalization

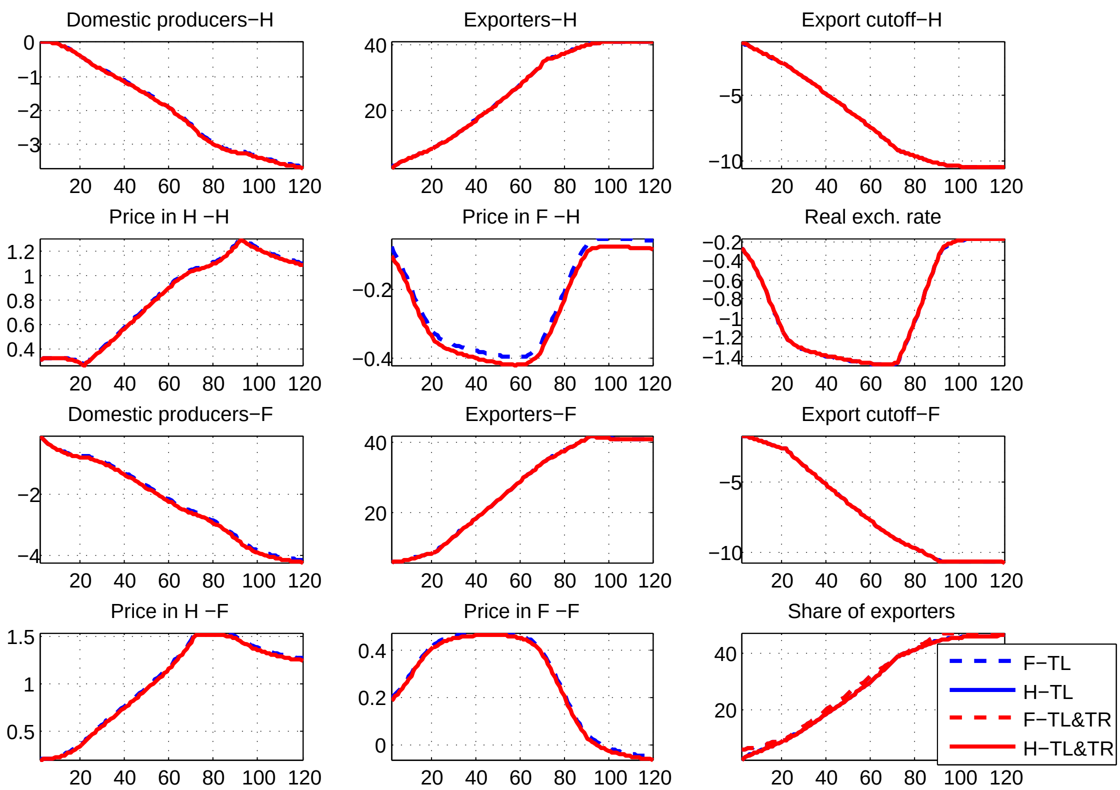
We use the model to analyze the impact of trade liberalization on employment in both developed and emerging countries. World trade liberalization is captured by a reduction in fixed export costs in both countries.

Trade liberalization is modeled in the following way: in a first phase, the "Home" country, which is the developed country, cuts its per-unit iceberg trade costs (τ_t). This process starts at the beginning of the simulation period and ends 70 quarters later (17.5 years). The cut in iceberg trade costs gives a competitive advantage to the developed country. In a second phase, which starts 5 years later (i.e. 20 quarters), the emerging country experiments the same decline in its own iceberg costs. Hence, 22.5 years after the initial reduction of trade costs observed in the developed country, iceberg costs in the developing country will have converged to those observed in the developed country. At this third phase, the two countries benefit from the same reduction in trade costs and trade liberalization becomes symmetrical. For the sake of clarity, we first analyze the dynamics in the developed country and then in the emerging country. We discuss the dynamics both in the short term, i.e. before than the emerging country benefits from trade liberalization, and in the medium to long term, i.e. when both countries can take advantage for the trade cost reductions.

The short-run adjustment on the goods markets. In the first phase of trade liberalization, i.e. when the developed country cuts its trade costs but the emerging country still does not benefit from new technologies allowing it to reduce its trade costs, lower trade costs allow exporters to have higher profits in the developed country. Trade translates into increased profitable opportunities for exporting firms, which induces more firms to enter the export market. These firms face lower costs and hence increase their labor demand, which ultimately leads to higher real wage. This, in turn, brings down the profits of the least productive firms such that the firm entries are reduced. Notice that these low productive firms produce only for the domestic market. Hence as it is shown in the Figure 2.1, the number of firms in the developed country declines, but at the same time, the number of exporters in this country increase (the export-cutoff decreases). Indeed, a higher proportion of exporting firms in the developed country leads to higher average quality of goods.

In the developed country, at each period, domestic market prices ($\rho_{d,t}$ in the model notation and "Price in H - H" in the figures) and export prices ($\rho_{x,t}$ in the model notation

Figure 2.1: The final good sector



Note: H and F indicate respectively the "Home" country (i.e. the developed country) which is represented by a solid line and the "Foreign" country (i.e. the emerging country) which is represented by a dotted line. The blue lines display the dynamics with only trade liberalization, and the red lines display the dynamics when the tax reform is implemented.

and "Price in F - H" in the figures) are given by the following equations:

$$\begin{aligned}\rho_{d,t} &= \frac{\phi}{\phi - 1}\frac{\varphi_t}{\widetilde{z}_d}\\ \rho_{x,t} &= \frac{\tau_t}{Q_t}\frac{\phi}{\phi - 1}\frac{\varphi_t}{\widetilde{z}_{x,t}}\end{aligned}$$

Hence, the increase in input prices, φ_t, generated by the expansion in final good producers' demand explains the rise in domestic market prices $\rho_{d,t}$. On the other hand, export prices $\rho_{x,t}$ drops as trade liberalization, through the decline in trade costs τ_t, compensates the increase in input prices as well as the decline in productivity ($\widetilde{z}_{x,t}$) of export firms. Finally, lower iceberg costs in the developed country leads to a decline in the real exchange rate (Q_t) underlining the gains in competitiveness of this country.

In the short run, the emerging economy does not observe a decline of trade costs. Instead, higher home prices in the developed country, combined with the decrease in the real exchange rate, lead consumers in the developed country to redirect their demand toward their trade partner. This increase in demand addressed to emerging economy motivates more exporting firms in this area. This, in turn, leads to a rise in input demand, and thus to a rise in the production costs (see Figure 2.1). As a consequence, input demand and production costs increase, which ultimately reduce the number of new firms entries: the number of firms (N_f = "Domestic producers - F") declines in the emerging country (see Figure 2.1).

Indeed, in the emerging country, at each period, the price of domestic goods ($\rho^*_{d,t}$ and "Price in H - F" in the figures) and the price of exported goods ($\rho^*_{x,t}$ and "Price in F - F" in the figures) are modeled as in the developed economy, in a symmetric way:

$$\begin{aligned}\rho^*_{d,t} &= \frac{\phi}{\phi - 1}\frac{\varphi^*_t}{\widetilde{z^*}_d}\\ \rho^*_{x,t} &= \tau_t Q_t\frac{\phi}{\phi - 1}\frac{\varphi^*_t}{\widetilde{z^*}_{x,t}}\end{aligned}$$

It is clear that the rise of input price causes the rise in the domestic price (ρ^*_d). The increase of the input price (φ^*) as well as the decline of productivity of exporters ($\widetilde{z}^*_x$) raises the export price, even though the real exchange rate (Q) declines.

The short-run adjustment on the labor markets. In the developed contry, higher input prices for final producers translate into higher marginal revenues for the intermediate good producers, and ultimately into higher wages. Figure 2.2 shows that labor demand increase in both the formal and the informal sector, driven by the increase in the price of intermediate goods sold to final producers. A part of this increase in the job surplus is redistributed to workers via wage increases. Figure 2.2 shows that wages increase in both the formal and the informal sector. Given that these wage increases are driven by the rise in the price of intermediate goods in both sectors (more demand must be satisfied by the final goods producers, leading to an increase of intermediate goods demands), they are similar across the formal and the informal sector and thus wage inequalities remain stable.

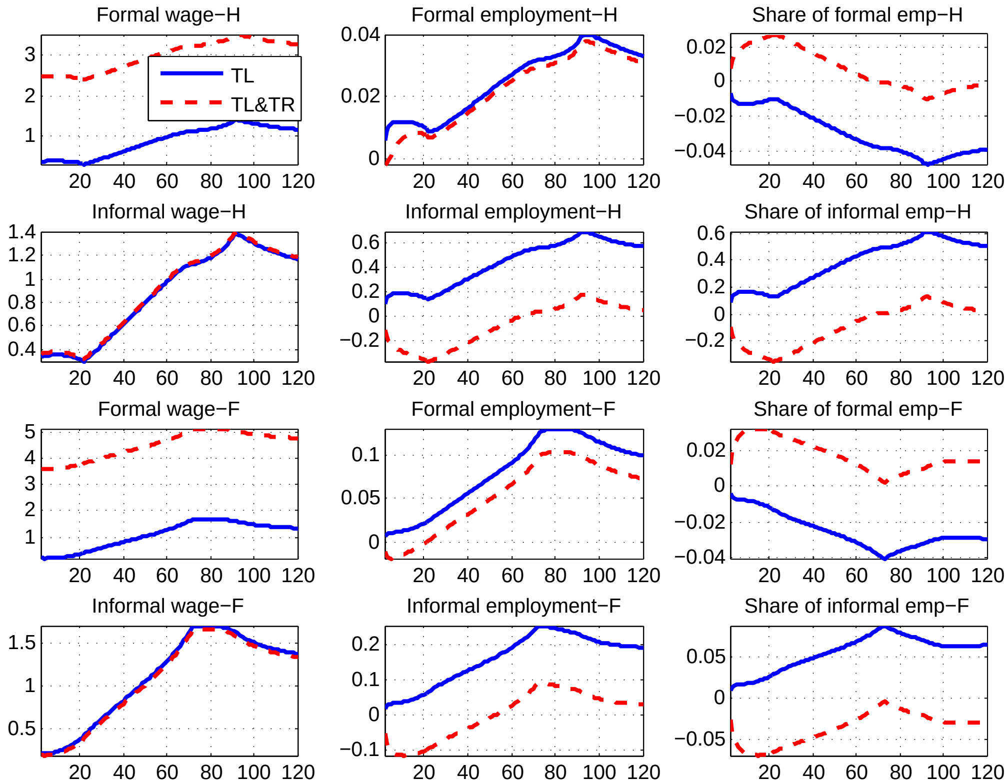
Although employment increases in both sectors, in the informal sector the increase is relatively larger, due to lower labor costs, which ensures that more job vacancies are opened in the informal sector. Indeed, expanded job creation in the informal sector encourages unemployed agents to search for a job more intensively in this sector, thus reinforcing the sector's advantage in the hiring process (see Figure 2.3). On the one side, at the beginning of the process trade liberalization induces higher informality in the developed country. On the other side it also induces a reduction in unemployment (see Figure 2.3).

Tightness on labor market increases in the emerging country, although for reasons different from those observed in the developed country, and consequently employment and wage rise. As in the developed country, lower labor costs in the informal sector favor this sector during the expansion (see Figure 2.2). Moreover, unemployment declines, while the share of informality goes up (see Figure 2.3). Note that the rise in informality is of small amplitude in the emerging economy. This is due to the initial share of informal employment. As the emerging economy has a larger share of informality, it causes a more negative congestion effect: the job filling rate falls more rapidly with vacancy postings. Hence, this curbs job openings in the informal sector.

The medium to long-run adjustments on the goods markets. In the medium run, trade liberalization also affects the emerging country, where iceberg costs also decline, although with a delay. Hence, higher firms' profits worldwide boost income and labor demand leading to higher wages. The increase in labor costs leads both economies to be more selective: the number of firms declines, but the share of exporting firms, which are more productive, increases (see Figure 2.1). The larger participation of the emerging country to the world trade stabilizes export prices in the developed country: the real exchange rate is more stable and the bias cost in favor of the developed country slows down (see Figure 2.1).

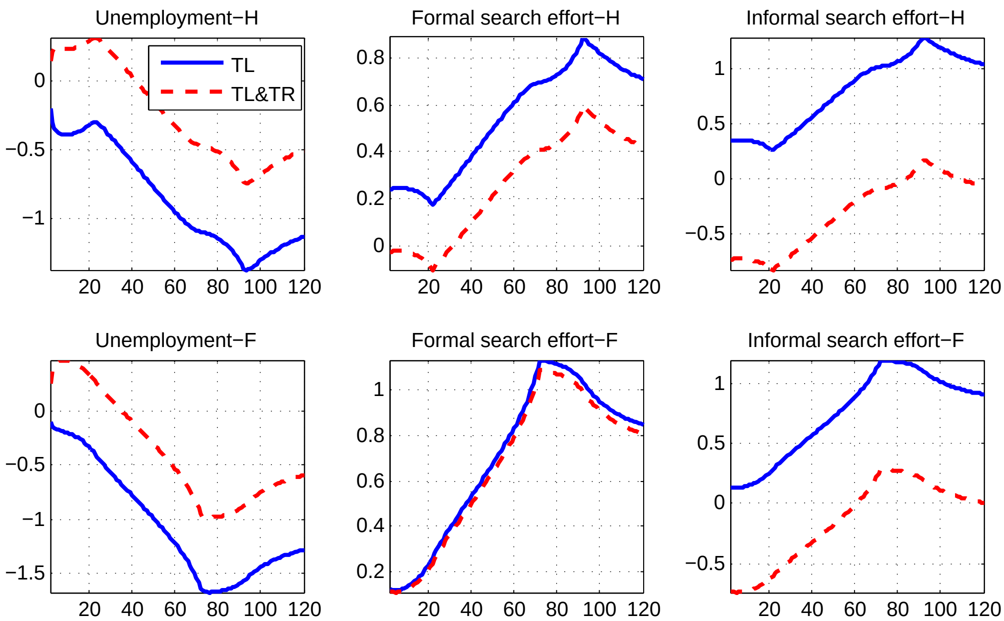
In the emerging economy, in the medium run, trade liberalization ultimately induces

Figure 2.2: The labor market



Note: H and F indicate respectively the "Home" country (i.e. the developed country) and the "Foreign" country (i.e. the emerging country). The blue lines display the dynamics with only trade liberalization, and the red lines display the dynamics when the tax reform is implemented.

Figure 2.3: Unemployment



Note: H and F indicate respectively the "Home" country (i.e. the developed country) and the "Foreign" country (i.e. the emerging country). The blue lines display the dynamics with only trade liberalization, and the red lines display the dynamics when the tax reform is implemented.

more firms to export, thereby increasing labor demand and real wages. As in the developed economy, this leads to high share of exporters and informality in emerging economy.

In the long run, when the developed country has reached its long-run level of iceberg costs, in the emerging country trade expansion is still ongoing. In the emerging country, revenue growth is now driven by iceberg cost reduction which takes place only in the emerging country and still generates growth gains. Growth gains, in this phase, are obviously more modest than during the first phase of trade expansion. However, the emerging country still benefits from decreasing iceberg costs. Hence, its competitiveness is restored and the real exchange rate increases (see Figure 2.1).

The medium to long-run adjustments on the labor markets. In the medium run, the increasing participation of both countries in the world trade, by increasing incomes and thus the demand for goods, boosts labor demand (see Figure 2.2) and reduces unemployment (see Figure 2.3).

In the long run, when trade costs drop only in the emerging country, income growth generated by new exports is marginal: employment gains become smaller and smaller in both countries (i.e. developed and emerging) and both sectors (i.e. formal and informal). When iceberg costs converge to their long-term levels in both countries, variables converge towards the new steady-state levels. This phase is characterized by an over-adjustment, which is the result of vacancy-posting strategies adopted by firms (see Figure 2.2). As long as profit opportunities grow, there are strong incentives to post vacancies to benefit from growth. This competition leads firms to over-hiring. Once growth falters, employment starts decreasing through the exogenous rate of destruction and the slowdown in new job opportunities. This process takes time and explains why, after the strong employment gains recorded during the period of trade expansion, both countries enter a phase characterized by a contraction on the labor market (see Figure 2.2). Since the separation rate is higher in the informal sector than in the formal sector, this decline in employment is faster in the informal sector, which explains the rise in the share of formal employment in this phase of the long-term adjustment (see Figure 2.2).

2.5 Tax reform

In order to reduce the increasing incidence of informality induced by trade liberalization, both countries should introduce incentives to develop businesses in the formal economy.

An easy way to promote formal employment is to reduce the payroll tax paid by firms. Nevertheless, the cost of this policy is a reduction of government budget, and thus a cut in public expenditures on social security. An alternative solution might be implementing a "budget-neutral" tax reform, consisting in increasing the consumption tax to fund the cut in payroll taxes. An advantage of this strategy is that the consumption tax has a larger base, it is easier to collect and more difficult to evade. This policy mix, called "social VAT", has been implemented in many European countries in the recent years, for instance in Denmark in 1988, in Sweden in 1993, in Germany in 2006 and in France in 2012.

In the rest of the paper, the tax reform is implemented in both countries at the beginning of their respective trade liberalization process. The tax reform is country-specific. We calibrate the tax reform as follows: *(i)* the reform is budget-neutral and *(ii)* the initial and the final levels of informality in both countries are the same. Given these constraints, the payroll tax is reduced from 8.0 percent to 5.8 percent with an increase in the consumption tax from 8 percent to 9.8 percent in the developed countries, whereas in the emerging country, the payroll tax is reduced from 28.0 percent to 24.0 percent with an increase in the consumption tax from 17.0 percent to 18.8 percent.

The impact on final goods sector. Figure 2.1 depicts the effects of trade liberalization in the final good sector when the government implements a budget-neutral tax reform. This scenario is represented by the red solid lines. Taxation has no direct impact on the behavior of final goods producers. The comparison with the pre-reform scenario (represented by the blue dotted lines in Figure 2.1) points out that the dynamics of variables in the final good sector remain unchanged because the main driver of both short-run and long-run changes in productivity and prices is trade liberalization. The tax reform only affects the distribution of jobs, across the formal and informal sector leaving the aggregate demand of intermediate goods unchanged.[10] This is due to the ambiguous effect of a budget-neutral tax reform on the tax wedge: on the one hand, it reduces the tax wedge by lowering the taxes paid by the employers, on the other hand it increases it by increasing the tax on consumption.

The impact on labor markets. Figure 2.2 reports the effects of trade liberalization on labor markets when the government implements a budget-neutral tax reform. This scenario is represented by the red solid lines. Recall that wages in both sectors are determined by

[10] To be more precise, changes in tax rates alter the equilibrium level of the production of intermediate goods. However, these changes have a second-order magnitude.

the following equations:

$$
\begin{aligned}
w_{Ft} &= \frac{\eta}{1-\tau^w_{F0}}\left(\frac{b}{(1+\tau^c_1)} - \vartheta\frac{e_{Ft}^{1+\varrho}}{1+\varrho} - \vartheta\frac{e_{It}^{1+\varrho}}{1+\varrho}\right) + \frac{1-\eta}{1+\tau^f_{F1}}\left(\varphi_t Z_{Ft} + \kappa_F\frac{\iota_F}{q_{Ft}}\right)\\
w_{It} &= \eta\left(\frac{b}{(1+\tau^c_1)} - \vartheta\frac{e_{Ft}^{1+\varrho}}{1+\varrho} - \vartheta\frac{e_{It}^{1+\varrho}}{1+\varrho}\right) + (1-\eta)\left(\varphi_t Z_{It} + \kappa_I\frac{\iota_{It}}{q_{It}}\right)
\end{aligned}
$$

where τ^w_{F0} is the tax paid by employees before the reform (indexed by 0). This tax rate remains unchanged, while the payroll tax paid by employers and the consumption tax jump instantaneously to their new post-reform values (respectively τ^f_{F1} and τ^c_1):

As observed for the baseline simulation without the tax reform (Figure 2.2, blue dotted lines), wages increase in both sectors. However, when the tax reform is implemented, the increase in wages is more remarkable in the formal sector than in informal sector (Figure 2.2). As a consequence, the wage gap between formal and informal workers is getting wider. Figure 2.4 shows that, before the tax reform, wages in the formal sector was 66.0 percent larger than in informal sector in the advanced economy and 11.0 percent in the emerging country (see blues dotted lines). After the reform, this gap rises to 69.0 percent in the advanced economy and to 14.5 percent in the emerging country (see solid red lines). Widening wage gaps across the two sectors stem from the reduction of tax wedges, leading to a larger job surplus and thus higher wages. The tax reform also changes the sharing rule between firms and workers, at the advantage of the workers. The underlying mechanism is due to two channels: on the one hand, the drop in the tax paid by employers increases the share of productivity paid to employees in the formal sector. On the other hand, the increase in the consumption tax reduces the disposable wage. However, this moderation is proportional to the weight of the unemployment benefits in the wage: as it is weak for workers in the formal sector, this wage moderation induced by the increase of the consumption tax is of small amplitude for the formal sector. The first channel clearly dominates and leads to wage increases in the formal sector after the tax reform.

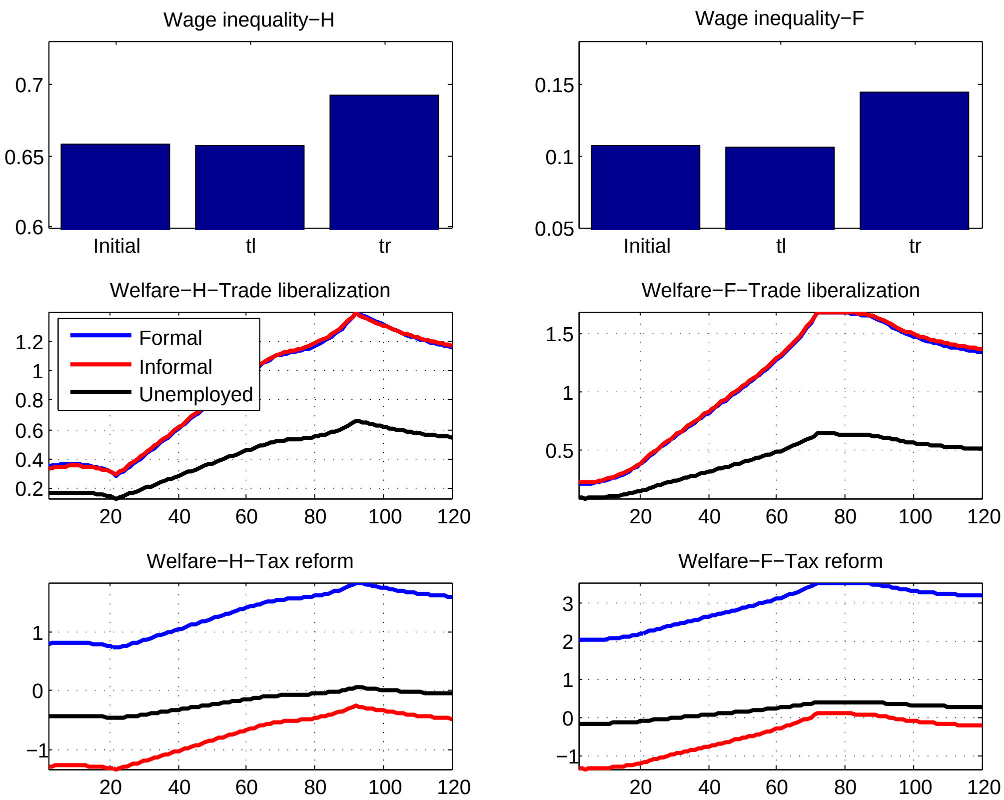
Given that the search effort is endogenous, the tax reform also changes the reservation wage of the workers. Indeed, the cut in payroll taxes stimulates firms to open new vacancies, which increase the chance for unemployed workers to find a job in the formal sector. The optimistic job prospects in the formal sector encourage the unemployed to focus their search efforts more on this sector. Search efforts increase in the formal sector and decline in the informal sector (see Figure 2.3, red solid lines). Hence, the tax reform ultimately redirects the labor force toward formal employment.[11] Figure 2.3 shows that the tax reform reduces the search effort relatively to the benchmark scenario (i.e. trade liberalization without the tax reform, represented by the blue dotted lines), explaining the increase in the reservation wage, and thus the rise in the wages.

Figure 2.3 shows that, following the tax reform, unemployment increases on impact and in the short-run. The underlying reason is that benefits from trade liberalization are gradual, while the tax reform is immediate: given the lack of attractiveness of the informal sector, search efforts – devoted to find a job in the informal sector before the implementation of the tax reform – now decrease, leading to an increase of unemployment in the short run (see Figure 2.3, red solid lines). At the beginning of the trade liberalization process, the marginal value of intermediate goods and workers' productivity, although higher, are not large enough to absorb the excess of unemployed workers who stop searching for an informal job. This explains why unemployment increases on impact and in the short-term especially in the emerging country, where the incidence of informality is higher than in the advanced economy.

Inequalities and welfare. Figure 2.4 shows that trade liberalization allows workers to reach higher welfare, regardless of the labor market status. Not surprisingly, welfare gains are higher for workers occupied in the informal sector. The underlying reason is that trade liberalization favors employment in the informal sector where firms open more jobs, wages increase leading to higher welfare gains for informal workers. This result has to be interpreted with some *caveats*. The initial welfare of the workers occupied in the informal sector is largely lower than the welfare of those occupied in the formal sector. Hence, following trade liberalization a larger share of workers suffer from poor working conditions associated to informality, although trade liberalization slightly reduces the welfare gap between formal and informal workers. When the tax reform is introduced, in both countries welfare gains for workers employed in the formal sector increase significantly (see Figure 2.4). This is mainly due to the large initial jump in wages in the formal sectors. Conversely, welfare associated to the outside options (i.e. unemployment or a job in the informal sector) are lower than those observed in the baseline scenario (i.e. trade liberalization without tax

[11] Similar conclusions are drawn in Antón who analyzes the effects of the 2012 tax reform in Colombia. He suggests that the reform would increase total employment by between 0.3 to 0.5 percent and formal employment by between 3.4 to 3.7 percent over the pre-reform scenario. In Brazil, tax cuts for small firms introduced by the reforms in 1996 and 2006 have led more than 9 millions of businesses into the formal sector.

Figure 2.4: Wage inequality and welfare



Note: H and F indicate respectively the "Home" country (i.e. the developed country) and the "Foreign" country (i.e. the emerging country). Wage inequality is defined by $w_{Ft}/w_{It} - 1$. Welfare is defined as consumption (purchasing power). For example, in the formal sector, it is $(1 - \tau_t^w)/(1 + \tau_t^c) * w_{Ft}$.

reform). This comes as no surprise, since the reduction in the welfare of workers employed in the informal sector is the corollary to the decline of informal employment share: only reduction in the welfare of this workers type allows labor market to reallocate toward the formal sector. The most important point is certainly the fact that the tax reform allows the welfare of the unemployed workers to increase, despite the large initial loses induced by the jump in the consumption tax (see Figure 2.4). These welfare gains for the unemployed workers are larger in the emerging country because more unemployed workers are eligible for the unemployment benefits following the tax reform.

2.6 Conclusion

In this paper, we show that trade liberalization boosts economic activity in both developed and emerging countries. However, we find that trade liberalization is associated to higher informality, which ultimately implies less job security and lower employment quality.

Policy makers should consider placing a high priority on promoting job quality and income equality. Policy interventions to curb informality should follow a comprehensive approach that rests on three pillars: increasing the benefits of formality, decreasing the costs of formalization and improving enforcement methods. In this respect, we investigate whether taxations may smooth the way for formalization of jobs. To this purpose, we extend the Melitz (2003) model and develop a two-country DSGE model, featuring a developed and emerging (or developing) country as in Cacciatore & Ghironi (2014). In addition, we embed the tax system and the informal labor sector in the model with the aim to analyze whether taxation may correct the bias toward informality introduced by trade liberalization. We argue that a fiscal reform can mitigate these adverse effects of trade on labor market. A "Social VAT", switching the tax burden from payroll taxes paid by firms in the formal sector to the consumption tax, can increase the incentives to operate in the formal sector. However, this comes at the cost of widening income disparities.

Of course, we acknowledge that a tax reform alone is not sufficient to reduce the incidence of low-quality jobs. Tax policy interventions should go hand in hand with more effective social protection systems and labor laws. Extending unemployment benefits to all workers in the formal sector including those working part-time and/or on temporary contracts, could prevent unemployed from looking for an informal job. Another step to enhance the quality of existing jobs is intensifying labor inspections in those sector where the incidence of informal work is higher.

Appendix

A Dynare equations

To solve the model, we use the Dynare software (see Adjemian et al. (2011)). After solving the steady state of the model, we use the following equation set in order to obtain the equilibrium paths.

- The equilibrium price index

$$1 = \tilde{\rho}_{d,t}^{1-\theta} N_{d,t}^{\frac{1-\phi}{1-\theta}} + \tilde{\rho}_{x,t}^{*1-\theta} N_{x,t}^{*\frac{1-\phi}{1-\theta}}$$

- Average export productivity

$$\tilde{\rho}_{x,t}^{-\theta} N_{x,t}^{\frac{\theta-\phi}{1-\theta}} Y_t^{C*} = \frac{\theta-1}{k_p-(\theta-1)} \frac{\tilde{z}_{x,t}}{\tau_t} f_{x,t}$$

- Labor market clearing

$$Z_F l_{Ft} + Z_I l_{It} = N_{d,t} \frac{\tilde{y}_{d,t}}{\tilde{z}_d} + N_{x,t} \frac{\tilde{y}_{x,t}}{\tilde{z}_{x,t}} \tau_t + N_{e,t} f_{e,t} + N_{x,t} f_{x,t}$$

- Law of motion of employment

$$l_{jt} = (1-\lambda_j) l_{jt-1} + q_{jt-1} V_{jt-1}$$

- New variety (product) creation

$$1 = (1-\delta)\beta E_t \left[\frac{C_{t+1}^{-\gamma_c}}{C_t^{-\gamma_c}} \frac{1+\tau_t^c}{1+\tau_{t+1}^c} \frac{\tilde{\rho}_{d,t+1}}{\tilde{\rho}_{d,t}} \left(\begin{array}{l} \frac{f_{e,t+1}}{f_{e,t}} - \frac{N_{x,t+1}}{N_{d,t+1}} \frac{f_{x,t+1}}{f_{e,t}} \\ + \frac{1}{(\theta-1) f_{e,t}} \left(\frac{\tilde{y}_{d,t+1}}{\tilde{z}_d} + \frac{N_{x,t+1}}{N_{d,t+1}} \frac{\tau_{t+1}}{\tilde{z}_{x,t+1}} \tilde{y}_{x,t+1} \right) \end{array} \right) \right]$$

- Job creation

$$1 = \beta E_t \left\{ \frac{C_{t+1}^{-\gamma_c}}{C_t^{-\gamma_c}} \frac{1+\tau_t^c}{1+\tau_{t+1}^c} \left[(1-\lambda_j) \frac{q_{jt}}{q_{jt+1}} + \frac{q_{jt}}{\kappa_j} \left(\varphi_{t+1} Z_{jt+1} - w_{jt+1} (1+\tau_{jt+1}^f) \right) \right] \right\}$$

- Wage determination

$$
\begin{aligned}
w_{Ft} &= \frac{\eta}{1-\tau^w_{Ft}}\left(\frac{b}{(1+\tau^c_t)} - \vartheta\frac{e^{1+\varrho}_{Ft}}{1+\varrho} - \vartheta\frac{e^{1+\varrho}_{It}}{1+\varrho}\right) \\
&\quad + \frac{1-\eta}{1+\tau^f_{Ft}}\left(\varphi_t Z_{Ft} + +\frac{\kappa_F}{q_{Ft}}\left[(1-\lambda_F)-(1-\lambda_F-\iota_{Ft})\frac{1+\tau^f_{Ft}}{1+\tau^f_{Ft+1}}\frac{1-\tau^w_{Ft+1}}{1-\tau^w_{Ft}}\right]\right) \\
w_{It} &= \eta\left(\frac{b}{(1+\tau^c_t)} - \vartheta\frac{e^{1+\varrho}_{Ft}}{1+\varrho} - \vartheta\frac{e^{1+\varrho}_{It}}{1+\varrho}\right) + (1-\eta)\left(\varphi_t Z_{It} + \kappa_I\frac{\iota_{It}}{q_{It}}\right)
\end{aligned}
$$

- Search intensity

$$
\begin{aligned}
\vartheta e^{\varrho}_{Ft} &= \left(\frac{1-\eta}{\eta}\right)\chi_F\left(\frac{V_{Ft}}{e_{Ft}U_t}\right)^{\epsilon}\left(\frac{1-\tau^w_{t+1}}{(1+\tau^f_{t+1})(1+\tau^c_{t+1})}\right)\frac{\kappa_F}{q_{Ft}} \\
\vartheta e^{\varrho}_{It} &= \left(\frac{1-\eta}{\eta}\right)\chi_I\left(\frac{V_{It}}{e_{It}U_t}\right)^{\epsilon}\left(\frac{1}{1+\tau^c_{t+1}}\right)\frac{\kappa_I}{q_{It}}
\end{aligned}
$$

- Euler equation for domestic bond holding

$$(1+\psi a_{t+1}) = (1+i_{t+1})\beta E_t\left(\frac{C^{-\gamma_c}_{at+1}}{C^{-\gamma_c}_{at}}\frac{1+\tau^c_t}{1+\tau^c_{t+1}}\right)$$

- Euler equation for foreign bond holding

$$(1+\psi a^*_{t+1}) = (1+i^*_{t+1})\beta E_t\left(\frac{C^{-\gamma_c}_{at+1}}{C^{-\gamma_c}_{at}}\frac{Q_{t+1}}{Q_t}\frac{1+\tau^c_t}{1+\tau^c_{t+1}}\right)$$

- Bond market clearing

$$a_{t+1} + a^*_{t+1} = 0$$

- Net foreign assets

$$(a_{t+1}-a_t) + Q_t(a^*_{t+1}-a^*_t) = i_t a_t + Q_t i^*_t a^*_t + Q_t N_{x,t}\tilde{\rho}_{x,t}\tilde{y}_{x,t} - N^*_{x,t}\tilde{\rho}^*_{x,t}\tilde{y}^*_{x,t}$$

- Law of motion for the stock of producing plants

$$N_{d,t+1} = (1-\delta)(N_{d,t}+N_{e,t})$$

- Share of exporting plants

$$N_{x,t} = \left(\frac{z_{\min}}{\tilde{z}_{x,t}}\right)^{k_p} \alpha^{\frac{k_p}{\theta-1}} N_{d,t}$$

- Export productivity cutoff

$$\tilde{z}_{x,t} = \alpha^{\frac{1}{\theta-1}} z_{x,t}$$

- Average price of a domestic variety

$$\tilde{\rho}_{d,t} = \frac{\phi}{\phi-1} \frac{\varphi_t}{\tilde{z}_d}$$

- Average price of an exported variety

$$\tilde{\rho}_{x,t} = \frac{\phi}{\phi-1} \frac{\tau_t}{Q_t} \frac{\varphi_t}{\tilde{z}_{x,t}}$$

- Average output of a domestic variety

$$\tilde{y}_{d,t} = \tilde{\rho}_{d,t}^{-\phi} N_{d,t}^{\frac{\theta-\phi}{1-\theta}} Y_t^C$$

- Average output of an exported variety

$$\tilde{y}_{x,t} = \tilde{\rho}_{x,t}^{-\phi} N_{x,t}^{\frac{\theta-\phi}{1-\theta}} Y_t^{C*}$$

- Aggregate demand

$$Y_t^C = \omega C_{at} + (1-\omega)(C_{Ft} + C_Z It + C_{ut}) + \kappa_F V_{Ft} + \kappa_I V_{It} + G_t$$

- Formal workers' consumption

$$C_{Ft} = w_{Ft} \;\; l_{Ft} \;\; \frac{1-\tau_t^w}{1+\tau_t^c}$$

- Unemployed agents' consumption

$$C_{ut} = \frac{b_t(1-l_t)}{1+\tau_t^c}$$

- Informal workers' consumption

$$C_{It} = w_{It} \ \frac{l_{It}}{1+\tau_t^c}$$

- Total consumption

$$C_t = \omega C_{at} + (1-\omega)(C_{Ft} + C_{It} + C_{ut})$$

- Unemployment

$$U_t = 1 - l_{Ft} - l_{It}$$

- Job filling rate

$$q_{jt} = \chi_j \left(\frac{e_{jt} U_t}{V_{jt}}\right)^{1-\varepsilon}$$

- Job finding rate

$$\iota_{jt} = \chi_j \left(\frac{V_{jt}}{e_{jt} U_t}\right)^{\varepsilon} e_{jt}$$

- Productivity shock

$$\log Z_{jt} = \phi^{Z1} \log Z_{jt-1} + \phi^{Z2} \log Z^*_{jt-1} + \epsilon^Z_{jt}$$

- Government spending

$$G_t = \tau_t^c[\omega C_{at} + (1-\omega)(C_{Ft} + C_{It} + C_{ut})] + (\tau_t^w + \tau_t^f) \ w_{Ft} \ l_{Ft} - b_t U_t$$

B Initial and final steady states

Figure 2.5: Goods markets

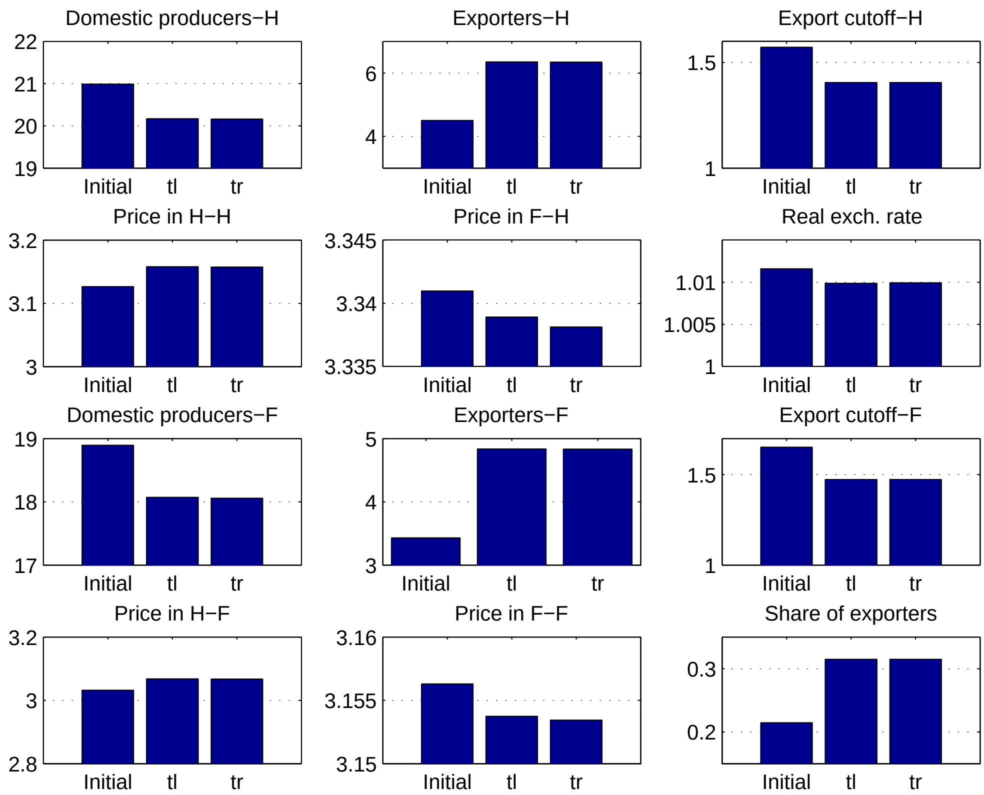


Figure 2.6: Labor markets

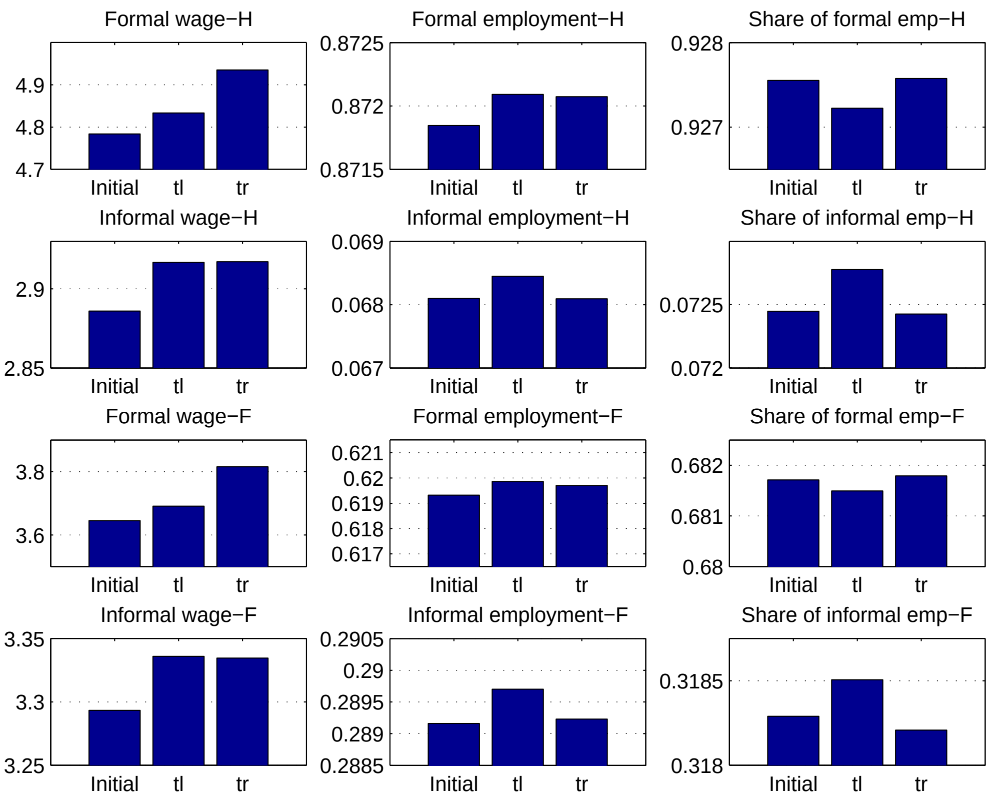
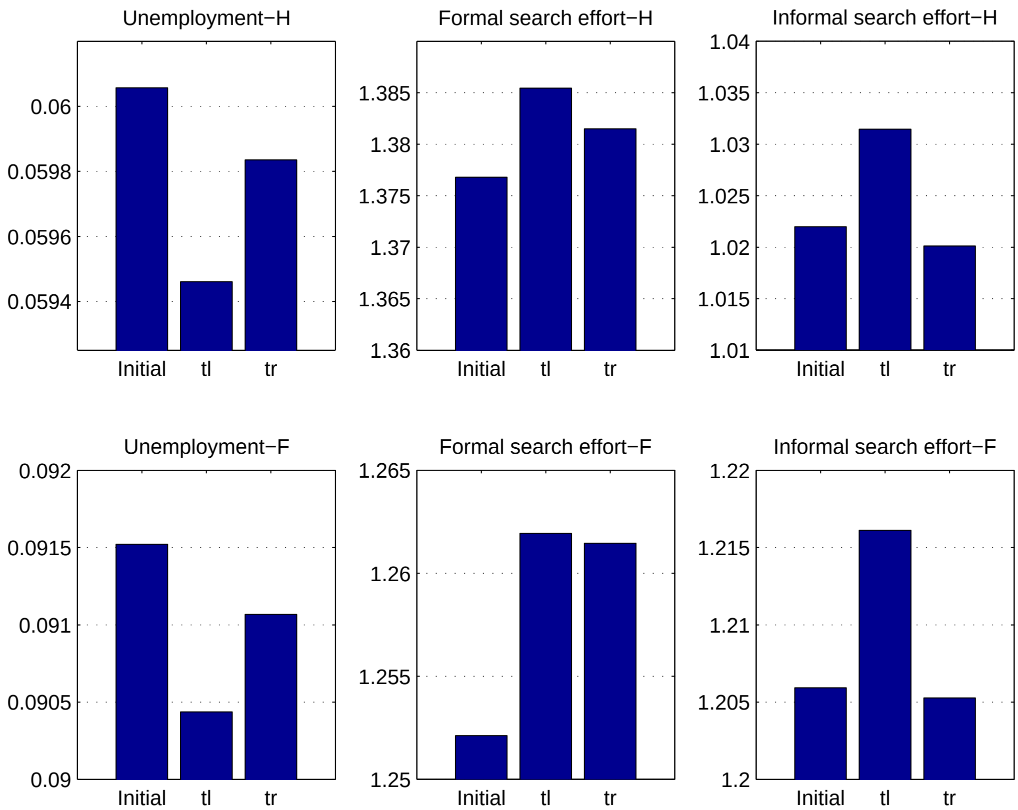


Figure 2.7: Unemployment



Chapter 3

The Role of Labor Market Institutions in the Transmission of Uncertainty Shocks

3.1 Introduction

Since the work by Bloom (2009), uncertainty about the future course of the economy has been identified as a possible driving force behind business cycle fluctuations. A number of recent papers have shown that an increase in uncertainty leads to a drop in economic activity: output, investment, consumption, and employment.[1] However, most of the analysis studies the impact of uncertainty shocks in single-country analysis and cross-country evidence focusing on the labor market is still scarce.[2]

This paper investigates heterogeneity on the effects of uncertainty shocks to labor markets across 30 OECD countries. Using country-specific VARs, I find that a sudden rise in uncertainty lowers output and increases unemployment. More importantly, however, there is substantial cross-country heterogeneity on the effects of uncertainty shocks. Why do some countries suffer severe rises in unemployment following an uncertainty shock? What can account for the cross-country differences in responses? There are a number of candidate channels that are available to account for the heterogeneity in responses: labor market institutions (LMIs), financial frictions, regulatory framework, etc. In particular, this paper focuses on the role of LMIs and explores how it can affect the responses of labor market to an uncertainty shock.

The labor market is a central institution in any modern economy, and it is characterized by pervasive regulation. Across nations, the labor market is subject to minimum wages, hiring and firing restrictions, compulsory collective bargaining and arbitrage, limitations on the number of hours, etc. Moreover, these LMIs vary across countries. Exploring the cross-sectional dimension by comparing differences across country groups, I provide evidence that heterogeneity in reactions of unemployment can be related to differential employment protection legislation (EPL), among others. The impact of an uncertainty shock visibly differs between the two subgroups (low EPL vs. high EPL). Following an uncertainty shock, countries with low EPL suffer higher rise in unemployment, take longer to recover to their pre-shock trend, and do not display a subsequent over-adjustment. On the other hand, high EPL countries present the modest and short-lived increase in unemployment, which is subsequently compensated for.

The economic mechanism I study is the following. When uncertainty hits the economy, the drops in real activity reduces labor demand. Firms should adjust their workforce by

[1] Related contributions include Alexopoulos & Cohen (2009), Bachmann et al. (2013), Caggiano et al. (2014), Leduc & Liu (2016), Riegler (2015), Guglielminetti (2016) and Oh & Sopraseuth (2017).

[2] Carriére-Swallow & Cépedes (2013), Gourio et al. (2013), and Bhattarai et al. (2016)

hiring less and laying off more. In theory, when firing costs are higher, firms find it easier and cheaper to absorb shocks by keeping workers. This mechanism is in line with the first moment shock. However, the second moment shock reinforces this mechanism through the real options channel. In periods of high uncertainty, firing costs which have larger fixed component come with a bigger cost, as it would be costly to hire new workers when productivity reverts quickly. Under irreversibility and uncertanty, firms become more cautious to lay workers off and separation margin is more important on business cycle fluctuations. Hence, EPL, which is closely related to fixed costs of firing, might be a key parameter to explaining the heterogenous responses in unemployment rate. High EPL (thereby incurring high non-convex firing cost) increases the option value of waiting more, reduces separations, and mitigates the rise in unemployment.

This paper is related to a number of recent studies that examine the impact of uncertainty shocks from a cross-country perspective. Bachmann et al. (2013) find that surprise increase in uncertainty have more persistent negative effects on economic activity in the US than in Germany. In particular, Germany features "wait and see" dynamics, whereas the evidence for "wait and see" effects in the US is mixed. They argue that "wait and see’ dynamics might be an important driving force in Germany because of frictions to adjusting labor. Gourio et al. (2013) show that a group of G7 countries presents a similar negative effect on unemployment, and there is some heterogeneity. However, they do not document what can cause heterogeneity. Carriére-Swallow & Cépedes (2013), which constitute key motivation for this paper, find substantial heterogeneity in reactions of investment and consumption to uncertainty shocks across 40 countries. In comparison to developed countries, emerging market economies suffer much more severe falls in investment and private consumption, and take longer to recover. They point to the importance of financial frictions channel. Using fifteen emerging market economies data, Bhattarai et al. (2016) show that an unanticipated rise in US stock market uncertainty has negative effects on their stock prices and exchange rate, and leads to capital outflows. Moreover, they find clear heterogeneity between South American countries and the rest of emerging market economies. This heterogeneity can be related to differential monetary policy reaction by these two groups of countries. However, little is known about the differential impact of uncertainty shocks on unemployment. Our originality lies in investigating cross-country heterogeneity in terms of labor market responses.

This work also contributes to a recent body of literature that investigates the role of LMIs for business cycle fluctuations. Much of the existing analysis of LMIs have focused on the impact on the underlying structural features of the economy[3], but only a few papers have studied their impact on business cycle fluctuations. In theory, stricter EPL reduces unemployment volatility as suggested by the search and matching models of Thomas & Zanetti (2009) and Zanetti (2011). On the other hand, little consensus emerges from empirical studies. Some studies find no effect on output volatility (Rumler & Scharler (2011)), while others find a negative effect on unemployment or output volatility (Merkl & Schmitz (2011)) or an inverted U-shaped effect on the relative unemployment to output volatility (Lochner (2014)). The available evidence is also inconclusive in the case of unemployment benefit or unions. However, none has considered uncertainty shocks for the impact of LMIs on business cycle dynamics. This paper fills this gap.

The rest of the paper is organized as follows: Section 2 explains the data and the empirical strategy. Section 3 presents the main results and economic mechanisms. Section 4 conducts a number of robustness checks. Section 5 concludes.

3.2 Data and Empirical methodology

In this section, I explain the data for empirical analysis as well as the methodology I adopt.

3.2.1 Data

The economic literature offers various methods for proxying the unobservable level of uncertainty: financial market indicators, news-based measure, survey-based measure, and forecast errors. There is no single general indicator of uncertainty, as such indicator has its advantages and pitfalls. The availability of indicators at country level represents an important constraints in the OECD context. Therefore, our baseline measure of uncertainty is stock market volatility, which is one of the most widely used measures in the literature (See Bloom (2014)). Implied volatility derived from equity options, however, are not available for many countries or over the long samples. I thus resort to realized volatility. Fortunately though, implied and realized equity volatilities are highly correlated[4].

On the other hand, in measuring uncertainty for a panel of countries, it is debatable whether the relevant measure is a local indicator, or a common global measure. Gourio et al. (2013) show that country-level risk measures constructed using local realized equity

[3]See the survey by Mortensen & Pissarides (1999)
[4]For US, they are correlated at 0.874 (1996-2015)

volatilities contain a large common component across OECD countries: the first principle component accounts for more than 40% of total variance in a large set of 27 OECD countries over 40 years. Moreover, they use the mean of country-level indices as a measure of global risk. Carriére-Swallow & Cépedes (2013) use the Chicago Board Options Exchange S&P 100 Volatility (VXO) index, to identify global shocks, given that it is debatable to what extent financial market series are a proper measure of local business condition in an emerging economy. In this paper, I use both local and global measures. In a benchmark model, I choose to use a local stock market volatility to take into account country-specific variations in uncertainty. Moreover, I test whether the results are robust to using VXO index as a common measure of global uncertainty.

Figure 3.1 shows the local uncertainty series for G5 countries (France, Germany, Japan, UK, and US) and identified global uncertainty shocks[5]. Realized equity volatility series contain a common component across countries: they tend to coincide around the most pronounced peaks (which are identified as global shocks), such as the period of Russian & LTCM default in 1998, WorldCom & Enron and Gulf War in 2002-2003, the global financial crisis in 2008-2009, and the euro area debt crisis in 2012. On the other hand, there are other periods, where some local crises are not identified as a global shock, such as the Asian crisis in 1997 and the dot-com bubble burst in 2001.

I use 30 OECD countries data[6] at the quarterly frequency for the period from 1996Q1 to 2015Q4. I import daily MSCI equity returns for the sample countries and build quarterly series of stock market volatility by computing standard deviations over calendar quarters. Unemployment rate and GDP data come from the OECD. Appendix 3.5 provides a detailed data description.

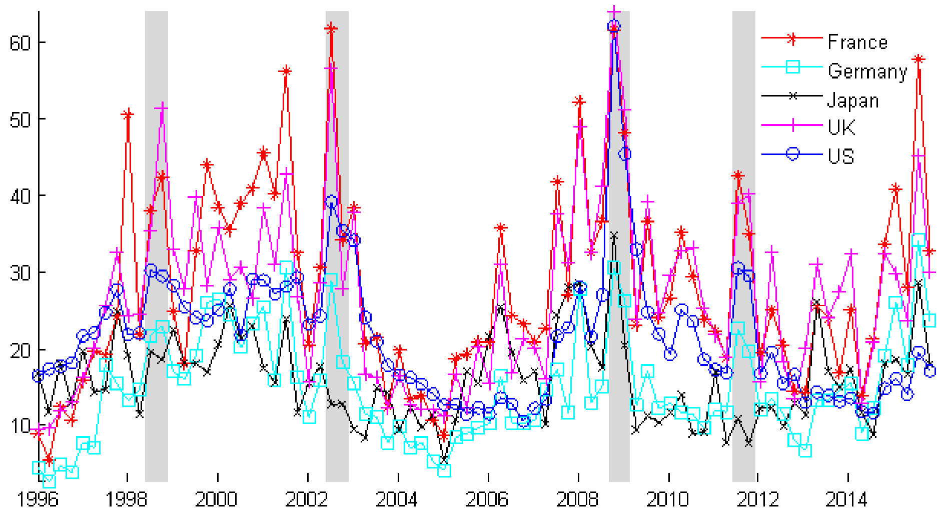
3.2.2 VAR specification

I analyze the effect of changes in uncertainty on unemployment rate and GDP. Specifically, to identify the effects of uncertainty shocks, I estimate country-specific VARs linking stock prices, unemployment rates, and real GDP. To do this, the dynamics of the vector $Y_t =$

[5]Following Bloom (2009), they are identified as periods in which the HP de-trended VXO index exceeds its mean by more than 1.65 standard deviations.

[6]They include Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States. I exclude 5 countries (Estonia, Iceland, Latvia, Luxembourg, and Slovenia) from OECD member countries, in which he has GDP less than 100 billion US dollars.

Figure 3.1: Uncertainty measures



Note: Shaded areas indicates global uncertainty shocks, identified in periods of Russian & LTCM default in 1998, WorldCom & Enron and Gulf War in 2002-2003, the global financial crisis in 2008-2009, and the euro area debt crisis in 2012. Following Bloom (2009), they are identified as periods in which the HP de-trended VXO index exceeds its mean by more than 1.65 standard deviations.

$[sp_t, vol_t, u_t, gdp_t]$ takes the following functional form:

$$\underbrace{\begin{bmatrix} \text{Equity return} \\ \text{Uncertainty measure} \\ \text{Unemployment rate} \\ \text{real GDP} \end{bmatrix}}_{Y_t} = B_0 + B_1 Y_{t-1} + ... B_p Y_{t-p} + A_0 \varepsilon_t \tag{3.1}$$

The sp_t variable is log of equity return, which is proxied by MSCI, vol_t is uncertainty measure, u_t is log of unemployment rate, and gdp_t is log of real GDP. This Cholesky ordering assumes that shocks instantaneously influence the stock market (levels and volatility), then real economic outcome (unemployment and output). For robustness, I also tested other orderings, which did not materially alter the impulse response functions. Including equity return as the first variable in the VAR is a conservative choice to control for first-moment shocks to returns as in Carriére-Swallow & Cépedes (2013)[7]. All variables are seasonally

[7]Uncertainty measures tend to rise in recessions and fall in booms. It is possible that uncertainty may reflect bad economic times rather than an uncertain future. Then, I include equity returns as an additional

adjusted, and detrended using the HP filter with smoothing parameter 1600. Two lags of each variables are included according to Akaike's information criterion. The magnitude of the orthogonalized shock to uncertainty is one standard deviation.

I estimate the model separately for each of the countries. I can then classify countries into groups based on their structural characteristics and explore the cross-sectional dimension by comparing differences across country groups.

3.3 Estimation results

3.3.1 Main findings

Our interest lies in the estimated responses of the domestic variables to the uncertainty shock. Figure 3.2 plots the median and the interquartile range of individual country impulse responses to a one-standard deviation shock to our measure of uncertainty for 30 OECD countries.

These results provide a first glimpse of the heterogeneity of the responses. While there is meaningful heterogeneity of unemployment responses to uncertainty shocks, a rise in uncertainty has significant effects on unemployment, averaging about 0.5 percent over the first 2 quarters, and fading away. As expected, in most countries, GDP decreases in response to a uncertainty shock. These results are consistent with existing empirical literature, which shows that high uncertainty leads to a contractionary effects on the economy. In Appendix 3.5, I report the impulse response functions country by country.

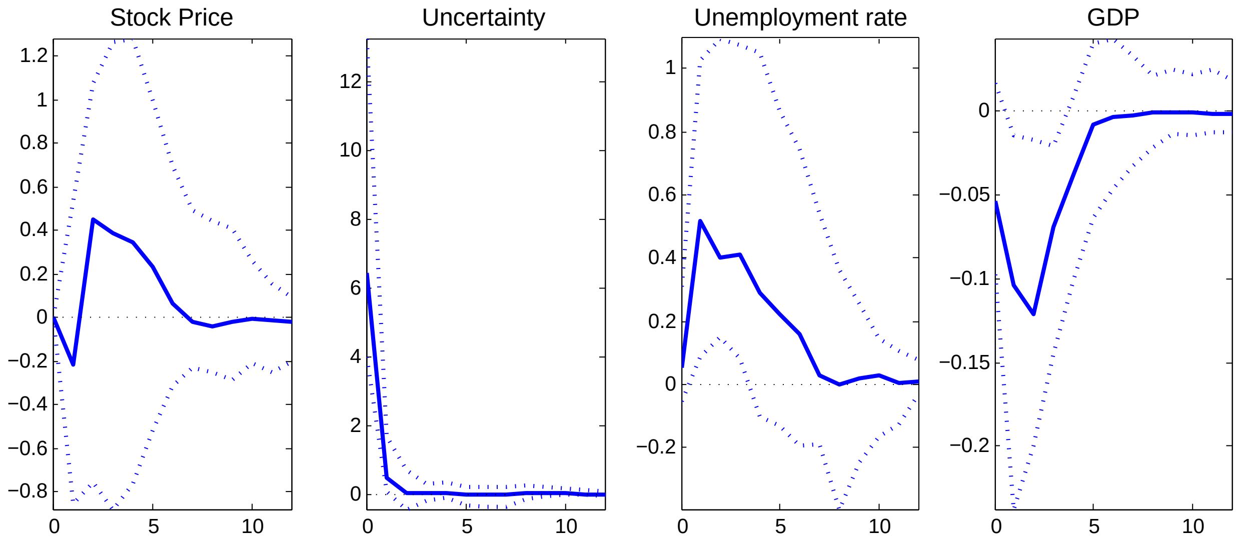
3.3.2 Candidate explanatory channels

The significant cross-section variation in unemployment responses potentially provides us with the evidence needed to look at the candidate explanatory channels. A number of potential channels are available to account for the heterogeneity in responses: labor market institutions, financial frictions, and regulatory framework.

Labor market institutions The large body of theoretical discussion about the effects of uncertainty focuses on "real options effects" following Bernanke (1983). The option value of

variable to control for potential effects from changes in equity returns

Figure 3.2: The impulse responses to an uncertainty shock



Note: The figure reports the cross-section variation of responses for different countries, with the median (solid line) and inter-quartile range (dotted line), to a one standard deviation shock to the uncertainty variable.

delay is high when uncertainty is high. Therefore, uncertainty makes firms cautions about decisions on investment and hiring, which adjustment costs can make expensive to reverse.

Labor adjustment entails non-convex costs[8], which are determined in part by LMIs. When we look at firm's decision in the labor market, hiring is likely to involve several sunk costs: job advertising, compensation of applicants, and training of newly hired employees. In addition, employment contracts are usually long-term relationships. With high uncertainty, the option value of waiting increases and firms should delay hirings. Leduc & Liu (2016) shows that in a search and matching model, vacancy posting is subject to real option effects with heightened uncertainty. On the other hand, separations should be also subject to an option value because it entails several sunk costs: procedural inconvenience, notice and severance pay, and difficulty of dismissal. Therefore, high uncertainty induces a drop in the number of layoffs. In a search and matching model with endogenous job separation, Schaal (2017) shows that separation is also subject to real option effects.

Empirical studies also show clearly that labor adjustments have fixed costs, in particular, with regard to separation. Abowd & Kramarz (2003) estimate hiring and firing costs, using

[8]These are fixed costs and partial irreversibility, then generate real options effects

a cross-sectional matched employer-employee data for France. They find that separation costs include a very large fixed component whereas hiring costs are much lower. Kramarz & Michaud (2010) estimate the functional form of hiring and firing costs using French data. They find that collective terminations entail very large fixed costs whereas hiring costs are small, with a negligible fixed component.

Let us look at the transmission of uncertainty shocks in the labor market. When uncertainty hits the economy, the drops in real activity reduce labor demand. Firms should adjust their workforce by hiring less and firing more. In theory, firing costs reduce job destruction during downturns. When firing costs are higher, firms find it easier and cheaper to absorb shocks by keeping workers. Instead, firms might adjust prices and wages. This mechanism is also in line with the first moment shock. Thomas & Zanetti (2009) and Zanetti (2011) find in a search and matching model that higher firing costs dampen the employment adjustment with the first moment shock. However, the second moment shocks reinforces this mechanism through the real options channel: in periods of high uncertainty, firing costs which have larger fixed component come with a bigger cost, as it would be costly to hire new workers when productivity reverts quickly. Under irreversibility and uncertainty, firms become more reluctant to lay workers off and separation margin is more important on business cycle fluctuations.

Hence, EPL, which is closely related to fixed costs of firing, might be a key parameter to explaining the heterogenous responses in unemployment to an uncertainty shock. We expect that high EPL (high firing cost) might increase the option value of waiting, induce lower separations, and alleviate the rise in unemployment.

Financial frictions A plausible explanation that could account for the heterogeneity in responses across countries is the presence of financial frictions. As the economy enters a period of high uncertainty, firms may find it more difficult to obtain financing for their projects if (i) banks find it more difficult to gauge the degree of risk involved in the project, (ii) banks are unable to obtain external financing themselves due to a shortage of liquidity or flight-to-quality episode, or (iii) firms suffer a deterioration of their balance sheets (perhaps due to a currency mismatch and sudden depreciation) which reduces the collateral available to post against new loans. The fall in the collateral value and/or the deterioration in the firms' balance sheets increase the negative effect of the uncertainty shock in the economy both in terms of the initial fall but also in terms of the persistence of the drop in investment. As a result, the decrease in investment might lead to the fall in labor demand and output.

Carriére-Swallow & Cépedes (2013) explore the link between the effects of uncertainty shocks and the functioning of financial markets. They show that economies with less-developed financial markets suffer more in terms of investment. We expect that the depths of local financial sector are inversely associated with the responses of unemployment.

Regulatory framework Product market flexibility is determined by the quality of business regulation and the degree of competition, which are likely to vary across countries. This regulatory framework might help describe the heterogeneity in the unemployment responses. Countries with regulatory frameworks that make investments or firm entry less irreversible should thus generate larger real-option values to waiting during the period of heightened uncertainty, and thus leads to a severe fall in real activity, then labor demand. We expect that there is a positive correlation between regulatory framework and the unemployment responses.

3.3.3 Which channel is more important?

In order to examine the differences in reactions across countries, I compute for each country the amplitude of impulse response function for unemployment rate, defined as the biggest value in the country's IRF. Moreover, I compute the correlations between the amplitudes of impulse responses and relevant country characteristics across 30 OECD countries. As proxies for labor market institutions, I use EPL[9], unemployment benefit (net replacement rates), minimum wage (relative to average wages of full-time workers), bargaining coverage (the ratio of employees covered by collective agreements, divided by all wage earners with right to bargaining), and trade union density (the ratio of union members divided by the total number of employees) by OECD. Among them, I view EPL as a useful measure of the firing costs. I also consider GDP per capita and financial depth, defined as private credit by deposit money banks to GDP (%), which are from World Bank. Financial depth is generally interpreted as a proxy for financial constraints. Indicators of product market regulation comes from the OECD[10]. I view this index as product market constraint or the degree of irreversibility in an economy.

[9]The OECD indicators of employment protection legislation measure the procedures and costs involved in dismissing individuals or groups of workers and the procedures involved in hiring workers on fixed-term or temporary work agency contracts. See http://www.oecd.org/els/emp/oecdindicatorsofemploymentprotection.htm

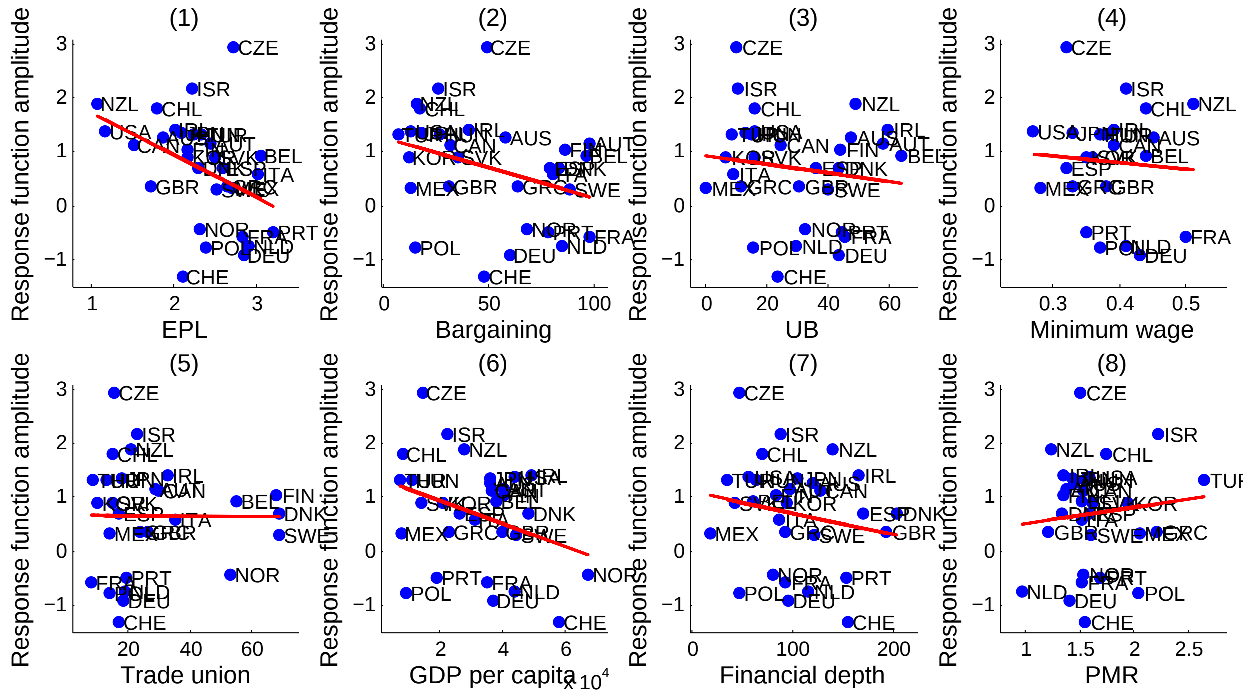
[10]See http://www.oecd.org/eco/growth/indicatorsofproductmarketregulationhomepage.htm#Sources

Table 3.1: Correlations between response function amplitudes and country characteristics

	Correlation
Labor market institutions	
Employment protection legislation	-0.43***
Unemployment benefit	-0.14
Minimum wage	-0.08
Bargaining coverage	-0.34*
Trade union density	0.00
Others	
GDP per capita	-0.34*
Financial depth	-0.19
Product market regulation	0.10

Notes: (i) Amplitude is defined as the biggest value in the country's IRF for the first 8 quarters. (ii) variables correspond to average value during 2008~2013. (iii) *, **, *** indicate statistical significance at 10%, 5%, 1%, respectively.

Figure 3.3: Response function amplitudes of unemployment rates and country characteristics



Note: In each panel, the vertical axis shows the response function amplitudes.

Table 3.1 and Figure 3.3 shows the correlations and scatter plots between the amplitudes of unemployment responses and structural characteristics of sample countries. The values of correlation coefficient have the expected signs as discussed in the previous section, even though some of them are not significant. When we first look at employment protection legislation, EPL is negatively correlated with the amplitude of the response in unemployment in a significant way. As discussed above, high EPL countries suffer more severe rise in unemployment rate. Bargaining coverage is also inversely associated with the response of unemployment. The role of other labor market characteristics such as unemployment benefit, minimum wage, and trade union density is ambiguous. When it comes to GDP per capita and financial depth, they are negatively correlated with the amplitude of the response in GDP. This finding echoes the results of Carriére-Swallow & Cépedes (2013). Emerging countries with less-developed financial markets suffer more with heightened uncertainty than advanced countries do. However, the role of financial depth is not significant. Moreover, product market regulation is positively associated with unemployment responses. With high uncertainty, regulation can come with a bigger cost and discourage entrepreneurs, leading to lower labor demand. Therefore, heavily regulated countries suffer more with high uncertainty. However, the effect of product market regulation is also not signifcant.

3.3.4 Subgroup analysis

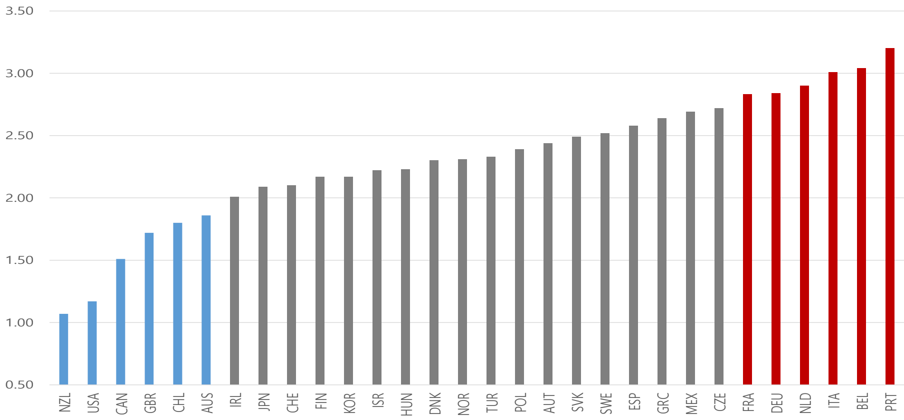
I can estimate average effects (Figure 3.2) using all the countries in the sample as well as those pertaining to the sub-groups of countries. This latter aspect of empirical exercises led us to explore the cross-sectional dimension and study the role of EPL in the transmission of uncertainty shocks. To do so, I split the OECD countries by EPL. Figure 3.4 represents EPL measures of 30 OECD countries. I construct a subpanel of Member states having lower EPL (six countries with the lowest EPL[11]) versus a subpanel of Member states with higher EPL (six countries with the highest EPL[12]).

Figure 3.5 reports the weighted average of impulse responses to a one standard deviation shock to uncertainty variable with 68 percent error bands for each of two groups (low EPL vs. high EPL). Weights are inversely proportional to the standard deviation of each impulse response. The impact of an uncertainty shock visibly differs between the two groups. Following an uncertainty shock, countries with low EPL suffer more severe rise in unemployment

[11] Portugal, Belgium, Italy, Netherland, Germany, and France (from lowest level)

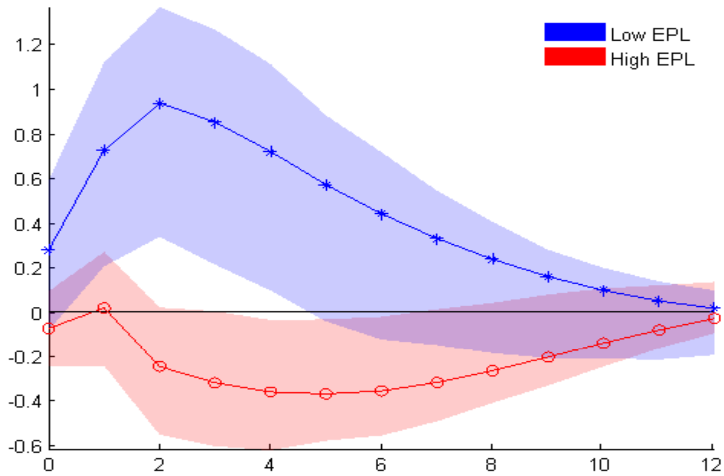
[12] New Zeland, United States, Canada, United Kingdom, Chile, and Australia (from highest level)

Figure 3.4: EPL for OECD countries



Note: EPLs correspond to average value during 2008 2013. Blue and red bars indicate the lowest EPL and the highest EPL countries, respectively

Figure 3.5: The weighted average of impulse responses of unemployment rates to a local uncertainty shock



Note: This figure plots the weighted average of individual impulse responses. Weights are inversely proportional to the standard deviation of each impulse response. Shaded areas present the 68 percent error bands.

and take longer to recover to their pre-shock trend. On the other hand, high EPL countries do not present a significant effect.

These results generalize the findings of Gourio et al. (2013) and Bachmann et al. (2013) with 30 OECD countries. Gourio et al. (2013) investigate a group of G7 countries: low EPL countries (Canada, Japan, UK, and US) suffer higher rise in unemployment rate than high EPL countries (France, Germany, and Italy) do. Bachmann et al. (2013) find that the response to a surprise increase in uncertainty in the US is quite different from the one in Germany: in the US, high uncertainty has larger and much more persistent effects on production and employment.

3.4 Robustness checks

In this section, I conduct a series of robustness exercises.

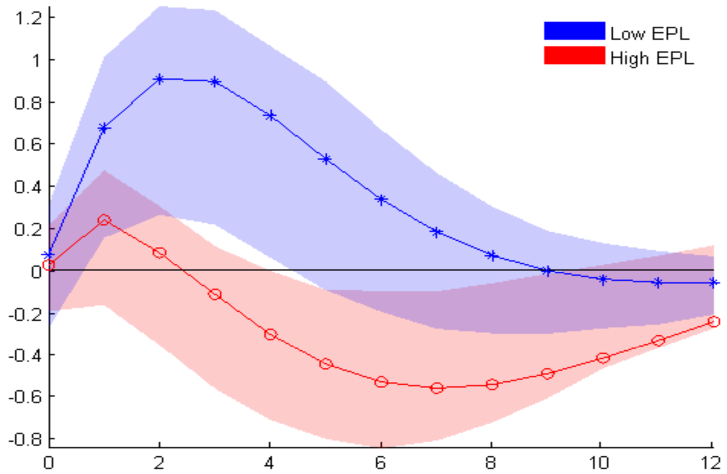
First of all, I replace local measures (individual country's equity return and realized equity volatility) with global measures (S&P 500 and VXO Index) in the VAR. I consider VXO as a common measure of global uncertainty. Figure 3.6 reports the weighted average of impulse responses to a one standard deviation shock to global uncertainty variable. The results are similar to those with local uncertainty measures. Importantly, there is no evidence of over-adjustment in low EPL countries when economies recover from the shocks, whereas the short-lived increase in unemployment in high EPL countries is subsequently compensated for. This similar evidence suggests that OECD countries suffer from both idiosyncratic and common uncertainty shocks, reflecting the high degree of interconnectedness of their economies.

In the baseline specification, I put equity return before uncertainty measures in the VARs. In this exercise, I remove equity return, then uncertainty comes first in the three variable VARs. Figure 3.7 presents the weighted average of impulse responses of three variable VARs. The effects of an uncertainty shock are bigger than those in the benchmark, and the difference between two groups is more significant.

Moreover, I construct another two subgroups by EPL. In this exercise, each subpanel has ten sample countries as a conservative choice.[13] Figure 3.8 shows the weighted average of

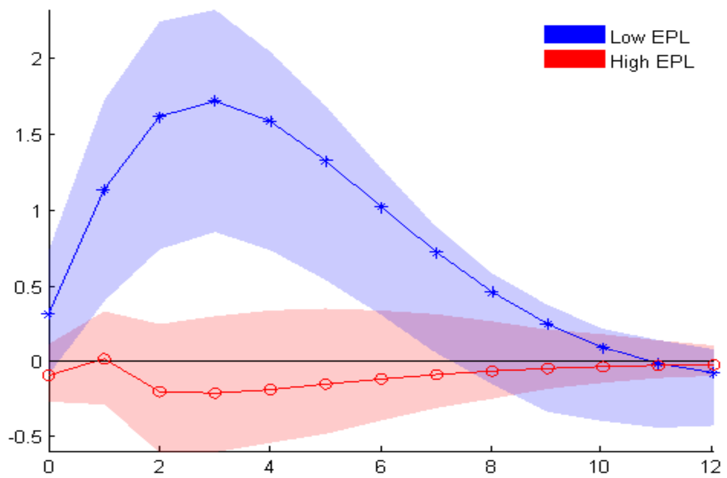
[13]ten countries with the lowest EPL (Portugal, Belgium, Italy, Netherland, Germany, France, Czech Republic, Mexico, Greece, and Spain (from lowest level)) versus ten countries with the highest EPL (New Zeland, United States, Canada, United Kingdom, Chile, Australia, Ireland, Japan, Switzerland, and Finland (from highest level))

Figure 3.6: The weighted average of impulse responses of unemployment rates to a global uncertainty shock



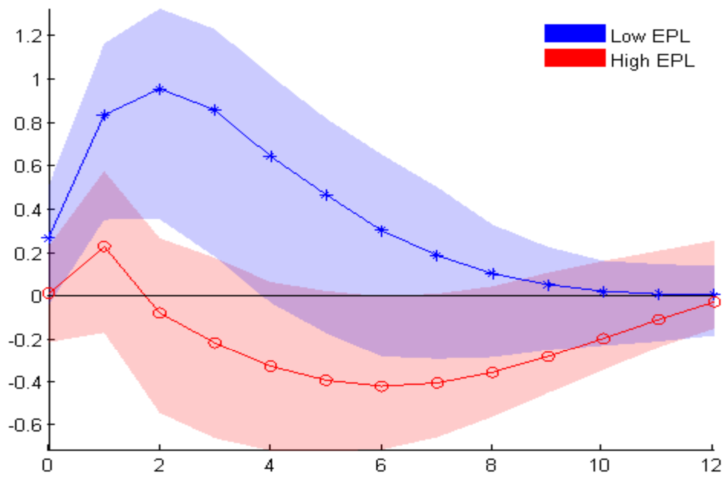
Note: This figure plots the weighted average of individual impulse responses. Weights are inversely proportional to the standard deviation of each impulse response. Shaded areas present the 68 percent error bands.

Figure 3.7: The weighted average of impulse responses of unemployment rates to a local uncertainty shock (three variable VAR)



Note: This figure plots the weighted average of individual impulse responses. Shaded areas present the 68 percent error bands.

Figure 3.8: The weighted average of impulse responses of unemployment rates to a local uncertainty shock (each panel has 10 sample countries)



Note: This figure plots the weighted average of individual impulse responses. Shaded areas present the 68 percent error bands.

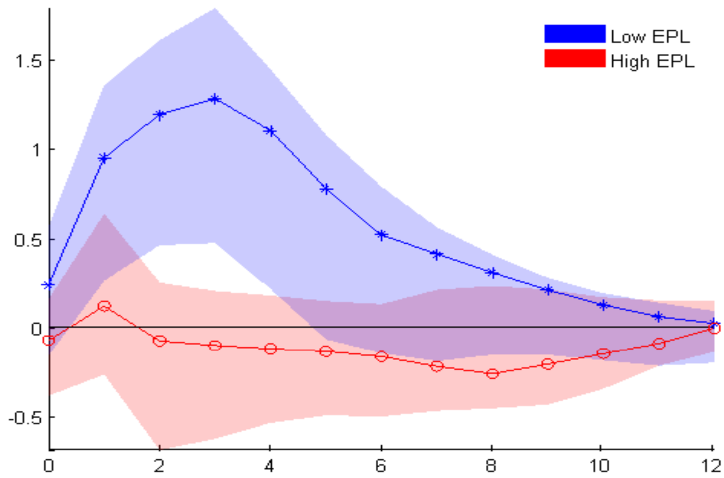
impulse responses with new subgropus. While the error bands are rather wide as expected, the results between two groups are significantly different.

In the baseline exercise, impulse responses of each group are the weighted average of the point estimates. I conduct an additional exercise with median impulse responses of each group. The median IRF in step i is defined as the median across all IRFs in step i as in Carriére-Swallow & Cépedes (2013). Figure 3.9 reports the median impulse response to a one standard deviation shock to a local uncertainty variable. Results remain roughly unchanged.

3.5 Conclusion

The effects of uncertainty shocks can vary across countries, depending on their structural characteristics, policy reactions, etc. This paper tries to focus on the role of LMIs in the transmission of uncertainty shocks. Using country-specific VARs, I show that there is substantial cross-country heterogeneity on the effects of uncertainty shocks. Exploring the cross-sectional dimension, I also provide evidence that EPL, which is closely associated with fixed cost of firing, is a key parameter to explaining the heterogeneous responses in unemployment rates. Stricter EPL mutes the reaction of unemployment, making it more costly

Figure 3.9: The median impulse response of unemployment rates to a local uncertainty shock



Note: This figure plots the median impulse responses. The median IRF in step i is defined as the median across all IRFs in step i. Shaded areas present the 68 percent error bands.

to lay workers off. Moreover, the second moment shock reinforces this mechanism through the real options channel. Under irreversibility and uncertainty, firms become more reluctant to lay workers off. The role of other country characteristics is ambiguous.

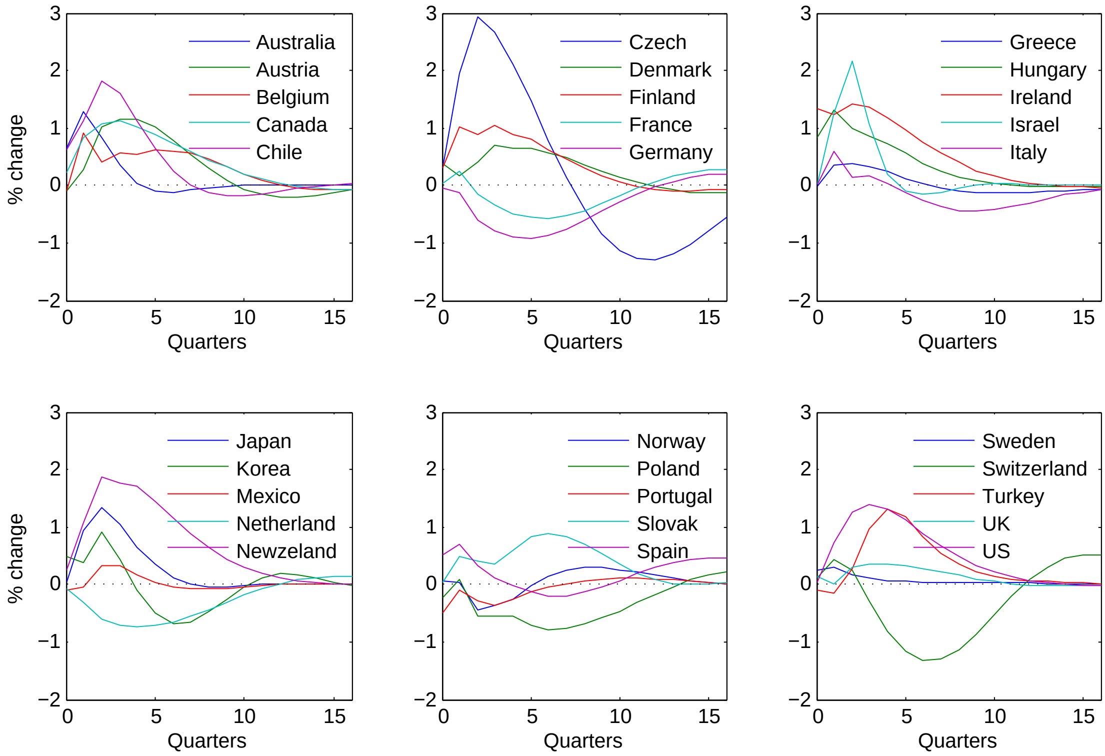
Appendix

A Data

- Macroeconomic series (unemployment rate and real GDP) come from the quarterly database of the OECD. Sample window starts in 1996q1 and ends in 2015q4.
- Stock market series come from the monthly database of MSCI and Bloomberg.
- OECD indicators of employment protection legislation
- GDP per capita (average value during 2008 2010) are from World Bank.
- Financial depth (average value during 2008 2010), defined as private credit by deposit money banks to GDP (%), are from World Bank.
- OECD indicators of product market regulation

B Impulse responses of unemployment rate (country by country)

Figure 3.10: Impulse responses of unemployment rate across countries



C Country names and symbols

Table 3.2: Country names and symbols

Country name	Symbol	Country name	Symbol
Australia	AUS	Japan	JPN
Austria	AUT	Korea	KOR
Belgium	BEL	Mexico	MEX
Canada	CAN	Netherland	NLD
Chile	CHL	New Zeland	NZL
Czech Republic	CZE	Norway	NOR
Denmark	DNK	Poland	POL
Finland	FIN	Portugal	PRT
France	FRA	Slovak Republic	SVK
Germany	DEU	Spain	ESP
Greece	GRC	Sweden	SWE
Hungary	HUN	Switzerland	CHE
Ireland	IRL	Turkey	TUR
Israel	ISR	United Kingdom	GBR
Italy	ITA	United States	USA

Bibliography

Abowd, J. M. & Kramarz, F. (1997). *The cost of hiring and separations*. Technical Report Working Paper 6110, NBER.

Abowd, J. M. & Kramarz, F. (2003). The costs of hiring and separations. *Labour Economics*, 10(5), 499 – 530.

Adjemian, S., Bastani, H., Karame, F., Juillard, M., Maih, J., Mihoubi, F., Perendia, G., Pfeifer, J., Ratto, M., & Villemot, S. (2014). *Dynare*. Reference manual, Cepremap.

Aguiar, M. & Gopinath, G. (2007). Emerging market business cycles: The cycle is the trend. *Journal of Political Economy*, 115(1), 69–102.

Alexopoulos, M. & Cohen, J. (2009). *Uncertain Times, Uncertain Measures*. Technical Report Working Paper 352, University of Toronto, Department of Economics.

Amiti, M. & Cameron, L. (2012). Trade liberalization and the wage skill premium: Evidence from indonesia. *Journal of International Economics*, 87(2), 277 – 287.

Anand, R. & Khera, P. (2016). *Macroeconomic Impact of Product and Labor Market Reforms on Informality and Unemployment in India*. IMF Working Papers 16/47, International Monetary Fund.

Anderson, J. E. & van Wincoop, E. (2003). Gravity with gravitas: A solution to the border puzzle. *American Economic Review*, 93(1), 170–192.

Andolfatto, D. (1996). Business cycles and labor-market search. *The American Economic Review*, (1), 112–132.

Andreasen, M., Fernandez-Villaverde, J., & Rubio-Ramirez, J. (2013). *The Pruned State-Space System for Non-Linear DSGE Models: Theory and Empirical Applications*. Technical Report Working Paper 18983, NBER.

Araujo, J. P. & Rodrigues, M. (2016). Taxation, credit constraints and the informal economy. *EconomiA*, 17(1), 43 – 55.

Bacchetta, M., E.-E. & Bustamante, J. (2009). *Globalization and informal jobs in developing countries. A joint study of the International Labour Office and the Secretariat of the World Trade Organization*. WTO and ILO.

Bachmann, R., Elstner, S., & Sims, E. (2013). Uncertainty and economic activity: evidence from business survey data. *AEJ.:Macroeconomics*, 5(2).

Bargain, O. & Kwenda, P. (2014). The informal sector wage gap: New evidence using quantile estimations on panel data. *Economic Development and Cultural Change*, 63(1), 117–153.

Bargain, O. & Magejo, P. (2010). *Is Informality Bad? Evidence from Brazil, Mexico and South Africa*. IZA Discussion Papers 4711, Institute for the Study of Labor (IZA).

Basu, S. & Bundick, B. (2017). Uncertainty shocks in a model of effective demand. *Econometrica*, 85, 937–958.

Batini, N., Levine, P., Lotti, E., & Yang, B. (2011). *Informality, Frictions and Monetary Policy*. School of Economics Discussion Papers 0711, School of Economics, University of Surrey.

Benigno, P. (2009). Price stability with imperfect financial integration. *Journal of Money, Credit and Banking*, 41, 121–149.

Bernanke, B. S. (1983). Irreversibility, uncertainty, and cyclical investment. *The Quarterly Journal of Economics*, 98(1), 85–106.

Bernard, A. B., Eaton, J., Jensen, J. B., & Kortum, S. (2003). Plants and productivity in international trade. *American Economic Review*, 93(4), 1268–1290.

Bhattarai, S., Chatterjee, A., & Park, W. (2016). *Global Spillover Effects of US Uncertainty*. Mimeo.

Bilbiie, F., Ghironi, F., & Melitz, M. (2012). Endogenous entry, product variety, and business cycles. *Journal of Political Economy*, 120(2), 304–345.

Bloom, N. (2009). The impact of uncertainty shocks. *Econometrica*, 77(3), 623–685.

Bloom, N. (2014). Fluctuations in uncertainty. *Journal of Economic Perspectives*, 28(2), 153–176.

Bloom, N., Floetotto, M., Jaimovich, N., Saporta, I., & Terry, S. (2012). *Really Uncertain Business Cycles*. NBER working paper 18245, NBER.

Born, B. & Pfeifer, J. (2014). Risk matters: The real effects of volatility shocks: Comment. *American Economic Review*, 104(12), 4231–39.

Bosch, M. & Esteban-Pretel, J. (2015). The labor market effects of introducing unemployment benefits in an economy with high informality. *European Economic Review*, 75, 1 – 17.

Bosch, M., ni Pacchioni, E. G., & Maloney, W. (2012). Trade liberalization, labor reforms and formal-informal employment dynamics. *Labour Economics*, 19(5), 653 – 667. Special Section on: Price, Wage and Employment Adjustments in 2007-2008 and Some Inferences for the Current European Crisis.

Busato, F. & Chiarini, B. (2004). Market and underground activities in a two-sector dynamic equilibrium model. *Economic Theory*, 23(4), 831–861.

Cacciatore, M. & Fiori, G. (2016). The macroeconomi effets of good and labor markets deregulation. *Review of Economic Dynamics*, 20, 1–24.

Cacciatore, M., Fiori, G., & Ghironi, F. (2016). Market deregulation and optimal monetary policy in a monetary union. *Journal of International Economics*, 99.

Cacciatore, M. & Ghironi, F. (2014). *Trade, Unemployment, and Monetary Policy*. Mimeo, HEC Montreal.

Caggiano, G., Castelnuovo, E., & Groshenny, N. (2014). Uncertainty shocks and unemployment dynamics in u.s. recessions. *Journal of Monetary Economics*, 67(Supplement C), 78 – 92.

Carriére-Swallow, Y. & Cépedes, L. F. (2013). The impact of uncertainty shock in emerging economies. *Journal of International Economics*, 90, 316–325.

Charlot, O., Malherbet, F., & Terra, C. (2015). Informality in developing economies: Regulation and fiscal policies. *Journal of Economic Dynamics and Control*, 51, 1–27.

Conesa, J. C., Díaz-Moreno, C., & Galdón-Sánchez, J. E. (2002). Explaining cross-country differences in participation rates and aggregate fluctuations. *Journal of Economic Dynamics and Control*, 26(2), 333 – 345.

Cook, D. & Nosaka, H. (2006). Dual labor markets and business cycles. *Proceedings*, (June).

Dellas, H., Malliaropulos, D., Papageorgiou, D., & Vourvachaki, E. (2017). *Fiscal policy with an informal sector*. Working Papers 235, Bank of Greece.

Den Haan, W. Ramey, G. & Watson, J. (2000). Job destruction and propagation of shocks. *American Economic Review*, 90, 482–498.

Dix-Carneiro, R. & Kovak, B. K. (2017). Trade liberalization and regional dynamics. *American Economic Review*, 107(10), 2908–46.

Djankov, S., La Porta, R., Lopez-de Silanes, F., & Shleifer, A. (2002). The regulation of entry. *Quarterly Journal of Economics*, 117, 1–37.

Ebell, M. & Haefke, C. (2009). Product market deregulation and the us employment miracle. *Review of Economic Dynamics*, 12, 479–504.

Elsby, M., Hobijn, B., & Sahin, A. (2008). *Unemployment Dynamics in the OECD*. NBER Working Paper 14617, NBER.

Epifani, P. & Gancia, G. (2006). Increasing returns, imperfect competition, and factor prices. *Review of Economics and Statistics*, 88(4), 583–598.

Feenstra, R. (2003). A homothetic utility function for monopolistic competition models, without constant price elasticity. *Economics Letters*, 78(1), 79–86.

Fernandez-Villaverde, J., Guerron-Quintana, P., Rubio-Ramirez, J., & Uribe, M. (2011). Risk matters: The real effects of volatility shocks. *American Economic Review*, 101, 2530–2561.

Flinn, C. J. (2006). Minimum wage effects on labor market outcomes under search, matching, and endogenous contact rates. *Econometrica*, 74(4), 1013–1062.

Fogli, A. & Perri, F. (2015). Macroeconomic volatility and external imbalances. *Journal of Monetary Economics*, 69, 1–15.

Fujita, S. & Ramey, G. (2009). The cyclicality of separation and job finding rates. *International Economic Review*, 50(2), 415–430.

Gasparini, L. & Tornarolli, L. (2007). *Labor Informality in Latin America and the Caribbean: Patterns and Trends from Household Survey Microdata*. CEDLAS, Working Papers 0046, CEDLAS, Universidad Nacional de La Plata.

Ghironi, F. & Melitz, M. (2005). International trade and macroeconomic dynamics with heterogeneous firms. *Quarterly Journal of Economics*, 120, 856–915.

Goldberg, P. K. & Pavcnik, N. (2003). The response of the informal sector to trade liberalization. *Journal of Development Economics*, 72(2), 463 – 496. 14th Inter-American Seminar on Economics.

Goldberg, P. K. & Pavcnik, N. (2007). Distributional effects of globalization in developing countries. *Journal of Economic Literature*, 45(1), 39–82.

Gonzaga, G., Filho, N. M., & Terra, C. (2006). Trade liberalization and the evolution of skill earnings differentials in brazil. *Journal of International Economics*, 68(2), 345 – 367.

Gourio, F., Siemer, M., & Verdelhan, A. (2013). International risk cycles. *Journal of International Economics*, 89, 471–484.

Guglielminetti, E. (2016). *The labor market channel of macroeconomic uncertainty*. Working Paper Banca dItalia 1068.

Hairault, J.-O., LeBarbanchon, T., & Sopraseuth, T. (2015). The cyclicality of the separation and job finding rates in france. *European Economic Review*, 76, 60–84.

Haltiwanger, J., Scarpetta, S., & Schweiger, H. (2006). Assessing job flows across conntries: The role of industry, firm size and regulations. (2450).

Heintz, J. & Pollin, R. (2003). Informalization , economic growth and the challenge of creating viable labor standards in developing countries.

Helpman, E., Itskhoki, O., & Redding, S. (2010). Inequality and unemployment in a global economy. *Econometrica*, 78(4), 1239–1283.

Hosios, A. (1990). On the efficiency of matching and and related models of search and unemployment. *Review of Economic Studies*, 57, 279–298.

ILO (2015). *Enterprise formalization: Fact or fiction? – New ILO/GIZ study on what works to formalize enterprises.*

Jütting, J., Parlevliet, J., & Xenogiani, T. (2008). *Informal Employment Re-loaded*. OECD Development Centre Working Papers 266, OECD Publishing.

Kim, S. & Lee, J. (2014). Accounting for ins and outs of unemployment in korea. *Korea and the World Economy*, 15(1), 17–44.

Kollmann, R. (2016). International business cycles and risk sharing with uncertainty shocks and recursive preferences. *Journal of Economic Dynamics and Control*, 72, 115–124.

Kovak, B. K. (2013). Regional effects of trade reform: What is the correct measure of liberalization? *American Economic Review*, 103(5), 1960–76.

Kramarz, F. & Michaud, M.-L. (2010). The shape of hiring and separation costs in france. *Labour Economics*, 17(1), 27 – 37.

Leduc, S. & Liu, Z. (2016). Uncertainty shocks are aggregate demand shocks. *Journal of Monetary Economics*, 82, 20–35.

Lochner, B. (2014). *Employment protection in dual labor markets: Any amplification of macroeconomic shocks?* Technical report.

Matsuyama, K. (2007). Beyond icebergs: Towards a theory of biased globalization. *The Review of Economic Studies*, 74(1), 237–253.

McCaig, B. (2011). Exporting out of poverty: Provincial poverty in vietnam and u.s. market access. *Journal of International Economics*, 85(1), 102 – 113.

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71(6), 1695–1725.

Menezes-Filho, N. A. & Muendler, M.-A. (2011). *Labor Reallocation in Response to Trade Reform*. Working Paper 17372, National Bureau of Economic Research.

Merkl, C. & Schmitz, T. (2011). Macroeconomic volatilities and the labor market: First results from the euro experiment. *European Journal of Political Economy*, 27(1), 44–60.

Miyamoto, H. (2016). *Uncertainty shocks and labor market dynamics in Japan.* Working paper, Kochi University of Technology.

Mortensen, D. & Pissarides, C. (1994). Job creation and job destruction in the theory of unemployment. *Review of Economic Studies*, 61, 397–415.

Mortensen, D. & Pissarides, C. (1999). *Job Reallocation, Employment Fluctuations and Unemployment*, chapter 18, (pp. 1171–1228). Amsterdam: Elsevier Science North Holland.

Nicoletti, G. & Scarpetta, S. (2003). Regulation, productivity and growth: Oecd evidence. *Economic Policy*, 18, 9–72.

OECD (2015a). *OECD Employment Outlook 2015.*

OECD (2015b). *OECD Science, Technology and Industry Scoreboard 2015:Innovation for growth and society.* Technical report, OECD, Paris.

Oh, S. & Sopraseuth, T. (2017). Frim entry, search and matching in a small open economy faced with uncertainty shocks: The case of korea. *Mimeo.*

Orsi, R., Raggi, D., & Turino, F. (2014). Size, trend, and policy implications of the underground economy. *Review of Economic Dynamics*, 17(3), 417 – 436.

Pappa, E., Sajedi, R., & Vella, E. (2015). Fiscal consolidation with tax evasion and corruption. *Journal of International Economics*, 96, S56 – S75. 37th Annual NBER International Seminar on Macroeconomics.

Petrongolo, B. & Pissarides, C. (2001). Looking into the black box : A survey of the matching function. *Journal of Economic Literature*, 39, 390–431.

Petrongolo, B. & Pissarides, C. A. (2008). The ins and outs of european unemployment. *American Economic Review*, 98(2), 256–62.

Pissarides, C. (2001). *Pissarides, C.* Technical report, LSE.

Riegler, M. (2015). *The Impact of Uncertainty Shocks on the Job-Finding Rate and Separation Rate.* Mimeo.

Robertson, R. (2004). Relative prices and wage inequality: evidence from mexico. *Journal of International Economics*, 64(2), 387 – 409.

Rumler, F. & Scharler, J. (2011). Labor Market Institutions And Macroeconomic Volatility In A Panel Of Oecd Countries. *Scottish Journal of Political Economy*, 58(3), 396–413.

Satchi, M. & Temple, J. (2009). Labor markets and productivity in developing countries. *Review of Economic Dynamics*, 12(1), 183 – 204.

Schaal, E. (2017). Uncertainty and unemployment. *Econometrica*.

Schneider, F. & Enste, D. H. (2000). Shadow economies: Size, causes, and consequences. *Journal of Economic Literature*, 38(1), 77–114.

Shimer, R. (2012). Reassessing the ins and outs of unemployment. *Review of Economic Dynamics*, 15, 127–148.

Slonimczyk, F. (2011). *The effect of taxation on informal employment: evidence from the Russian flat tax reform*. Technical report.

Thomas, C. & Zanetti, F. (2009). Labor market reform and price stability: An application to the euro area. *Journal of Monetary Economics*, 56(6), 885 – 899.

Verhoogen, E. A. (2008). Trade, quality upgrading, and wage inequality in the mexican manufacturing sector*. *The Quarterly Journal of Economics*, 123(2), 489–530.

Waseem, M. (2018). Taxes, informality and income shifting: Evidence from a recent pakistani tax reform. *Journal of Public Economics*, 157, 41 – 77.

Zanetti, F. (2011). Labor market institutions and aggregate fluctuations in a search and matching model. *European Economic Review*, 55(5), 644 – 658.

Zenou, Y. (2008). Job search and mobility in developing countries. theory and policy implications. *Journal of Development Economics*, 86(2), 336 – 355.

Zhang, Y. & Wan, G. (2006). Globalization and the urban poor in china. 2006(28).