Essays on the Macroeconomics of Market Reforms and Self-Employment

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

Doctor of Philosophy

University of Washington

2020

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Program Authorized to Offer Degree:
Economics

University of Washington

Abstract

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The labor market is undoubtedly the closest and most intimate aspect of the economy that the individuals face. The type of employment has also evolved over time alongside the labor market. While much study has been focused on the labor market, not enough light has been shed on self-employment, which is unique in that it is a form of employment at the borderline of workers and firms. Relating the motivation for starting one's own business to the possibility of finding wage-paying jobs is even rarer, as much of previous literature see self-employment from the perspective of credit constraints or avoiding costly labor and tax regulations. As the share of self-employment is non-negligible (which is especially true in developing, small open economies), a proper understanding of self-employment is crucial in successfully carrying out structural reforms as well.

With this agenda in mind, this dissertation seeks to understand two main issues. First is exploring how individuals' decisions towards choosing into self-employment can be tied to the state of the labor market (i.e. the probability of finding wage-paying work). This additional source of employment eventually affects the composition of the labor market and thus the business cycle dynamics. The second topic of the dissertation is studying the consequences of such self-employment on the macroeconomic efficiency and the outcomes of structural reforms on the product and labor markets.

Chapter 1[1] focuses on the consequences of different decisions regarding the international financial market integration and exchange rate policy in a small open economy, Korea. The chapter is targeted towards a deeper understanding of a combination of policies under two important ingredients in a Dynamic Stochastic General Equilibrium (DSGE) model: producer entry into domestic and export markets and labor market frictions. Results show that under flexible exchange rates, access to international financial markets increases the volatility of both business creation and the number of exporting plants, with the effects on employment volatility being more modest. The exchange rate peg can have unfavorable consequences for the effects of terms of trade appreciation, and more financial integration is not necessarily beneficial under a peg. The combination of a floating exchange rate and internationally complete markets would be the best scenario for Korea among those the chapter focuses on.

Chapter 2 introduces workers' endogenous transition in and out of self-employment in the traditional Diamond-Mortensen-Pissarides (DMP) framework, while keeping the crucial ingredients in a closed economy DSGE framework as explored in Chapter 1. Under such settings, labor market composition becomes more volatile, leading to greater fluctuations and higher welfare costs from business cycles. A comparison with a centrally planned economy shows that self-employment becomes an additional source of inefficiency in the economy. The lack of job creation by the self-employed implies reforms being less effective when targeted towards them.

Chapter 3 brings together the first two chapters by allowing self-employment in a small open economy, calibrated for Korea. Specifically, the hiring firms produce tradable goods and engage in exporting, while the self-employed produce nontradable goods and only serve the domestic market. The model displays a much higher rate of self-employment (around 36% of employment) compared to the closed economy calibrated for the U.S. in Chapter 2. It also shows the real exchange rate appreciating and terms of trade depreciating under financial

[1] This chapter is based on the co-authored work with Fabio Ghironi and Matteo Cacciatore.

autarky after a productivity shock, where the size of the fluctuations depends on the firm creation in both tradable and nontradable sectors. Allowing international borrowing leads to more consumption smoothing but relatively less entry in both hiring and self-employed firms, with unemployment becoming less volatile and terms of trade initially appreciating.

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ACKNOWLEDGMENTS

Thanks to the unique pandemic situation we are in at the moment, I am currently confined in a small studio, going through a mandatory 2-week quarantine in Korea. I have no one to see and nowhere to be, which means now is an excellent time to ponder over my last few years of the Ph.D. and write my acknowledgments.

My years in the Ph.D. program have been all about being professional and following the rules in academia (Beamer much?). However, as my good roommate of six years put it, there will be maybe negative five people who are going to read my 170+ page dissertation. I have also used the partying face emoji during my defense and no one gave me a hard time for it. So I have decided to go somewhat casual in the acknowledgments. My reading committee already signed the form, so I am good on the administrative front as well.

Of course, I would like to start by thanking my advisor, Fabio Ghironi, for all his help, guidance, support, advice, mentoring, motivation, (a ton of) patience, and basically everything he has generously offered me during the whole Ph.D. process. He was my academic papa. While I have had many teachers and professors along the way, Fabio was truly the person I could name as my mentor. I was extremely lucky to have him as my advisor, and words – despite me speaking two languages – fail me to express this adequately. I would also like to thank my dissertation committee members – Matteo Cacciatore, Mu-Jeung Yang, and Theo Eicher – for their invaluable input and hard questions that helped me push this dissertation further.

This long process would not have been possible without my family's love and support. When I first started my master's in Economics back in Korea, my grand announcement of me deciding to quit the program after a month in was met with "do whatever you want."

This *laissez-faire* approach eventually made me not quit, so thank you mom and dad (and no, I am not being sarcastic here)! Thank you for always being more than happy to have me over during breaks and stay with you too, rent-free. You are the best parents one could ever hope for, and I would give you both honorary Ph.D.s for it if I could (my dad already has one, but who wouldn't want two? Also, Fabio agreed to sign them if needed). As for my brother, he was never shy to point out my nerdy dad jokes and tell me to keep quiet about me being so highly educated whenever I acted silly around him. I still make the nerdy dad jokes so he somewhat failed but hey, it is the thought that counts. I would also like to thank my coolest and smartest aunt in the world who always believed in my possibilities, in both academics and drinking wine. I love you all!

Next, I am dedicating this paragraph to Laurel, my good roommate of six years, for teaching me how to debug codes and helping me keep my sanity. You were the one who always listened to my rants over so many years and offered to go through a green-card marriage if I was in the danger of being kicked out of the country. I am so happy we both graduated with our degrees and are on our way to successful (i.e. working 16 hours a day with no weekends) careers! Special thanks to Kathy and Willie as well, who were basically my American parents (yes, that includes me using their Netflix account), sending me their utmost support and love all along the way.

I was extremely lucky to have so many friends who rooted for me too. First is Hyunryung, my good friend since undergrad who received her Ph.D. in Aeronautics and Astronautics (i.e. the field that receives reactions like "Oh wow, cool!" from strangers. Mine gets "That's very nice." This is based on a true story during an Uber ride) and has been my driving teacher for the last few months. Thank you for always being so willing to help out in a pinch and expose yourself to the great risk of being at my side while I am driving. Tee, I am going to miss the workouts (at least while we had them) and the brunch we had together every Saturday, as well as the weekday lunches at the Sociology department kitchen. I am very glad I had the

courage to ask you if you wanted to have lunch together on our first day at math camp. To Jiyoung – I am so happy I have you in my life. You are truly like the sister I have never had. I will continue to think that way whenever I crash at your swanky new place when I am in Seattle. Hope that is okay with you. To Seo-Ah, my best friend of 13 years (and counting) and my personal photographer, I love how we get right back on track even after not seeing each other for months. I know I can count on you for anything, including remembering all the embarrassing things I did during my undergraduate years. Gueyon, you will not believe how much support, guidance, and love I received from you. You were definitely one of the many good things that happened to me during my master's. To my vida, thank you for coming to my brownbag seminar, for that is where everything started – and will hopefully continue. Our hours of playing Age of Empires II and your referee report on my job market paper really helped with the final push of this dissertation (and believe me, not too many people have read my job market paper from cover to cover).

Honestly, there are countless friends and colleagues who helped me through this journey, and mentioning everyone would require my acknowledgments to be a separate paper (which, unfortunately, will not count towards my tenure requirement). If I have not mentioned you, as we academics say it, all errors are mine – but I hope you will know that you are all in my heart.

DEDICATION

to my family and friends, who were always with me during the whole ride

Chapter 1

FINANCIAL MARKET INTEGRATION, EXCHANGE RATE POLICY, AND THE DYNAMICS OF BUSINESS AND EMPLOYMENT IN KOREA[1]

1.1 Introduction

Korea transitioned from limited exchange rate flexibility and low integration in international financial markets in the 1980s to the current environment of a floating won and high capital market integration. In the process, it experienced a severe currency and banking crisis in 1997-98, which precipitated the advent of increased exchange rate flexibility. Much has been written on the crisis that engulfed Korea and other Asian countries, and on the interaction of policy choices with respect to capital account opening and exchange rate policy in exposing countries to such events.[2] Even abstracting from the topic of crises, the effects of international financial market integration and exchange rate policies are classic subjects of study in international macroeconomics.[3] Importantly, these studies typically abstract from features of economic dynamics that are becoming increasingly accepted as necessary ingredients for empirically relevant positive analysis and for policy conversation: producer entry into domestic and export markets, and labor market frictions that result in unemployment.[4]

The purpose of this paper is to use a medium-scale, dynamic, stochastic, general equilibrium (DSGE) model that features these ingredients—in addition to the standard ingredients

[1]This chapter is based on the co-authored work with Fabio Ghironi and Matteo Cacciatore.

[2]Eichengreen (2004a, 2008) summarizes events and explanations and provides references to much literature.

[3]See Heathcote and Perri (2014) for a survey of literature on international financial market integration and risk sharing and Corsetti et al. (2010) for a survey on monetary policy in open economies.

[4]References to much recent literature that introduces one or both of these ingredients in analyses of macroeconomic fluctuations and/or policy problems can be found in Cacciatore and Ghironi (2012).

of New Keynesian open economy macroeconomics—to shed light on the consequences of different decisions with respect to international financial market integration and exchange rate policy for Korea. The exercise allows us to highlight the importance for results of channels hitherto unexplored in the literature and that suggest interesting avenues for further theoretical and empirical exploration.

The model we use is a small open economy version of the benchmark framework for analysis of macro interdependence and monetary policy with micro-level dynamics developed by Cacciatore and Ghironi (2012). In the model, monopolistically competitive producers decide endogenously on the number of plants (or product lines) they operate subject to sunk costs of new product creation. Plants are heterogeneous in their productivities and face fixed export costs as in Melitz (2003). Therefore, only the products of sufficiently productive plants are exported abroad. These micro-level producer dynamics, which have become the benchmark for international trade analysis, are combined with search-and-matching labor market frictions as in Diamond (1982a, b) and Mortensen and Pissarides (1994). Hiring workers requires firms to post vacancies and incur costs of vacancy posting. A standard matching technology translates the number of aggregate vacancies and the aggregate unemployment rate into new job matches in each period. Wages are determined by Nash bargaining between workers and firms. These ingredients are combined with the standard assumptions of wage and price stickiness of a vast New Keynesian literature to complete the setup for our exercises. We consider three scenarios for international financial integration and two possibilities for monetary policy: financial autarky, internationally incomplete markets with asset trade restricted to nominal bonds, and complete markets, under an exchange rate peg or a float. In the latter case for exchange rate policy, we assume that monetary policy sets the interest rate according to an empirically plausible interest rate rule as a function of inflation and the output gap.

We take the case of incomplete markets under flexible exchange rates as benchmark for comparison of the model's properties to those of the data on Korea's business cycle in the period 1998–2007. Even if it fails to generate a countercyclical trade balance, the model does well on several dimensions. We then tackle the following question: Suppose Korea operates under the floating won regime, but it does it under financial autarky or complete markets. How would its macroeconomic dynamics differ and what would be the consequences for welfare?

We find that access to international financial markets increases the volatility of both business creation (producer entry) and the number of exporting plants, but the effects on employment volatility are more modest. Financial integration implies better consumption risk sharing, with lower consumption volatility and higher correlation of consumption with the rest of the world. As a consequence, welfare costs of business cycles for Korea become significantly lower.

The next exercise that we perform studies how financial integration and the exchange rate regime interact to shape macroeconomic dynamics in response to shocks and the welfare implications of different scenarios. We find that an exchange rate peg can have unfavorable consequences especially for the effects of shocks that cause terms of trade appreciation. At the same time, more financial integration is not necessarily beneficial under a peg, because of unfavorable employment and business creation consequences. On welfare grounds, the combination of a floating exchange rate and full insurance in internationally complete markets is the best scenario for Korea among those we considered.

To the best of our knowledge, our paper makes a novel contribution to the literature by highlighting the role of producer-level dynamics and labor market frictions in shaping the consequences of different scenarios for international financial market integration and the exchange rate regime. However, there is much that the paper does not do: While it suggests mechanisms that can make an exchange rate peg undesirable, the paper does not include any modeling of the 1997–98 crisis, and it should not be interpreted as a theory of the crisis. This is so also because the model abstracts from financial market frictions other than in the menu of internationally traded assets, and it is well known that the banking sector played a crucial role in the crisis.

The model departs from the benchmark New Keynesian small open economy framework (as developed, for instance, by Galí and Monacelli, 2005) only by introducing richer micro-level producer dynamics and search-and-matching frictions in labor markets. By doing so, we are abstracting from many model features of potential relevance to the specific case of Korea. We are making this choice intentionally: A vast literature has applied the off-the-shelf Galí-Monacelli-type model to a large number of vastly heterogeneous countries. Our interest here is in performing a similar exercise and applying what we view as a benchmark New Keynesian small open economy model with producer dynamics and labor market frictions to the case of Korea. Restricting the extension of the basic framework to the ingredients we focus on allows us to hone in most transparently on the novel results we can learn from the joint introduction of these model features. The development of model versions that incorporate more Korea-specific features is an obvious extension of our analysis that we leave for future research.

Finally, the paper also does not provide an empirical assessment of the importance for Korea of the producer-level dynamics we highlight. Borrowing the terminology of Prescott (1986), we present "theory ahead of business cycle measurement," which will require longer time series of extensive margin data for rigorous testing than those currently available. We view the construction of such data and its use in empirical analysis of the mechanisms we explore as a major task for future research.[5]

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 discusses the properties of the model by presenting impulse responses to a productivity shock and comparing model-generated business cycle moments to those of the data. Section 4 studies the consequences of different degrees of international financial market integration under flexible exchange rates. Section 5 focuses on the consequences of terms of trade shocks. Section 6 analyzes the combined effects of different exchange rate and financial market integration scenarios. Section 7 summarizes sensitivity analysis exercises. Section 8 concludes. An Appendix presents technical details.

[5]See Bilbiie et al. (2012) and Cacciatore and Ghironi (2012) for references to literature that supports the relevance for economic dynamics of the mechanisms we highlight in countries other than Korea.

1.2 The Model

The model we employ is an application of the framework developed by Cacciatore and Ghironi (2012). The difference is that Korea is a prototype small open economy. As is now standard practice in the literature, we model the small open economy as a limiting case of a two-country dynamic general equilibrium model in which one country (the small open economy, also referred to as Home) is of measure zero relative to the rest of the world (Foreign henceforth). As a consequence, the policy decisions and macroeconomic dynamics of the small open economy have no impact on Foreign. Next we describe in detail the behavior of households and firms in the small open economy.[6]

1.2.1 Household Preferences

The small open economy is populated by a unit mass of atomistic households, where each household is viewed as an extended family with a continuum of members along the unit interval. In equilibrium, some family members are employed, while others are unemployed. As is common in the literature, we assume that family members insure each other perfectly against variations in labor income due to changes in employment status, so that there is no ex post heterogeneity across individuals in the household (see Andolfatto, 1996, and Merz, 1995).[7]

The representative household in the Home economy maximizes the expected intertemporal utility function $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t [u(C_t) - l_t \nu(h_t)]$, where $\beta \in (0,1)$ is the discount factor, C_t is a consumption basket that aggregates domestic and imported goods as described below, l_t is the number of employed workers, and h_t denotes hours worked by each employed worker.

[6] Cacciatore et al. (2015) use the model presented here to study the consequences of structural reforms and trade integration for New Zealand.

[7] Nakajima (2012) and Obiols-Homs (2012) explore the consequences of market incompleteness in the search-and-matching models of labor market frictions. We retain the standard assumption of market completeness to preserve the representative household framework of benchmark New Keynesian modeling and focus most transparently on the consequences of extending the framework to include producer dynamics and search-and-matching frictions.

Period utility from consumption, $u(.)$, and disutility of effort, $\nu(.)$, satisfy the standard assumptions.

The consumption basket C_t aggregates Home and Foreign sectoral consumption outputs, $C_t(n)$, in Dixit and Stiglitz (1977) form:

$$C_t = \left[\int_0^1 C_t(n)^{\frac{\phi-1}{\phi}} dn \right]^{\frac{\phi}{\phi-1}} \tag{1.1}$$

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

$$P_t = \left[\int_0^1 P_t(n)^{1-\phi} dn \right]^{\frac{1}{1-\phi}}, \tag{1.2}$$

where $P_t(n)$ is the price index for sector n, expressed in Home currency.

1.2.2 Production

There are two vertically integrated production sectors. In the upstream sector, perfectly competitive firms use labor to produce a non-tradable intermediate input. In the downstream sector, each consumption-producing sector n is populated by a representative monopolistically competitive multi-product firm that purchases the intermediate input and produces differentiated varieties of its sectoral output. In equilibrium, some of these varieties are exported while the others are sold only domestically.[8]

Intermediate Goods Production

There is a unit mass of intermediate producers. Each of them employs a continuum of workers. Labor markets are characterized by search and matching frictions as in the Diamond-

[8] This production structure greatly simplifies the introduction of labor market frictions and sticky prices in the model.

Mortensen-Pissarides (DMP) framework.[9] To hire new workers, firms need to post vacancies, incurring a cost of κ units of consumption per vacancy posted. The probability of finding a worker depends on a constant-return-to-scale matching technology, which converts aggregate unemployed workers, U_t, and aggregate vacancies, V_t, into aggregate matches, $M_t = \chi U_t^{1-\varepsilon} V_t^{\varepsilon}$ where $\chi > 0$ and $0 < \varepsilon < 1$. Each firm meets unemployed workers at a rate $q_t \equiv M_t/V_t$. As in Krause and Lubik (2007) and other studies, we assume that newly created matches become productive only in the next period. For an individual firm, the inflow of new hires in period $t+1$ is therefore $q_t v_t$, where v_t is the number of vacancies posted by the firm in period t.[10]

Firms and workers can separate exogenously with probability $\lambda \in (0,1)$. Separation occurs only between firms and workers who were active in production in the previous period. As a result, the law of motion of employment, l_t (those who are working at time t), in a given firm is given by $l_t = (1-\lambda)l_{t-1} + q_{t-1}v_{t-1}$.

The representative intermediate firm produces output $y_t^I = Z_t l_t h_t$, where Z_t is exogenous aggregate productivity.[11] We normalize steady-state productivity, Z, to 1 and assume that Z_t follows an AR(1) process in logarithms, $logZ_t = \phi_Z logZ_{t-1} + \varepsilon_t$, where ε_t represents i.i.d. draws from a normal distribution with zero mean and standard deviation σ_ε.

As in Arseneau and Chugh (2008), firms face a quadratic cost of adjusting the hourly nominal wage rate, w_t. For each worker, the real cost of changing the nominal wage between period $t-1$ and t is $\vartheta \pi_{w,t}^2/2$, where $\vartheta \leq 0$ is in units of consumption, and $\pi_{w,t} \equiv (w_t/w_{t-1}) - 1$ is the net wage inflation rate. If $\vartheta = 0$, there is no cost of wage adjustment.

Intermediate goods producers sell their output to final producers at a real price φ_t, expressed in units of consumption. Intermediate producers choose the number of vacancies, v_t, and employment, l_t, to maximize the expected present discounted value of their profit

[9] See Diamond (1982a, b) and Mortensen and Pissarides (1994).

[10] In equilibrium, $v_t = V_t$

[11] Note that the assumption of a unit mass of intermediate producers ensures that y_t^I is also the total output of the intermediate sector.

stream:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{u_{C,t}}{u_{C,0}} \left(\varphi_t Z_t l_t h_t - \frac{w_t}{P_t} l_t h_t - \frac{\vartheta}{2} \pi_{w,t}^2 l_t - \kappa v_t \right), \tag{1.3}$$

subject to the dynamics of employment, where $u_{C,t}$ denotes the marginal utility of consumption in period t. Profit in any period consists of output sales less labor costs inclusive of wage adjustment costs plus vacancy costs. Future profits are discounted at the stochastic discount factor of domestic households, who are assumed to own Home firms.

Combining the first-order conditions for vacancies and employment yields the following job creation equation:

$$\frac{\kappa}{q_t} = \mathbb{E}_t \left\{ \beta_{t,t+1} \left[(1-\lambda) \frac{\kappa}{q_{t+1}} + \varphi_{t+1} Z_{t+1} h_{t+1} - \frac{w_{t+1}}{P_{t+1}} h_{t+1} - \frac{\vartheta}{2} \pi_{w,t+1}^2 \right] \right\}, \tag{1.4}$$

where $\beta_{t,t+1} \equiv \beta u_{C,t+1}/u_{C,t}$ is the one-period-ahead stochastic discount factor. The job creation condition states that, at the optimum, 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 time-t match. Profits from the match take into account the future marginal revenue product from the match and its wage cost, including future nominal wage adjustment costs.

Wage and Hours The nominal wage is the solution to an individual Nash bargaining process, and the wage payment divides the match surplus between workers and firms. Due to the presence of nominal rigidities, we depart from the standard Nash bargaining convention by assuming that bargaining occurs over the nominal wage payment rather than the real wage payment.[12] With zero costs of nominal wage adjustment ($\vartheta = 0$), the real wage that emerges would be identical to the one obtained from bargaining directly over the real wage. This is no longer the case in the presence of adjustment costs.

[12] The same assumption is made by Arseneau and Chugh (2008), Gertler et al. (2008), and Thomas (2008).

The details of wage determination are set out in the Appendix. There we show that the equilibrium sharing rule can be written as $\eta_{w,t} H_t = (1 - \eta_{w,t}) J_t$, where $\eta_{w,t}$ is the bargaining share of firms, H_t is worker surplus, and J_t is firm surplus (see Appendix A for the expressions). As in Gertler and Trigari (2009), the equilibrium bargaining share is time-varying due to the presence of wage adjustment costs. Without these costs, we would have a time-invariant bargaining share $\eta_{w,t} = \eta$, where η is the weight of firm surplus in the Nash bargaining problem. (The steady-state value of $\eta_{w,t}$, η_w, differs from η if wages are sticky and there is non-zero steady-state wage inflation.)

The bargained wage satisfies:

$$\frac{w_t}{P_t} h_t = \eta_{w,t} \left(\frac{\nu(h_t)}{u_{C,t}} + b \right) + (1 - \eta_{w,t}) \left(\varphi_t Z_t h_t - \frac{\vartheta}{2} \pi_{w,t}^2 \right) \\ + \mathbb{E}_t \left\{ \beta_{t,t+1} J_{t+1} \left[(1 - \lambda)(1 - \eta_{w,t}) - (1 - \lambda - \iota_t)(1 - \eta_{w,t+1}) \frac{\eta_{w,t}}{\eta_{w,t+1}} \right] \right\}, \tag{1.5}$$

where $\nu(h_t)/u_{C,t} + b$ is the worker's outside option (the utility value of leisure plus an unemployment benefit b), and ι_t is the probability of becoming employed at time t, defined by $\iota_t \equiv M_t/U_t$. With flexible wages, the third term on the right-hand side of this equation reduces to $(1 - \eta)\iota_t \mathbb{E}_t(\beta_{t,t+1} J_{t+1})$, or, in equilibrium, $\kappa(1 - \eta)\iota_t/q_t$. In this case, the real wage bill per worker is a linear combination – determined by the constant bargaining parameter η – of the worker's outside option and the marginal revenue product generated by the worker (net of wage adjustment costs) plus the expected discounted continuation value of the match to the firm (adjusted for the probability of worker's employment). The stronger the bargaining power of firms (the higher η), the smaller the portion of the net marginal revenue product and continuation value to the firm appropriated by workers as wage payments, while the outside option becomes more relevant. When wages are sticky, bargaining shares are endogenous, and so is the distribution of surplus between workers and firms. Moreover, the current wage bill reflects also expected changes in bargaining shares.

As is common practice in the literature, we assume that hours per worker are determined by firms and workers in a privately efficient way, i.e., so as to maximize the joint surplus of their employment relation.[13] The joint surplus is the sum of the firm's surplus and the worker's surplus, i.e., $J_t + H_t$, as defined in A.1 and A.4. The maximization yields a standard intratemporal optimality condition for hours worked that equates the marginal revenue product of hours per worker to the marginal rate of substitution between consumption and leisure: $\nu_{h,t}/u_{C,t} = \varphi_t Z_t$, where $\nu_{h,t}$ is the marginal disutility of effort.

Final Goods Production

A contribution of Cacciatore and Ghironi (2012) is to show how price stickiness can be introduced in a tractable way in the Ghironi and Melitz (2005) model of trade and macroeconomic dynamics, while preserving the aggregation properties of Melitz's (2003) heterogeneous firms model. This is done by introducing price stickiness at the level of sectoral product bundles for domestic sale and export that aggregate individual product varieties produced by plants with heterogeneous productivity. In this sub-section we describe final goods creation and production, the export decision, and price setting.

In each consumption sector, n, the representative, monopolistically competitive firm n produces the sectoral output bundle, $Y_t(n)$, sold to consumers in Home and Foreign. Producer n is a multi-product firm that produces a set of differentiated product varieties, indexed by ω and defined over a continuum Ω:

$$Y_t(n) = \left(\int_{\omega \in \Omega}^{\infty} y_t(\omega, n)^{\frac{\theta-1}{\theta}} d\omega \right)^{\frac{\theta}{\theta-1}}, \tag{1.6}$$

where $\theta > 1$ is the symmetric elasticity of substitution across product varieties.[14]

Each product variety $y(\omega, n)$ is created and developed by the representative final producer n. Since consumption-producing sectors are symmetric in the economy, henceforth we omit

[13] See, among others, Thomas (2008) and Trigari (2009).

[14] Sectors (and sector-representative firms) are of measure zero relative to the aggregate size of the economy. Notice that $Y_t(n)$ can also be interpreted as a bundle of product features characterizing product n.

the index n to simplify notation. The cost of the product bundle Y_t, denoted by P_t^y, is:

$$P_t^y = \left(\int_{\omega \in \Omega}^{\infty} p_t^y(\omega)^{1-\theta} d\omega \right)^{\frac{1}{1-\theta}}, \tag{1.7}$$

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

The number of products created and commercialized by each final producer is endogenously determined. At each point in time, only a subset of varieties $\Omega_t \subset \Omega$ is actually available to consumers. To create a new product, the final producer needs to undertake a sunk investment, $f_{e,t}$, in units of intermediate input. Product creation requires each final producer to create a new plant that will produce the new variety.[15] Plants employ different technologies indexed by relative productivity z. To save notation, we identify a variety with the corresponding plant productivity z, omitting ω. Upon product creation, the productivity level of the new plant z is drawn from a common distribution $G(z)$ defined over $[z_{min}, \infty)$. This relative productivity level remains fixed thereafter. Each plant uses intermediate input to produce its differentiated product variety, with real marginal cost:

$$\varphi_{z,t} \equiv \frac{p_t^y(z)}{P_t} = \frac{\varphi_t}{z}. \tag{1.8}$$

At time t, each final Home producer 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:

$$N_{d,t+1} = (1-\delta)(N_{d,t} + N_{e,t}). \tag{1.9}$$

When serving the Foreign market, each final producer faces per-unit iceberg trade costs,

[15] Alternatively, we could model product creation by assuming that monopolistically competitive firms produce product varieties (or features) that are sold to final producers, in this case interpreted as retailers. The two models are equivalent. Details are available upon request.

$\tau_t > 1$, and fixed export costs, $f_{x,t}$.[16] Fixed export costs are denominated in units of the intermediate input and are paid for each exported product. Thus, the total fixed cost is $F_{x,t} = N_{x,t} f_{x,t}$, where $N_{x,t}$ denotes the number of product varieties (or features) exported to Foreign. Without fixed export costs, each producer would find it optimal to sell all its product varieties in Home and Foreign. Fixed export costs imply that only varieties produced by plants with sufficiently high productivity (above a cut-off level $z_{x,t}$, determined below) are exported.[17]

To proceed further, we define two special average productivity levels (weighted by relative output shares): (i) an average $\tilde{z}_d$ for all producing plants, and (ii) an average $\tilde{z}_{x,t}$ for all plants that export:

$$\tilde{z}_d = \left[\int_{z_{min}}^{\infty} z^{\theta-1} dG(z)\right]^{\frac{1}{\theta-1}}, \quad \tilde{z}_{x,t} = \left[\frac{1}{1-G(z_{x,t})}\int_{z_{x,t}}^{\infty} z^{\theta-1} dG(z)\right]^{\frac{1}{\theta-1}}. \tag{1.10}$$

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

$$N_{x,t} \equiv [1 - G(z_{x,t})]\, N_{d,t} = \left(\frac{z_{min}}{\tilde{z}_{x,t}}\right)^{k_p} \alpha^{\frac{k_p}{\theta-1}} N_{d,t}. \tag{1.11}$$

The output bundles for domestic and export sale, and associated unit costs, are defined

[16]Empirical micro-level studies have documented the relevance of plant-level fixed export costs—see, for instance, Bernard and Jensen (2004). Although a substantial portion of fixed export costs are probably sunk upon market entry, we follow Ghironi and Melitz (2005) and do not model the sunk nature of these costs explicitly. We conjecture that introducing these costs would further enhance the persistence properties of the model by inducing hysteresis in the extensive margin of export decisions. Alessandria and Choi (2007) develop a model with heterogeneous firms, sunk export costs, and Walrasian labor markets (but no entry in domestic markets). Comin et al. (2009) show that a model with sunk export entry costs and endogenous technology adoption and diffusion makes it possible to replicate lower-frequency fluctuations referred to as medium-term business cycles (see also Comin and Gertler, 2006). Their extended framework thus provides a microfoundation for results in Aguiar and Gopinath (2007).

[17]Notice that $z_{x,t}$ is the lowest level of plant productivity such that the profit from exporting is positive.

as follows:

$$Y_{d,t} = \left[\int_{z_{min}}^{\infty} y_{d,t}(z)^{\frac{\theta-1}{\theta}} dG(z)\right]^{\frac{\theta}{\theta-1}}, \quad Y_{x,t} = \left[\int_{z_{x,t}}^{\infty} y_{x,t}(z)^{\frac{\theta-1}{\theta}} dG(z)\right]^{\frac{\theta}{\theta-1}}, \tag{1.12}$$

$$P^y_{d,t} = \left[\int_{z_{min}}^{\infty} p^y_t(z)^{1-\theta} dG(z)\right]^{\frac{1}{1-\theta}}, \quad P^y_{x,t} = \left[\int_{z_{x,t}}^{\infty} p^y_t(z)^{1-\theta} dG(z)\right]^{\frac{1}{1-\theta}}. \tag{1.13}$$

Using equations (1.8) and (1.13), the real costs of producing the bundles $Y_{d,t}$ and $Y_{x,t}$ can then be expressed as:

$$\frac{P^y_{d,t}}{P_t} = N_{d,t}^{\frac{1}{1-\theta}} \frac{\varphi_t}{\tilde{z}_d}, \quad \frac{P^y_{x,t}}{P_t} = N_{x,t}^{\frac{1}{1-\theta}} \frac{\varphi_t}{\tilde{z}_{x,t}}. \tag{1.14}$$

The present discounted cost facing the final producer in the determination of product creation and the export bundle is thus:

$$\mathbb{E}_t \left\{ \sum_{s=t}^{\infty} \beta_{t,s} \left[\frac{P^y_{d,s}}{P_s} Y_{d,s} + \tau_s \frac{P^y_{x,s}}{P_s} Y_{x,s} + \left(\frac{N_{s+1}}{1-\delta} - N_s \right) f_{e,s}\varphi_s + N_{x,s} f_{x,s} \varphi_s \right] \right\}. \tag{1.15}$$

The producer chooses $N_{d,t+1}$ and the productivity cutoff $z_{x,t}$ to minimize this expression subject to (1.11), (1.14), and $\tilde{z}_{x,t} = \alpha^{\frac{1}{\theta-1}} z_{x,t}$.[18]

The first-order condition with respect to $z_{s,t}$ yields:

$$\frac{P^y_{x,t}}{P_t} Y_{x,t} \tau_t = \frac{(\theta-1)k_p}{[k_p - (\theta-1)]} f_{x,t} N_{x,t} \varphi_t. \tag{1.16}$$

The above condition states that, at the optimum, 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.

[18] Equation (1.11) implies that, by choosing $z_{x,t}$, the producer also determines $N_{x,t}$.

The first-order condition with respect to $N_{d,t+1}$ determines product creation:

$$\varphi_t f_{e,t} = (1-\delta)\,\mathbb{E}_t\Bigg\{\beta_{t,t+1}\Bigg[\varphi_{t+1}\left(f_{e,t+1} - \frac{N_{x,t+1}}{N_{d,t+1}} f_{x,t+1}\right) + \frac{1}{\theta-1}\left(\frac{P^y_{d,t+1} Y_{d,t+1}}{P_{t+1} N_{d,t+1}} + \frac{P^y_{x,t+1} Y_{x,t+1}}{P_{t+1} N_{x,t+1}} \frac{N_{x,t+1}}{N_{d,t+1}} \tau_{t+1}\right)\Bigg]\Bigg\}. \tag{1.17}$$

In equilibrium, the cost of producing an additional variety, $\varphi_t f_{e,t}$, must equal its expected benefit (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).

We are now left with the determination of domestic and export prices. We denote by $P_{d,t}$ the price (in Home currency) of the product bundle $Y_{d,t}$ and let $P_{x,t}$ be the price (in Foreign currency) of the exported bundle $Y_{x,t}$. Each final producer faces the following domestic and foreign demand for its product bundles:

$$Y_{d,t} = \left(\frac{P_{d,t}}{P_t}\right)^{-\phi} Y_t^C, \quad Y_{x,t} = \left(\frac{P_{x,t}}{P_t^*}\right)^{-\phi} Y_t^{C*} \tag{1.18}$$

where Y_t^C and Y_t^{C*} are aggregate demands of the consumption basket in Home and Foreign. Aggregate demand in each country includes sources other than household consumption, but it takes the same form as the consumption basket, with the same elasticity of substitution $\phi > 1$ across sectoral bundles. This ensures that the consumption price index for the consumption aggregator is also the price index for the aggregate demand of the basket.

Prices in the final sector are sticky. We follow Rotemberg (1982) and assume that final producers must pay quadratic price adjustment costs when changing domestic and export bundle prices, which we assume are set in accordance with producer currency pricing (PCP): Each final producer sets $P_{d,t}$ and the domestic currency price of the export bundle, $P^d_{x,t}$, letting the price in the foreign market be $P_{x,t} = \tau_t P^d_{x,t}/S_t$, where S_t is the nominal exchange rate (units of Home currency per unit of Foreign). The nominal costs of adjusting domestic and export price are, respectively, $\Gamma_{d,t} \equiv \nu\pi^2_{d,t} P_{d,t} Y_{d,t}/2$, and $\Gamma^d_{x,t} \equiv \nu(\pi^d_{x,t})^2 P^d_{x,t} Y_{x,t}/2$, where

$\nu \geq 0$ determines the size of the adjustment costs (domestic and export prices are flexible if $\nu = 0$), $\phi_{d,t} \equiv (P_{d,t}/P_{d,t-1}) - 1$ and $\phi^d_{x,t} \equiv (P^d_{x,t}/P^d_{x,t-1}) - 1$.

In the absence of fixed export costs, the producer would set a single price $P_{d,t}$ and the law of one price (adjusted for the presence of trade costs) would determine the export price as $P_{x,t} = \tau_t P_{x,t} = \tau_t P_{d,t}/S_t$. With fixed export costs, however, the composition of domestic and export bundles is different, and the marginal costs of producing these bundles are not equal. Therefore, final producers choose two different prices for the Home and Foreign markets even under PCP.

We relegate the details of optimal price setting to Appendix B. We show there that the (real) price of Home output for domestic sales is given by:

$$\frac{P_{d,t}}{P_t} = \frac{\phi}{(\phi - 1)\Xi_{d,t}} \left(\frac{P^y_{d,t}}{P_t} \right), \tag{1.19}$$

where:

$$\Xi_{d,t} \equiv 1 - \frac{\nu}{2}\pi^2_{d,t} + \frac{\nu}{\theta - 1} \left\{ \pi_{d,t}(1 + \pi_{d,t}) - \mathbb{E}_t \left[\beta_{t,t+1}\pi_{d,t+1} \frac{(1 + \pi_{d,t+1})^2}{1 + \pi^C_{t+1}} \frac{Y_{d,t+1}}{Y_{d,t}} \right] \right\} \tag{1.20}$$

and $\pi_{C,t} \equiv (P_t/P_{t-1}) - 1$. As expected, price stickiness introduces endogenous markup variations: The cost of adjusting prices gives firms an incentive to change their markups over time in order to smooth price changes across periods. When prices are flexible ($\nu = 0$), the markup is constant and equal to $\phi/(\phi - 1)$.

The (real) price of Home output for export sales is equal to:

$$\frac{P_{x,t}}{P^*_t} = \frac{\phi}{(\phi - 1)\Xi^d_{x,t}} \left(\frac{\tau_t P^y_{x,t}}{Q_t P_t} \right), \tag{1.21}$$

where $Q_t \equiv S_t P^*_t / P_t$ is the consumption-based real exchange rate (units of Home consumption per units of Foreign), and:

$$\Xi_{x,t}^{d} \equiv 1 - \frac{\nu}{2}(\pi_{x,t}^{d})^{2} + \frac{\nu}{(\phi - 1)} \left\{ (1+\pi_{x,t}^{d})\pi_{x,t}^{d} - \mathbb{E}_{t}\left[\beta_{t,t+1}\pi_{x,t+1}^{d} \frac{\left(1+\pi_{x,t+1}^{d}\right)^{2}}{1+\pi_{t+1}^{C}} \frac{Y_{x,t+1}}{Y_{x,t}} \right] \right\}. \tag{1.22}$$

Absent fixed export costs $z_{x,t} = z_{min}$ and $\Xi_{x,t}^{d} = \Xi_{d,t}$. Plant heterogeneity and fixed export costs, instead, imply that the law of one price does not hold for the exported bundles.

For future purposes, define the average real 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 real price of an exported variety, $\tilde{\rho}_{x,t} \equiv N_{x,t}^{\frac{1}{\theta-1}}(P_{x,t}/P_{t}^{*})$. Combining equations (1.14), (1.19), and (1.21), we have:

$$\tilde{\rho}_{d,t} = \mu_{d,t}\frac{\varphi_{t}}{\tilde{z}_{d}}, \quad \tilde{\rho}_{x,t} = \mu_{x,t}\frac{\tau_{t}}{Q_{t}}\frac{\varphi_{t}}{\tilde{z}_{x,t}}, \tag{1.23}$$

where $\mu_{d,t} \equiv \phi/[(\phi-1)\Xi_{d,t}]$ and $\mu_{x,t} \equiv \phi/[(\phi-1)\Xi_{x,t}^{d}]$. Finally, letting $\tilde{y}_{d,t}$ and $\tilde{y}_{x,t}$ denote the average output of, respectively, a domestic and exported variety, we have

$$\tilde{y}_{d,t} \equiv \tilde{\rho}_{d,t}^{-\phi} N_{d,t}^{\frac{\theta-\phi}{1-\theta}} Y_{t}^{C}, \quad \tilde{y}_{x,t} \equiv \tilde{\rho}_{x,t}^{-\phi} N_{x,t}^{\frac{\theta-\phi}{1-\theta}} Y_{t}^{C*}. \tag{1.24}$$

1.2.3 Household Budget Constraint and Intertemporal Decisions

In our benchmark scenario, we assume that international assets markets are incomplete, as the representative household can invest only in nominal riskless bonds denominated in Home and Foreign currency. Home-currency bonds are traded only domestically. Let A_{t+1} and $A_{*,t+1}$ denote, respectively, nominal holdings of Home and Foreign bonds at Home.[19] To ensure a determinate steady-state equilibrium and stationary responses to temporary shocks in the model, we follow Turnovsky (1985), and, more recently, Benigno (2009), and assume a

[19]Foreign nominal holdings of Foreign bonds are denoted by $A_{*,t+1}^{*}$

quadratic cost of adjusting Foreign bond holding, $\psi \left(A_{*,t+1}/P_t^*\right)^2/2$.[20] These costs are paid to financial intermediaries whose only function is to collect these transaction fees and to rebate the revenue to households in lump-sum fashion in equilibrium.

The Home household's period budget constraint is:

$$\begin{aligned}A_{t+1}+S_tA_{*,t+1}+\frac{\psi}{2}S_tP_t^*\left(\frac{A_{*,t+1}}{P_t^*}\right)^2+P_tC_t\\ =(1+i_t)A_t+(1+i_t^*)A_{*,t}S_t+w_tL_t+P_tb(1-l_t)+T_t^G+T_t^A+T_t^I+T_t^F,\end{aligned} \quad (1.25)$$

where i_t and i_t^* are, respectively, the nominal interest rates on Home and Foreign bond holdings between $t-1$ and t, known with certainty as of $t-1$. Moreover, T_t^G is a lump-sum transfer (or tax) from the government, T_t^A is a lump-sum rebate of the cost of adjusting bond holdings from the intermediaries to which it is paid, and T_t^I and T_t^F are lump-sum rebates of profits from intermediate and final goods producers.[21]

Let $a_{t+1} \equiv A_{t+1}/P_t$ denote real holdings of Home bonds (in units of Home consumption) and let $a_{*,t+1} \equiv A_{*,t+1}/P_t^*$ denote real holdings of Foreign bonds (in units of Foreign consumption). The Euler equations for bond holdings are:

$$1+\psi a_{t+1}=(1+i_{t+1})\,\mathbb{E}_t\left(\frac{\beta_{t,t+1}}{1+\pi_{C,t+1}}\right), \quad (1.26)$$

$$1+\psi a_{*,t+1}=(1+i_{t+1}^*)\,\mathbb{E}_t\left[\beta_{t,t+1}\frac{Q_{t+1}}{Q_t(1+\pi_{C,t+1}^*)}\right], \quad (1.27)$$

where $\pi_{C,t}^* \equiv (P_t^*/P_{t-1}^*)-1$.

[20] Given that idiosyncratic risk is pooled among domestic households, and foreign households only trade foreign currency-denominated bonds, domestic-currency-denominated bonds are in zero net supply. That is, in reality only foreign-currency-denominated bonds are traded in equilibrium. As a result, defining the intermediation costs over the foreign currency bond only is sufficient to pin down the overall steady-state net foreign asset position.

[21] In equilibrium, $T_t^G=-P_tb(1-l_t)$, $T_t^A=S_tP_t(\psi/2)(A_{*,t+1}/P_t^*)^2$, $T_t^I=P_t(\varphi_tZ_tl_t-(w_t/P_t)l_t-(\vartheta/2)\pi_{w,t}^2l_t-\lambda V_t)$, $T_t^F=\left(\frac{\mu_{d,t}-1}{\mu_{d,t}}-\frac{\mu}{2}(\pi_{d,t})^2\right)\tilde{\rho}_{d,t}N_{d,t}\tilde{y}_{d,t}+Q_t\left(\frac{\mu_{x,t}-1}{\mu_{x,t}}-\frac{\mu}{2}(\pi_{x,t})^2\right)\tilde{\rho}_{x,t}N_{x,t}\tilde{y}_{x,t}-\varphi_t(N_{x,t}f_{x,t}+N_{e,t}f_{e,t})$.

We present below the law of motion for net foreign assets that follows from imposing equilibrium conditions in the household's budget constraint. Other details on the equilibrium can be found in Appendix C.

1.2.4 Net Foreign Assets and the Trade Balance

Bonds are in zero net supply, which implies that the equilibrium for the domestic bonds, being nontraded, is $a_t = 0$ in all periods. Home net foreign assets are determined by:

$$Q_t a_{*,t+1} = q_t \frac{1+i_t^*}{1+\pi_{C,t}^*} a_{*,t} + Q_t N_{x,t} \tilde{\rho}_{x,t} \tilde{y}_{x,t} - N_{x,t}^* \tilde{\rho}_{x,t}^* \tilde{y}_{x,t}^*. \tag{1.28}$$

Defining $1 + r_t^* \equiv (1+i_t^*)/(1+\pi_{C,t}^*)$, the change in net foreign assets between t and $t+1$ is determined by the current account:

$$Q_t(a_{*,t+1} - a_{*,t}) = CA_t \equiv Q_t r_t^* a_{*,t} + TB_t, \tag{1.29}$$

where TB_t is the trade balance:

$$TB_t \equiv Q_t N_{x,t} \tilde{\rho}_{x,t} \tilde{y}_{x,t} - N_{x,t}^* \tilde{\rho}_{x,t}^* \tilde{y}_{x,t}^*. \tag{1.30}$$

1.2.5 Monetary Policy and Data-Consistent Variables

Before describing monetary policy in the small open economy, we must address an issue that concerns the data that are actually available to the central bank, i.e. we need to determine the empirically-relevant variables that should enter the theoretical representation of monetary policy (as well as be used for comparison of model properties to the data in our exercises below).

As pointed out by Ghironi and Melitz (2005), in the presence of endogenous product creation and "love for variety" in the production of final consumption-varieties, variables measured in units of consumption do not have a direct counterpart in the data, i.e., they are not data-consistent. As the economy experiences entry of Home and Foreign firms, the welfare-consistent aggregate price index P_t can fluctuate even if product prices remain constant. In the data, however, aggregate price indexes do not take these variety effects into account.[22] To resolve this issue, we follow Ghironi and Melitz (2005), and we construct an average price index $\tilde{P}_t \equiv (N_{d,t} + N^*_{x,t})^{1/(\theta-1)} P_t$. The average price index $\tilde{P}_t$ is closer to the actual CPI data constructed by statistical agencies than is the welfare-based index P_t, and, therefore, it is the data-consistent CPI implied by the model. In turn, given any variable X_t in units of consumption, its data-consistent counterpart is $X_{R,t} \equiv X_t P_t / \tilde{P}_t$. The data-consistent CPI inflation rate is $\tilde{\pi}^C_t \equiv (\tilde{P}_t/\tilde{P}_{t-1}) - 1$.

We now specify monetary policy for the small open economy. As shown by Kim (2013), a standard interest rate rule in the spirit of Taylor (1993) describes Korean monetary policy quite well. We begin by assuming that the central bank of the small open economy sets the contemporaneous policy interest rate according to a rule that can be taken as an operational description of a flexible inflation targeting policy:

$$1 + i_{t+1} = (1 + i_t)^{\varrho_i} \left[(1 + i)(\pi_{C_R,t})^{\varrho_\pi} \left(\hat{Y}^g_{R,t} \right)^{\varrho_{Y^g}} \right]^{1-\varrho_i}, \tag{1.31}$$

where $\hat{Y}^g_{R,t} \equiv Y_{R,t}/Y^{flex}_{R,t}$ denotes the output gap – deviations of real output, $Y_{R,t}$, from real output under flexible prices and wages, $Y^{flex}_{R,t}$ – and $\pi_{C_R,t}$ denotes data-consistent CPI inflation.[23]

Table 1.1 summarizes the key equilibrium conditions of the model-small open economy. The table contains 13 equations that determine 13 endogenous variables of interest: C_t, $\tilde{\rho}_{d,t}$, l_t, h_t, V_t, $N_{d,t}$, w_t/P_t, $\tilde{z}_{x,t}$, $\pi_{w,t}$, $\pi_{C,t}$, i_{t+1}, $a_{*,t+1}$, and Q_t. (Other variables that appear in the table are determined as described above.)

[22] There is much empirical evidence that gains from variety are mostly unmeasured in CPI data, as documented most recently by Broda and Weinstein (2010).

[23] The sensitivity analysis of Section 1.7 summarizes the implications of replacing the policy rule (1.31)—our representation of inflation targeting under a flexible exchange rate—with a rule that allows for a response of the policy rate to exchange rate dynamics, capturing features of a managed exchange rate regime that arguably describes important features of Bank of Korea policymaking since the Asian crisis of 1997-98.

1.2.6 Foreign Aggregates

As summarized in Table 1.1, six Foreign variables directly affect the macroeconomic dynamics in the small open economy: Y_t^{C*}, i_t^*, $\pi_{C,t}^*$, $N_{x,t}^*$, $\tilde{y}_{x,t}^*$, $\tilde{\rho}_{x,t}^*$. Aggregate demand, Y_t^{C*}, the nominal interest rate, i_t^*, and inflation, $\pi_{C,t}^*$, are determined by treating the rest of the world (Foreign) as a closed economy that features the same production structure, technology and frictions that characterize the small open economy.[24] Here we focus on the determination of the number of Foreign exporters, $N_{x,t}^*$, the average output of Foreign exported varieties, $\tilde{y}_{x,t}^*$, and their average relative price, $\tilde{\rho}_{x,t}^*$. Since the small open economy is infinitesimally small relative to the rest of the world, these variables affect macroeconomic dynamics in the small open economy without having any effect on Y_t^{C*}, i_t^*, and $\pi_{C,t}^*$.

We assume that Foreign producers solve a profit maximization problem that is equivalent to that faced by Home producers, including the assumption that export prices are denominated in producer currency. The number of Foreign exporters is a time-varying fraction of the number of Foreign producers that serve their domestic market:

$$N_{x,t}^* \equiv \left[1 - G\left(z_{x,t}^*\right)\right] N_{d,t}^* = \left(\frac{z_{min}}{\tilde{z}_{x,t}^*}\right)^{k_p} \alpha^{\frac{k_p}{\theta-1}} N_{d,t}^*, \tag{1.32}$$

where $\tilde{z}_{x,t}^*$ is determined by imposing a zero export-profit condition that is the Foreign counterpart to equation (1.16):

$$(\tilde{\rho}_{x,t}^*)^{-\theta} (N_{x,t}^*)^{\frac{\theta-\phi}{1-\theta}} Y_t^C = \frac{(\theta-1)}{k_p - (\theta-1)} \frac{\tilde{z}_{x,t}^*}{\tau_t^*} f_{x,t}^*. \tag{1.33}$$

In the above expression, τ_t^* and $f_{x,t}^*$ denote, respectively, iceberg trade costs and fixed export costs for Foreign firms (both costs are exogenous). The average output of a variety exported

[24] We do not report the details of the foreign economy. They are discussed in depth by Cacciatore and Ghironi (2012).

by Foreign to Home is:

$$\tilde{y}^*_{x,t} = \left(\tilde{\rho}^*_{x,t}\right)^{-\phi} \left(N^*_{x,t}\right)^{\frac{\theta-\phi}{1-\phi}} Y^C_t, \tag{1.34}$$

where the average relative price $\tilde{\rho}^*_{x,t}$ is given by:

$$\tilde{\rho}^*_{x,t} = Q_t \mu^*_{x,t} \tau^*_t \frac{\varphi^*_t}{\tilde{z}^*_{x,t}}. \tag{1.35}$$

In the above expression, φ^*_t denotes the marginal costs of production of an individual variety in the rest of the world; the term $\mu^*_{x,t}$ denotes the export markup:

$$\mu^*_{x,t} \equiv \xi_t \frac{\phi}{(\phi-1)\Xi^{*d}_{x,t}}, \tag{1.36}$$

where:

$$\Xi^{*d}_{x,t} \equiv 1 - \frac{\nu}{2}\left(\pi^{*d}_{x,t}\right)^2 + \nu(1+\pi^{*d}_{x,t})\pi^{*d}_{x,t} - \frac{\nu}{(\phi-1)}\mathbb{E}_t\left[\beta^*_{t,t+1}\left(1+\pi^{*d}_{x,t+1}\right)\pi^{*d}_{x,t+1}\frac{Y^*_{x,t+1}}{Y^*_{x,t}}\right],$$

$Y^*_{x,t} = \left(N^*_{x,t}\right)^{\frac{\theta}{\theta-1}} \tilde{y}^*_{x,t}$, $1+\pi^{*d}_{x,t} \equiv \left(1+\pi^*_{C,t}\right)\left(Q_{t-1}/Q_t\right)\left(\tilde{\rho}^*_{x,t}/\tilde{\rho}^*_{x,t-1}\right)$ denotes Foreign export price inflation, and ξ_t is a Foreign export markup shock that we will use below to introduce shocks to the terms of trade.

1.3 Calibration and Model Properties

1.3.1 Calibration

We interpret periods as quarters and calibrate the rest-of-the-world parameters to match standard post-war U.S. macroeconomic data. We choose the United States to represent the "rest-of-the-world" economy for our model Korea because Korea stabilized the exchange rate of the won against the U.S. dollar for much of the post-Bretton Woods period, and we will discuss the consequences of different exchange rate policies vis-á-vis the dollar below.

With the exception of the monetary policy coefficients in the interest rate rule, and the process of exogenous shocks, we assume that the parameters that characterize the small open economy are symmetric to the rest of the world. Given that Korea is an advanced economy, we view this as a plausible assumption.[25] Table 1.2 summarizes the calibration. (In the table and below, variables without time indexes denote steady-state levels; parameters denoted with a star are specific to the rest of the world, i.e., the calibration of those parameters is not symmetric across countries.)

Rest of the World

We set the discount factor β to 0.99, implying an annual real interest rate of 4 percent. The period utility function is given by $u_t = C_t^{1-\gamma_C}/(1-\gamma_C) - l_t h_t^{1+\gamma_h}/(1+\gamma_h)$. The risk aversion coefficient γ_C is equal to 2, while the Frisch elasticity of labor supply $1/\gamma_h$ is set to 0.4, a mid-point between empirical micro and macro estimates.[26] The elasticity of substitution across product varieties, θ is set to 3.8 following Bernard et al. (2003), who find that this value fits U.S. plant and macro trade data. Following Ghironi and Melitz (2005), we set the elasticity of substitution across Home and Foreign goods, ϕ, equal to θ. Also as in Ghironi and Melitz (2005), we set $k_p = 3.4$, and normalize z_{min} to 1.

To ensure steady-state determinacy and stationarity of net foreign assets, we set the bond adjustment cost parameter ψ to 0.0025 as in Ghironi and Melitz (2005). The scale parameter for the cost of adjusting prices, ν, is equal to 80, as in Bilbiie et al. (2007). We choose ϑ, the scale parameter of nominal wage adjustment costs, so that the model reproduces the

[25] Concerning market regulation parameters, OECD indexes for barriers to producer entry and employment protection legislation for Korea and the U.S. are very similar (Online OECD Employment Database, OECD). The same is true for the unemployment benefit replacement rate (Benefits and Wages: Statistics, OECD).

[26] The value of this elasticity has been a source of controversy in the literature. Students of the business cycle tend to work with elasticities that are higher than microeconomic estimates, typically unity and above. Most microeconomic studies, however, estimate this elasticity to be much smaller, between 0.1 and 0.6. For a survey of the literature, see Card (1991). Keane and Rogerson (2012) offer a reconciliation that credibly supports the range of estimates typically adopted in macroeconomic simulations. Our results are not affected significantly if we hold hours constant at the optimally determined steady-state level.

volatility of unemployment relative to GDP observed in the data. This implies $\vartheta = 260$. To calibrate the entry costs, we follow Ebell and Haefke (2009a) and set f_e so that regulation costs imply a loss of 5.2 months of per capita output.

Unemployment benefits, b, are equal to 54 percent of the steady-state wage, the average value for the U.S. reported by OECD (2004). The steady-state, flexible-wage bargaining share of workers, $1 - \eta$, is equal to 0.4, as estimated by Flinn (2006) for the U.S. The unemployment elasticity of the matching function, $1 - \varepsilon$, is also equal to 0.4, within the range of estimates reported by Petrongolo and Pissarides (2006) and such that the standard Hosios condition for efficiency in the absence of other distortions holds in steady state. The exogenous separation rate between firms and workers, λ, is 10 percent, as reported by Shimer (2005). To pin down exogenous plant exit, δ, we target the portion of worker separation due to plant exit equal to 40 percent reported by Haltiwanger et al. (2006).

Two labor market parameters are left for calibration: the scale parameter for the cost of vacancy posting, κ, and the matching efficiency parameter, χ. We set these parameters to match the steady-state probability of finding a job and the probability of filling a vacancy. The former is 60 percent, while the latter is 70 percent, in line with Shimer (2005).

For the productivity process, we follow King and Rebelo (1999) and set persistence equal to 0.979 and standard deviation of innovations to 0.0072. In our benchmark scenario, we assume that there are no shocks to the Foreign export markup, i.e., we set $\xi_t = 1$ in all periods. Finally, the parameter values in the policy rule for the Federal Reserve's interest rate setting are those estimated by Clarida et al. (2000). The inflation and GDP gap weights are 1.65 and 0.34, respectively, while the smoothing parameter is 0.71. These are commonly used values for parameters characterizing Federal Reserve interest rate setting under normal economic conditions since the early 1980s.

Small Open Economy

As discussed above, parameters are assumed to be symmetric across countries, with the exception of the coefficients appearing in the interest rate rule (1.31), the persistence of productivity shocks, and the standard deviation of productivity innovations. Moreover, three exogenous variables are specific to the small open economy: the fixed export cost $f_{x,t}$; iceberg trade costs related to imports, τ_t^*; and iceberg trade costs related to exports, τ_t. We assume that these costs are constant. Thus, we drop the time index for simplicity. Moreover, we assume that iceberg trade costs related to imports (exports) are the sum of tariffs, $\tau^{T*}(\tau^T)$, and non-tariff barriers, $\tau^{NT*}(\tau^{NT})$, i.e., $\tau^* = 1 + \tau^{T*} + \tau^{NT*}$ $(\tau = 1 + \tau^T + \tau^{NT})$. Finally, we let both tariff and non-tariff components of trade costs be equal across costs related to exports and imports, so that $\tau = \tau^*$ and trade costs associated with exports and imports are fully symmetric.

We calibrate trade costs and parameters specific to the small open economy to match features of Korean macroeconomic data for the period 1998-2007, which corresponds to the financial integration era, prior to the global crisis of 2008-09.

We set $\tau^{T*} = 0.07$ and calibrate non-tariff barriers τ^{NT*} so that total trade (imports plus exports) over GDP is equal to 66 percent, the average value for Korea over the calibration period. We choose f_x so that the share of exporting plants is equal to 21 percent, consistent with the evidence in Aw et al. (2000).

Finally, we set the parameter values in the historical rule for Korean interest rate setting consistent with the estimates in Kim (2013). The inflation and GDP gap weights are $\varrho_\pi = 1.87$ and $\varrho_{Y^g} = 0.19$, respectively, while the smoothing parameter is $\varrho_i = 0.84$. We set the persistence of productivity ϕ_Z to 0.999, consistent with the evidence of a unit root in Korean productivity (Kim et al., 2009). We calibrate the volatility of productivity innovations to match the volatility of Korea's GDP. This requires setting $\sigma_\varepsilon = 0.02$.

1.3.2 Model Properties

We now discuss the propagation of aggregate shocks in the model, and compare business cycle dynamics to the data. We focus on the scenario of internationally incomplete asset markets and endogenous interest rate setting under flexible exchange rates described in Section 1.2 as the benchmark to explain the model's properties and compare them to data.

Figure 1.1 shows the impulse responses of our model-Korea to a one-percent innovation in domestic productivity. Unemployment (U_t) declines in the periods immediately following the shock. On impact, the higher expected return of a match induces domestic intermediate input producers to post more vacancies, which results in higher employment the following period. Firms and workers renegotiate nominal wages because of the higher surpluses generated by existing matches, and wage inflation ($\pi_{w,t}$) increases. Wage adjustment costs make the effective firm's bargaining power procyclical, i.e., $\eta_{w,t}$ rises.[27] Other things equal, the increase in $\eta_{w,t}$ dampens the response of the renegotiated equilibrium wage, amplifying the response of job creation to the shock.

Higher productivity causes entry of domestic product lines to increase and the export cutoff, $z_{s,t}$ to fall. Accordingly, a larger number of Korean goods are available to domestic and foreign consumers. Korea runs a current account deficit in response to the productivity increase (CA_t falls), as it is optimal to borrow from abroad to finance increasing producer entry. Korea's terms of trade (defined as $TOT_t \equiv Q_t \tilde{\rho}_{x,t}/\tilde{\rho}^*_{x,t}$) depreciate—the relative price of Korean exports in terms of Korean imports falls—so that Korean goods become relatively cheaper. However, the terms of trade depreciation is mild compared to standard international business cycle models. Producer entry and the countercyclical response of $z_{x,t}$ counteract the effects of higher productivity on marginal costs, and domestic export prices fall by less than in a model that abstracts from entry and heterogeneity.

Table 1.3 compares the second moments for key macroeconomic aggregates to those implied by Korean data for the period 1998:Q1-2007:Q4. Korea was hit by a combined currency-and-banking crisis in late 1997. Therefore, we take 1998 as the beginning of a floating exchange rate regime for the won. Except for the trade balance, all the data used to compute the moments in Table 1.3 were transformed by taking logarithms; all series were then HP-filtered with smoothing parameter 1,600. In the table, Model I refers to the benchmark case in which the only stochastic shocks are productivity shocks in the intermediate

[27]Intuitively, $\eta_{w,t}$ increases to ensure optimal sharing of the cost of adjusting wages between firms and workers.

goods sector. In that case, the model matches the moments for real GDP, consumption, and unemployment fairly well, but it overstates the volatility of investment (which, in our model, is given by investment in new product creation: $I_t \equiv \varphi_t f_{e,t} N_{e,t}$, and $I_{R,t} \equiv P_t I_t / \tilde{P}_t$.). The model correctly captures the fact that imports are more volatile than exports, although their absolute volatility is smaller than in the data. The model also performs reasonably well at reproducing the observed correlations of macroeconomic variables with GDP and successfully generates cross-country GDP correlation that is higher than consumption correlation. This result is a challenge for standard international business cycle models. Costly producer entry and labor market frictions dampen the resource shifting effect that often leads to counterfactually low GDP correlation across model-countries.[28] Model II augments the productivity shocks with an exogenous stochastic component in terms of trade dynamics (discussed in more detail in Section 1.7 below), a result of which is that the model matches trade-related volatilities more closely, even if it fails to replicate the countercyclicality of the trade balance observed in the data.[29]

1.4 The Macroeconomic Consequences of Financial Integration

1.4.1 Business Cycles Dynamics

We now study how international financial market integration affects business cycle fluctuations and the dynamics of producer entry and employment in our model-Korea. To address this issue, we compare the properties of the model under internationally incomplete markets

[28] This result does not depend on the fact that the Home economy is of negligible size relative to Foreign—in other words, on the fact that Foreign output is not affected by resource shifting toward Home. The result arises also in Cacciatore and Ghironi (2012) original version of the model with symmetric country size.

[29] In contrast to Cacciatore and Ghironi's (2012) model with symmetric country size, investment in product creation is not sufficient to generate a countercyclical trade balance for our calibration of the small open economy framework. The most straightforward way to match this feature of the data would be to include physical capital in the production function, and investment in capital accumulation. We refrain from doing that to restrict the departures from the benchmark New Keynesian small open economy model of Galí and Monacelli (2005) to labor market frictions and the dynamics of market entry—the model features we want to focus on. (By assuming that output is only a function of labor and exogenous productivity, the standard New Keynesian model cannot generate countercyclical trade balances.)

to two extreme cases: financial autarky or complete markets. Taking the scenario of integration in incomplete markets as the most empirically plausible representation of Korea's situation in 1998-2007, the question we address in this section is how would Korea's dynamics in the same period have differed if Korea had operated its exchange rate float under financial autarky or in an environment of full international insurance.

Under financial autarky, equation (1.28) is replaced by the condition that trade is balanced in every period, $TB_t = 0$, together with the requirement that holdings of foreign bonds are zero in every period, $a_{*,t+1} = 0$, for any t. By contrast, under complete markets, equation (1.28) is replaced by the condition $u_{C^*,t}/u_{C,t} = Q_t$, which represents the optimal risk sharing agreement between agents in the small economy and agents in the rest of the world. Risk sharing requires that the marginal benefit of an extra unit of domestic consumption obtained from Foreign via insurance be equal to the marginal compensation that Foreign agents receive for this insurance provision, given by the marginal utility of foreign consumption multiplied by the relative price of C_t in terms of C_t^* (the inverse of the domestic real exchange rate, Q_t). When a complete set of state-contingent securities is available, the risk-sharing condition holds in a decentralized equilibrium independently of other nominal and real frictions.

Figure 1.2 compares the impulse responses to a one-percent innovation in Home productivity under financial autarky (dashed lines) and complete markets (dash-dotted lines), as well as the intermediate case of incomplete markets (solid lines).

Under financial autarky, households in the small open economy cannot borrow from abroad to finance increased producer entry. As a result, a smaller number of producers enter the domestic market relative to the benchmark scenario with incomplete markets. Meanwhile, consumption responds by more, as lack of international borrowing reduces the ability to smooth its dynamics. Notice that the persistence of the productivity process plays an important role here: the more persistent the productivity shock, the stronger the response of consumption. The reason is that highly persistent shocks have a larger impact on the household's permanent income.

The dynamics of unemployment reflect two opposing forces. While smaller producer entry reduces the demand for intermediate inputs (and thus vacancy posting and employment), higher consumption of final goods has an opposite effect. As a result, unemployment dynamics are not significantly affected. Since a smaller number of producers enters the export market, the marginal cost of production for the export bundle, $P^y_{x,t}/P_t = N_{x,t}^{\frac{1}{1-\theta}} \varphi_t / \tilde{z}_{x,t}$, falls by less under financial autarky. This leads to terms of trade depreciating by less.

By contrast, complete markets result in strong production shifting toward the relatively more productive economy. Intuitively, risk sharing induces stronger positive cross-country consumption correlation. Since Foreign consumption is not affected by the Home productivity shock, the response of consumption is lower relative to the incomplete market scenario. In turn, increased borrowing from abroad finances higher investment in product creation in the more productive country. This higher product creation also leads to a larger number of domestic products sold abroad.

As before, the dynamics of unemployment are not significantly different relative to the case of incomplete markets. However, the terms of trade depreciate by more under complete markets, reflecting the larger number of Home firms exporting to Foreign.

Table 1.4 summarizes the business cycle implications of the extent to which Korea is integrated in international financial markets. Consistent with the impulse responses discussed above, financial integration reduces the volatility of consumption and increases the volatility of investment and product creation. The effect is stronger for higher levels of international risk sharing.

Interestingly, GDP and unemployment volatility does not display a monotonic relationship with the degree of financial market integration: For both GDP and unemployment, volatility is minimized under incomplete markets. Once again, this reflects the compositional effects of consumption and investment dynamics under the alternative international asset market structures that we consider. Instead, the volatility of the terms of trade increases with financial integration. This result is in contrast with Heathcote and Perri (2002), who find that terms of trade volatility is higher under financial autarky relative to complete markets. The reason is that in our model, fluctuations in the number of exported products affect terms of trade. In turn, since complete markets result in stronger extensive margin fluctuations, terms of trade volatility increases. Finally, not surprisingly, the pattern of international correlations reflects the consequences of increased risk sharing. Relative to the incomplete markets scenario, the correlation between Home and Foreign consumption increases with full risk sharing, while the cross-country correlation of output falls.

1.4.2 Implications for Welfare and Efficiency

Similar to Cacciatore and Ghironi (2012), the model features several distortions: price and wage stickiness, firm monopoly power in the presence of endogenous output, positive unemployment benefits, and non-technological, non-optimized trade barriers. In addition, under financial autarky or incomplete markets, risk-sharing is inefficient (and costs of adjusting bond holdings imply a resource loss under incomplete markets). Since we abstract from optimal fiscal and monetary policy, both the model's steady state and business cycle fluctuations are not efficient. Alternative degrees of financial integration affect the welfare consequences of business cycles by directly determining the importance of the financial market distortion (the lack of risk sharing) and by contributing to shape the implications of the other distortions.

Table 1.5 computes the welfare cost of business cycles associated to the three alternative international asset markets we consider. We compute the percentage Δ_{BC} of steady-state consumption that would make Home households indifferent between living in a world with uncertainty under a given asset structure m (m = financial autarky, incomplete markets, or complete markets) and living in a deterministic world:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} u\left(C_t^a, l_t^a, h_t^a\right) = \frac{1}{1-\beta} u\left[\left(1 + \frac{\Delta_{BC}}{100}\right) C, l, h\right]. \quad (1.37)$$

First-order approximation methods are inappropriate to compute the welfare associated with each financial market arrangement. This is because the solution of the model implies that the expected value of each variable coincides with its non-stochastic steady state. However, in an economy with a distorted steady state, volatility affects both the first and second moments of the variables that determine welfare. Hence we compute welfare by taking a second-order approximation to the policy functions. Thus, a lower value of Δ_{BC} implies that the welfare costs of business cycles computed are reduced.

Table 1.5 shows that financial integration leads to a substantial reduction in the welfare cost of our model-Korea's business cycle. In particular, Δ_{BC} falls from 2.06 percent of steady-state consumption under financial autarky to 0.25 percent under complete markets. To understand this result, notice first that in the presence of steady-state distortions induced by monopoly power and positive unemployment benefits, the welfare cost of business cycles (up to second order) depends endogenously on both the mean and volatility of consumption and employment (in contrast, household welfare does not depend on first-order endogenous terms if the steady state is undistorted). In turn, the endogenous connection between macroeconomic volatility and the average level of consumption and employment around which the economy fluctuates explains why financial integration induces sizable effects on the cost of business cycles. Since the level of financial integration does not significantly affect employment fluctuations, consumption dynamics have a first-order effect on the welfare cost of business cycles. In particular, when the ability of households to insure against idiosyncratic shocks increases, consumption volatility falls, and average welfare rises.

1.5 The Role of Terms Trade Shocks

In the benchmark version of our model, Home's terms of trade fluctuate only endogenously in response to Home and Foreign productivity shocks due to the presence of firm monopoly power in both countries. However, the model understates the volatility of the terms of trade relative to GDP, suggesting that un-modeled forces affect Korea's terms of trade fluctuations. Indeed, existing evidence suggests that terms of trade shocks are an important driver of Korea's business cycles (Broda, 2004).

To address this issue, we consider the case of exogenous terms of trade shocks, in the form of exogenous shocks ξ_t to the Foreign export markup, $\mu^*_{x,t}$.[30] Normalizing the steady-state value of ξ_t to 1, we assume that ξ_t follows an $AR(1)$ process in logarithms, $log\xi_t = \phi_\xi log\xi_{t-1} + \omega_t$, where ω_t represents $i.i.d.$ draws from a normal distribution with zero mean and standard deviation σ_ω. We calibrate the persistence of the shock ϕ_ξ and the standard deviation of innovations to match the observed autocorrelation and standard deviation of Korea's terms of trade. This requires setting $\phi_\xi = -0.25$ and $\sigma_\omega = 0.45$.[31] As shown in Table 1.3, when business cycles are driven by both productivity and terms of trade shocks, the model reproduces the observed volatility of imports and exports relative to GDP more closely. The correlation of TOT_t with output is also closer the data, though the model continues to miss the countercyclicality of the trade balance and implies countercyclical imports in contrast with data.

Figure 1.3 shows the impulse responses to a one-standard deviation decrease in the Foreign export markup. The reduction in the Foreign markup appreciates Korea's terms of trade. In turn, cheaper imports cause the demand for Foreign goods to rise. At the same time, the appreciation of the terms of trade generates a positive wealth effect that sustains aggregate demand for domestic output. Thus, expenditure switching toward Foreign goods does not increase unemployment in the aftermath of the shock. Korea's consumption increases by 0.5 percent at the peak. By contrast, GDP slightly falls, reflecting the initial decline of the trade balance. During the transition, the number of foreign exporters increases, while the terms of trade revert back to the steady-state level.

Figure 1.3 also presents the adjustment to the same Foreign markup shock under financial autarky (dotted line) and complete markets (dashed line). In contrast to what was observed with productivity shocks, the response of consumption is smaller under financial autarky,

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[30]On the supply side, ξ_t captures international, commodity-market specific shocks. On the demand side, it can be interpreted as reflecting changes in world demand (preferences). We obtain similar result if we model terms of trade shocks as exogenous shocks to the time-varying markup of Home exporters.

[31]Notice that this does not imply that terms of trade dynamics become fully exogenous in the model. It is only these two moments that are determined exogenously by calibration. The exogenous shock ξ_t and the endogenous nature of the terms of trade in our model then jointly affect the equilibrium path of TOT_t.

whereas the dynamics under complete markets essentially mirror those under incomplete markets. To understand this result, first notice that financial autarky implies that Home households cannot finance a trade deficit in response to terms of trade appreciation. In turn, since productivity is constant, less resources are available for domestic consumption and investment, and both variables increase by less.

Table 1.4 studies the business cycle implications of financial integration when the small open economy is subject to both terms of trade and productivity shocks. The implications of financial integration for the volatility of consumption and product creation are same as described in the previous section.

Table 1.5 computes the welfare cost of business cycles. While the presence of terms of trade shocks does not change the main message, inefficient terms of trade fluctuations increase the welfare cost of business cycles for a given international asset market structure. Moreover, the gains from financial integration are somewhat smaller compared to the scenario in which only productivity shocks drive the Korean business cycle. The reason is that inefficient Foreign markup shocks induce inefficient fluctuations in the real exchange rate, which, through the risk-sharing condition, ultimately result in more volatile, and thus suboptimal, consumption.

1.6 The Role of Exchange Rate Policy

The exercises that we performed so far allowed us to discuss how Korea's dynamics in the period since the won was allowed to float may have been different if Korea, instead of being financially integrated under the empirically most plausible scenario of incomplete markets, had pursued a policy of financial autarky (akin to the pre-1992 situation) or if integration had accomplished the outcome of full insurance in complete financial markets. However, the model also allows us to consider a different exercise, which is to address the consequences of different combinations of exchange rate and financial market integration environments. For instance, a combination of fixed exchange rate and financial autarky can be taken to represent Korea's mix of exchange rate and international financial market policy between the 1980s and the beginning of the 1990s. Continuation of the fixed exchange rate regime, but now in an environment of international integration in incomplete financial markets can represent the period between 1992 and the crisis of late 1997.[32] And it is interesting to consider whether internationally complete markets can be a better representation of Korea's integration with global financial markets than incomplete markets for the period between 1998 and 2007.

We perform this exercise in Figure 1.4 and Figure 1.5, which present impulse responses to productivity and terms of trade shocks under these different combinations of exchange rate policy and financial market integration, and in Tables 1.6, 1.7 and 1.8, where model-generate business cycle moments under these scenarios are compared to the properties of the data in the relevant periods. Table 1.9 presents the welfare implications of the different scenarios. We limit ourselves to highlighting below what we view as the most important features of the results.

The impulse responses under complete markets are intuitively identical across Figures 1.2 and 1.4 and Figures 1.3 and 1.5, as they are computed under the same assumption of flexible exchange rates. In the case of a productivity shock, the exchange rate regime does not have a significant qualitative impact. Responses are similar across Figures 1.2 and 1.4, and even quantitative differences are small. With respect to the responses to productivity shocks, our model suggests that the interest rate rule followed by the Bank of Korea under a floating won has been generating responses that are not very different from those under a peg. Instead, responses to the terms of trade shock show striking differences. In contrast to the environment of floating exchange rates, a decrease in the Foreign export markup that causes the terms of trade of our model-Korea to appreciate under financial autarky causes significant declines in consumption, GDP, and employment in the early part of the dynamics if the exchange rate is fixed. The number of new product lines also falls for a few quarters

[32]The exchange rate of the won was not exactly fixed against the dollar after 1980. A managed peg with target bands around a "crawling" parity is a better description of reality, but we take the fixed exchange rate scenario as a rough approximation to reality better to highlight possible differences with the post-Asian crisis period.

after an initial upward movement. Integration under incomplete markets makes it possible to benefit from employment gains if the exchange rate is flexible, but unemployment rises if the exchange rate is fixed, and expansion in the number of new entrants is shorter-lived, with product creation actually falling below the steady state for part of the subsequent dynamics.

The comparison of model-generated business cycle moments to the properties of the data yields a familiar mixed picture. Replicating the cyclicality of the trade balance remains a challenge for the model also when we consider different exchange rate regimes and time periods. Importantly, however, the results in Table 1.8 support our choice of incomplete markets as benchmark representation of Korea's situation under flexible exchange rate: On balance, the model's performance relative to the data is better in Table 1.3 than in Table 1.8.

Table 1.9 shows that the costs of business cycles increase somewhat by moving from financial autarky to incomplete financial markets under a peg if only productivity shocks are considered, but they decrease more significantly if both productivity and terms of trade shocks are accounted for. This is consistent with the observations above on unfavorable employment and business creation effects of pegging the exchange rate under incomplete markets when terms of trade shocks happen. From a welfare perspective, full insurance under a float remains the best scenario implied by our model for Korea.[33]

1.7 Sensitivity Analysis

To verify the robustness of our results, we performed sensitivity analysis along three dimensions.

First, we investigated whether our results are robust to the presence of forward-looking targets in the policy rule considered above. Specifically, we re-ran all the simulations assuming response to expected next-period inflation in (1.31) under flexible exchange rates.

Second, we considered alternative values for the parameters whose calibration is relatively

[33] In the environment of multiple distortions of our model, it is not automatic that increasing financial market integration should always be welfare-improving. See Auray and Eyquem (2014) and Leblebicioğlu (2009) for other examples of situations where financial integration can lower welfare in second-best environments.

controversial in the literature. For household preferences, we considered a higher Frisch elasticity of labor supply ($1/\gamma_h = 4$, as typically assumed in the business cycle literature). We evaluated the importance of nominal rigidity by considering smaller values for the scale parameters of price and wage adjustment costs ($\nu = \vartheta = 20$). Finally, we considered an alternative value for the elasticity of the matching function ($\varepsilon = 0.4$, the lower bound of the estimates reported by Petrongolo and Pissarides, 2006). We studied the effects of changing one parameter value at a time relative to the benchmark calibration. The main results are very robust to the alternative parameter values we considered. (Details are available upon request.)

Third, we studied the consequences of replacing the policy rule (1.31) – and thus the assumption of a flexible exchange rate – with a rule that captures policymaking in the form of a managed exchange rate regime as described by Benigno and Benigno (2008). Several studies have found that the behavior of the Bank of Korea at various points in time (including after the crisis of 1997) is appropriately described by a policy rule that includes a response to exchange rate dynamics.[34] Thus, we re-computed all figures and tables replacing the assumption of a flexible exchange rate and rule (1.31) with the policy rule:

$$1 + i_{t+1} = (1 + i_t)^{\varrho_i} \left[(1 + i) \left(\pi_{C_R,t}\right)^{\varrho_\pi} \left(\hat{Y}^g_{R,t}\right)^{\varrho_{Y^g}} \left(S_t / S_{t-1}\right)^{\varrho_S} \right]^{1-\varrho_i} . \tag{1.38}$$

We followed Milani and Park (2015) and calibrated the response coefficients as follows: $\varrho_\pi = 1.63$, $\varrho_{Y^g} = 0.11$, $\varrho_S = 0.13$, and $\varrho_i = 0.83$. Figures and tables for this scenario can be found in Appendix D. Consistent with the fact that Milani and Park (2015) do not find a large response to exchange rate depreciation in their empirical results, the results of our simulations show very little or no difference between the managed exchange rate rule and the flexible exchange rate results discussed above. Second moments change slightly, but most changes are in the second decimal digit. Impulse responses also look very similar, and welfare

[34] For instance, Chung et al. (2007), Eichengreen (2004b), Milani and Park (2015), Ortiz et al. (2009), and Ortiz and Sturzenegger (2007).

costs are almost identical to flexible exchange rates. Flexible exchange rates under complete markets remain the best policy regime for our model-Korea on welfare grounds.[35]

1.8 Conclusions

We studied the consequences of financial integration and exchange rate policy in a medium-scale, calibrated model of the Korean economy that features endogenous producer entry and labor market frictions. Under a flexible exchange rate and an empirically plausible representation of Korea's monetary policy since the 1997-98 crisis, access to international financial markets increases the volatility of both business creation and the number of exporting plants, but the effects on employment volatility are more modest. Financial integration results in better consumption risk sharing, with lower consumption volatility and higher correlation with the rest of the world. The result is a substantial reduction in the welfare cost of business cycles for Korea.

Financial integration and the exchange rate regime interact to shape macroeconomic dynamics in response to shocks and the welfare implications of different scenarios. An exchange rate peg can have unfavorable consequences for the effects of terms of trade appreciation. At the same time, more financial integration is not necessarily beneficial under a peg. Overall, our results show that the combination of a floating exchange rate and full insurance in internationally complete markets would be the best scenario for Korea among those we considered.

As better and longer time series of extensive margin data become available, it will be possible to assess rigorously the quantitative relevance for Korea of the endogenous producer dynamics that our model features. We view this and the extension of the model to incorporate more features of empirical relevance to the Korean economy – including financial market

[35]Korea's GDP fluctuations in the years since the Asian crisis were not dissimilar from those of Hong Kong's GDP, with the difference that Hong Kong successfully defended its exchange rate peg. It is an open question whether this suggests irrelevance of the exchange rate regime for short-term fluctuations of Korea and Hong Kong since 1998 or whether the similarity between the dynamics of GDP in Korea and Hong Kong is the result of the patterns of shocks that affected these economies since 1998.

frictions other than in the menu of internationally traded assets – as very important areas for future research.

Table 1.1. Model summary

Equilibrium Price Index: $1 = \tilde{\rho}_{d,t}^{1-\theta} N_{d,t}^{\frac{1-\phi}{1-\theta}} + \tilde{\rho}_{x,t}^{*\,1-\theta} N_{x,t}^{*\,\frac{1-\phi}{1-\theta}}$
Equilibrium Exports: $\tilde{\rho}_{x,t}^{-\theta} N_{x,t}^{\frac{\theta-\phi}{1-\theta}} Y_t^{C*} = \frac{(\theta-1)}{k_p-(\theta-1)} \frac{\tilde{z}_{x,t}}{\tau_t} f_{x,t}$
Labor Market Clearing: $l_t h_t = N_{d,t} \frac{\widetilde{y}_{d,t}}{Z_t \tilde{z}_d} + N_{x,t} \frac{\widetilde{y}_{x,t}}{Z_t \tilde{z}_{x,t}} \tau_t + N_{e,t} \frac{f_{e,t}}{Z_t} + N_{x,t}$
Employment Dynamics: $l_t = (1-\lambda) l_{t-1} + q_{t-1} V_{t-1}$
Product Creation: $1 = \mathbb{E}_t \left\{ \beta_{t,t+1} \frac{\tilde{\rho}_{d,t+1}}{\tilde{\rho}_{d,t}} \left[\begin{array}{c} \frac{\mu_{d,t}}{\mu_{d,t+1}} \left(\frac{f_{e,t+1}}{f_{e,t}} - \frac{N_{x,t+1}}{N_{d,t+1}} \frac{f_{x,t+1}}{f_{e,t}} \right) + \\ \frac{1}{(\theta-1) f_{e,t}} \left(\frac{\mu_{d,t}}{\mu_{d,t+1}} \widetilde{y}_{d,t+1} + \frac{N_{x,t+1}}{N_{d,t+1}} \frac{Q_{t+1} \tilde{\rho}_{x,t+1} \tilde{z}_{x,t+1}}{\tilde{\rho}_{d,t+1} \tilde{z}_d} \frac{\mu_{d,t+1}}{\mu_{x,t+1}} \widetilde{y}_{x,t+1} \right) \end{array} \right] \right\}$
Job Creation: $1 = E_t \left\{ \beta_{t,t+1} \left[(1-\lambda) \frac{q_t}{q_{t+1}} + \frac{q_t}{\kappa} \left(\varphi_{t+1} Z_{t+1} h_{t+1} - \frac{w_{t+1}}{P_{t+1}} h_{t+1} - \frac{\vartheta}{2} \pi_{w,t+1}^2 \right) \right] \right\}$
Determination of Hours: $v_{h,t}/u_{C,t} = \varphi_t Z_t$
Wage Inflation: $1 + \pi_{w,t} = \frac{w_t/P_t}{w_{t-1}/P_{t-1}} (1 + \pi_{C,t})$
Equilibrium Wage Bargain: $\begin{array}{l} \frac{w_t}{P_t} h_t = \eta_{w,t} \left(\frac{v(h_t)}{u_{C,t}} + b \right) + (1-\eta_{w,t}) \left(\varphi_t Z_t h_t - \frac{\vartheta}{2} \pi_{w,t}^2 \right) \\ + E_t \left\{ \beta_{t,t+1} J_{t+1} \left[(1-\lambda)(1-\eta_{w,t}) - (1-\lambda-\iota_t)(1-\eta_{w,t+1}) \frac{\eta_{w,t}}{\eta_{w,t+1}} \right] \right\} \end{array}$
Monetary Policy Rule: $1 + i_{t+1} = (1+i_t)^{\varrho_i} \left\{ (1+i) \left[\mathbb{E}_t \left(\frac{\hat{P}_{t+k}}{\hat{P}_{t+k-1}^{I_P}} \right)^{1-I_{\tilde{Y}}} \left(E_t \hat{Y}_{t+k}^N \right)^{I_{\tilde{Y}}} \right]^{\varrho} \left[\left(\hat{Y}_{R,t}^g \right)^{\varrho_{Y^g}} \right] \right\}^{1-\varrho_i}$
Euler Equation for Domestic Bonds: $1 = (1 + i_{t+1}) \mathbb{E}_t \beta_{t,t+1} \left(\frac{1}{1+\pi_{C,t+1}} \right)$
Euler Equation for Foreign Bonds: $1 + \psi a_{*t+1} = \left(1 + i_{t+1}^* \right) E_t \left\{ \beta_{t,t+1} \frac{Q_{t+1}}{Q_t \left(1+\pi_{C,t+1}^* \right)} \right\}$
Foreign Asset Accumulation: $Q_t (a_{*,t+1} - a_{*,t}) = Q_t \frac{(1+i_t^*)}{\left(1+\pi_{C,t}^*\right)} a_{*,t} + Q_t N_{x,t} \tilde{\rho}_{x,t} \tilde{y}_{x,t} - N_{x,t}^* \tilde{\rho}_{x,t}^* \tilde{y}_{x,t}^*$

Table 1.2. Calibration

	Parameter
Risk Aversion	$\gamma_C = 2$
Frisch Elasticity	$1/\gamma_h = 0.28$
Discount Factor	$\beta = 0.99$
Elasticity Matching Function	$\varepsilon = 0.4$
Firm Bargaining Power	$\eta = 0.6$
Unemployment Replacement Rate	$b/w = 0.54$
Exogenous separation	$\lambda = 0.1$
Vacancy Cost	$\kappa = 0.56$
Matching Efficiency	$\chi = 0.74$
Elasticity of Substitution	$\theta = 3.8$
Plant Exit	$\delta = 0.05$
Pareto Shape	$k_p = 3.4$
Pareto Support	$z_{\min} = 1$
Sunk Entry Cost	$f_e = 0.40$
Fixed Export Costs	$f_x = 0.008$
Iceberg Trade Costs	$\tau = 1.26$
Rotemberg Wage Adj. Cost	$\vartheta = 290$
Rotemberg Price Adj. Cost	$\nu = 80$
Policy Rule - Interest Rate Smoothing	$\varrho_i = 0.84$
Policy Rule - Inflation Parameter	$\varrho_\pi = 1.87$
Policy Rule - Output Gap Parameter	$\varrho_{Y^g} = 0.19$
Bond Adjustment Cost	$\psi = 0.0025$

Table 1.3. Business cycle statistics, benchmark scenario

	σ_X			σ_X/σ_{Y_R}			$corr(X_t, Y_{R,t})$		
Variable	*Data*	*Model I*	*Model II*	*Data*	*Model I*	*Model II*	*Data*	*Model I*	*Model II*
Y_R	1.51	1.51	1.75	1	1	1	1	1	1
C_R	1.98	1.89	1.90	1.31	1.22	1.08	0.74	0.73	0.61
I_R	4.15	10.45	11.18	2.74	6.71	6.38	0.78	0.47	0.23
U	13.18	12.88	12.90	8.71	8.27	7.37	-0.57	-0.58	-0.51
X_R	4.43	2.23	3.46	2.93	1.43	1.98	0.37	0.74	0.14
IM_R	5.03	2.72	5.87	3.33	1.75	3.35	0.67	0.41	-0.22
TB_R/Y_R	1.13	0.55	0.68	0.75	0.35	0.39	-0.47	0.13	0.36
TOT	2.19	0.59	2.49	1.45	0.38	1.45	-0.50	-0.64	-0.57
$corr(Y_{R,t}, Y^*_{R,t})$	0.34	0.29	0.26						
$corr(C_{R,t}, C^*_{R,t})$	0.08	0.02	0.02						

Note: Data moments refer to the period 1998:Q1-2007:Q4;
$\sigma_X \equiv$ standard deviation of variable X (percentage points);
$corr(X_t, Y_{R,t}) \equiv$ contemporaneous correlation of variable X with data-consistent, real GDP;
Model I $\equiv$ productivity shocks only; *Model II* $\equiv$ productivity and terms of trade shocks.

Table 1.4. Business cycle moments under different asset markets

Variable	Financial Autarky						Incomplete Markets						Complete Markets					
	Model I			*Model II*			*Model I*			*Model II*			*Model I*			*Model II*		
Y_R	2.00	1	1	2.00	1	1	1.56	1	1	1.75	1	1	2.08	1	1	2.19	1	1
C_R	2.00	1	1	2.00	1	1	1.89	1.22	0.73	1.90	1.08	0.61	0.70	0.34	-0.05	0.72	0.33	-0.12
I_R	8.61	4.31	0.68	8.66	4.34	0.68	10.45	6.71	0.47	11.18	6.38	0.23	13.77	6.62	0.40	14.24	6.49	-0.53
U	13.86	6.95	-0.70	13.87	6.95	-0.70	12.88	8.27	-0.58	12.90	7.37	-0.51	13.55	6.51	-0.56	13.57	6.18	-0.53
N_E	8.70	4.36	0.69	8.72	4.37	0.69	10.67	6.85	0.48	11.26	6.43	0.26	14.07	6.77	0.42	14.44	6.58	0.32
X_R	1.73	0.86	0.97	4.49	2.25	0.40	2.23	1.43	0.74	3.46	1.98	0.14	4.42	2.12	0.99	4.94	2.25	0.71
IM_R	1.73	0.86	0.97	4.49	2.25	0.40	2.72	1.75	0.41	5.87	3.35	-0.22	2.57	1.24	-0.79	6.13	2.79	-0.59
TB_R/Y_R	0	0	0.73	0	0	0.73	0.55	0.35	0.13	0.68	0.39	0.36	0.88	0.42	0.95	0.94	0.43	0.95
TOT	0.47	0.24	-0.94	1.99	0.99	-0.19	0.59	0.38	-0.64	2.49	1.45	-0.57	1.47	0.71	-0.95	2.92	1.33	-0.72
$corr(Y_{R,t}, Y^*_{R,t})$		0.01			0.01			0.29			0.26			0.21			0.20	
$corr(C_{R,t}, C^*_{R,t})$		0.01			0.01			0.02			0.02			0.69			0.67	

Note: For every *Model*, the first column reports absolute standard deviations (σ_X, percentage points), the second column reports standard deviations relative to real, data-consistent GDP (σ_X/σ_{Y_R}), and the third column reports contemporaneous correlations with real, data-consistent GDP ($corr(X_t, Y_{R,t})$); *Model I* $\equiv$ productivity shocks only; *Model II* $\equiv$ productivity and terms of trade shocks.

Table 1.5. Welfare cost of business cycles under different asset markets

	ΔWelfare		
	Financial Autarky	Incomplete Markets	Complete Markets
Model I	2.06	1.91	0.25
Model II	4.30	4.05	3.16

ΔWelfare ≡ change in welfare cost of business cycles (percentage of steady-state consumption);
Model I ≡ productivity shocks only; *Model II* ≡ productivity and terms of trade shocks.

Table 1.6. Financial autarky under fixed exchange rates

	σ_X			σ_X/σ_{Y_R}			$corr(X_t, Y_{R,t})$		
Variable	*Data*	*Model I*	*Model II*	*Data*	*Model I*	*Model II*	*Data*	*Model I*	*Model II*
Y_R	1.71	1.78	2.57	1	1	1	1	1	1
C_R	0.74	1.78	2.57	0.43	1	1	0.30	1	1
I_R	5.61	6.62	9.37	3.28	3.72	3.65	0.64	0.91	0.09
U	18.52	11.04	13.61	10.83	6.20	5.30	-0.16	-0.87	-0.56
X_R	6.83	1.54	3.47	3.99	0.87	1.35	0.42	0.98	-0.10
IM_R	5.23	1.54	3.47	3.06	0.87	1.35	0.30	0.98	-0.10
TB_R/Y_R	0.91	0	0	0.53	0	0	0.29	-0.06	-0.04
TOT	3.17	0.41	2.33	1.85	0.23	0.91	-0.05	-0.93	-0.75
$corr(Y_{R,t}, Y^*_{R,t})$	0.17	0.06	0.04						
$corr(C_{R,t}, C^*_{R,t})$	0.31	0.06	0.04						

Note: Data moments refer to the period 1980:Q1-1991:Q4;
σ_X ≡ standard deviation of variable X (percentage points);
$corr(X_t, Y_{R,t})$ ≡ contemporaneous correlation of variable X_t with data-consistent, real GDP;
Model I ≡ productivity shocks only; *Model II* ≡ productivity and terms of trade shocks.

Table 1.7. Incomplete markets under fixed exchange rates

Variable	σ_X			σ_X/σ_{Y_R}			$corr(X_t, Y_{R,t})$		
	Data	*Model I*	*Model II*	*Data*	*Model I*	*Model II*	*Data*	*Model I*	*Model II*
Y_R	1.06	1.56	2.16	1	1	1	1	1	1
C_R	1.02	1.99	1.99	0.97	1.27	0.92	0.71	0.85	0.62
I_R	4.13	10.62	12.20	3.91	6.80	5.64	0.85	0.63	0.06
U	14.93	14.57	14.65	14.10	9.33	6.77	-0.39	-0.63	-0.49
X_R	3.25	1.77	2.57	3.07	1.13	1.19	0.56	0.71	0.08
IM_R	4.95	2.60	6.18	4.67	1.67	2.86	0.89	0.64	-0.42
TB_R/Y_R	1.25	0.44	0.76	1.18	0.28	0.35	-0.67	-0.13	0.51
TOT	2.06	0.47	2.80	1.95	0.30	1.29	0.00	-0.61	-0.74
$corr(Y_{R,t}, Y^*_{R,t})$	-0.30	0.13	0.09						
$corr(C_{R,t}, C^*_{R,t})$	-0.41	-0.03	-0.03						

Note: Data moments refer to the period 1992:Q1-1997:Q4;
$\sigma_X \equiv$ standard deviation of variable X (percentage points);
$corr(X_t, Y_{R,t}) \equiv$ contemporaneous correlation of variable X with data-consistent, real GDP;
Model I $\equiv$ productivity shocks only; *Model II* $\equiv$ productivity and terms of trade shocks.

Table 1.8. Complete markets under flexible exchange rates

	σ_X			σ_X/σ_{Y_R}			$corr(X_t, Y_{R,t})$		
Variable	*Data*	*Model I*	*Model II*	*Data*	*Model I*	*Model II*	*Data*	*Model I*	*Model II*
Y_R	1.51	2.08	2.19	1	1	1	1	1	1
C_R	1.98	0.70	0.72	1.31	0.34	0.33	0.74	-0.05	-0.12
I_R	4.15	13.77	14.24	2.74	6.62	6.49	0.78	0.40	0.29
U	13.18	13.55	13.57	8.71	6.51	6.18	-0.57	-0.56	-0.53
X_R	4.43	4.42	4.94	2.93	2.12	2.25	0.37	0.99	0.71
IM_R	5.03	2.57	6.13	3.33	1.24	2.79	0.67	-0.79	-0.59
TB_R/Y_R	1.13	0.88	0.94	0.75	0.42	0.43	-0.47	0.95	0.95
TOT	2.19	1.47	2.92	1.45	0.71	1.33	-0.50	-0.95	-0.72
$corr(Y_{R,t}, Y^*_{R,t})$	0.34	0.21	0.20						
$corr(C_{R,t}, C^*_{R,t})$	0.08	0.69	0.67						

Note: Data moments refer to the period 1998:Q1-2007:Q4;
$\sigma_X \equiv$ standard deviation of variable X (percentage points);
$corr(X_t, Y_{R,t}) \equiv$ contemporaneous correlation of variable X with data-consistent, real GDP;
Model I $\equiv$ productivity shocks only; *Model II* $\equiv$ productivity and terms of trade shocks.

Table 1.9. Welfare cost of business cycles under different asset markets and monetary policies

	ΔWelfare		
	Financial Autarky Fixed Exchange Rates	Incomplete Markets Fixed Exchange Rates	Complete Markets Flexible Exchange Rates
Model I	1.97	2.15	0.25
Model II	4.72	4.29	3.16

ΔWelfare $\equiv$ change in welfare cost of business cycles (percentage of steady-state consumption);
Model I $\equiv$ productivity shocks only; *Model II* $\equiv$ productivity and terms of trade shocks.

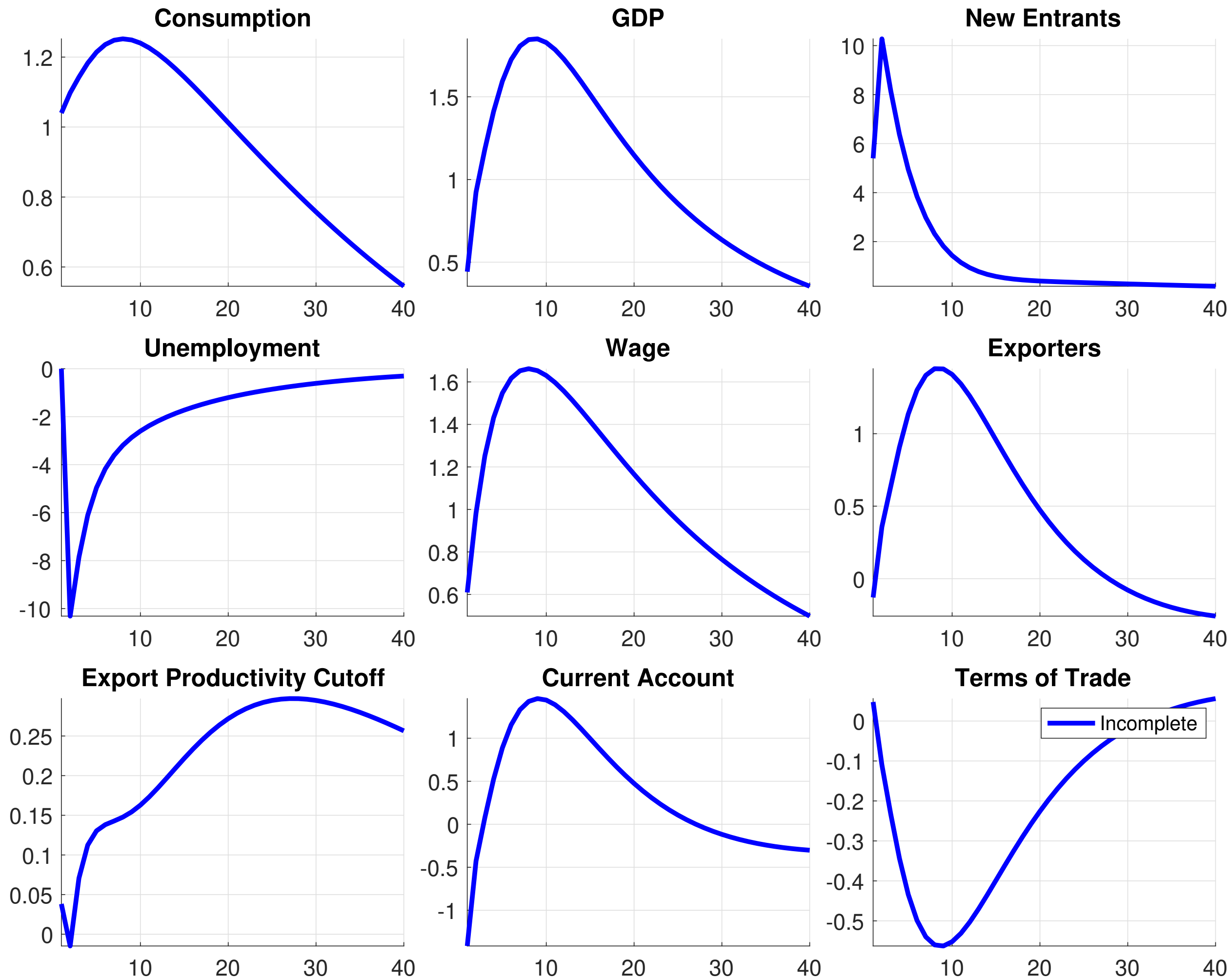


Figure 1.1. Home productivity shock, incomplete markets with flexible exchange rates. Responses show percentage deviations from steady state. Unemployment and current account are in deviations from steady state.

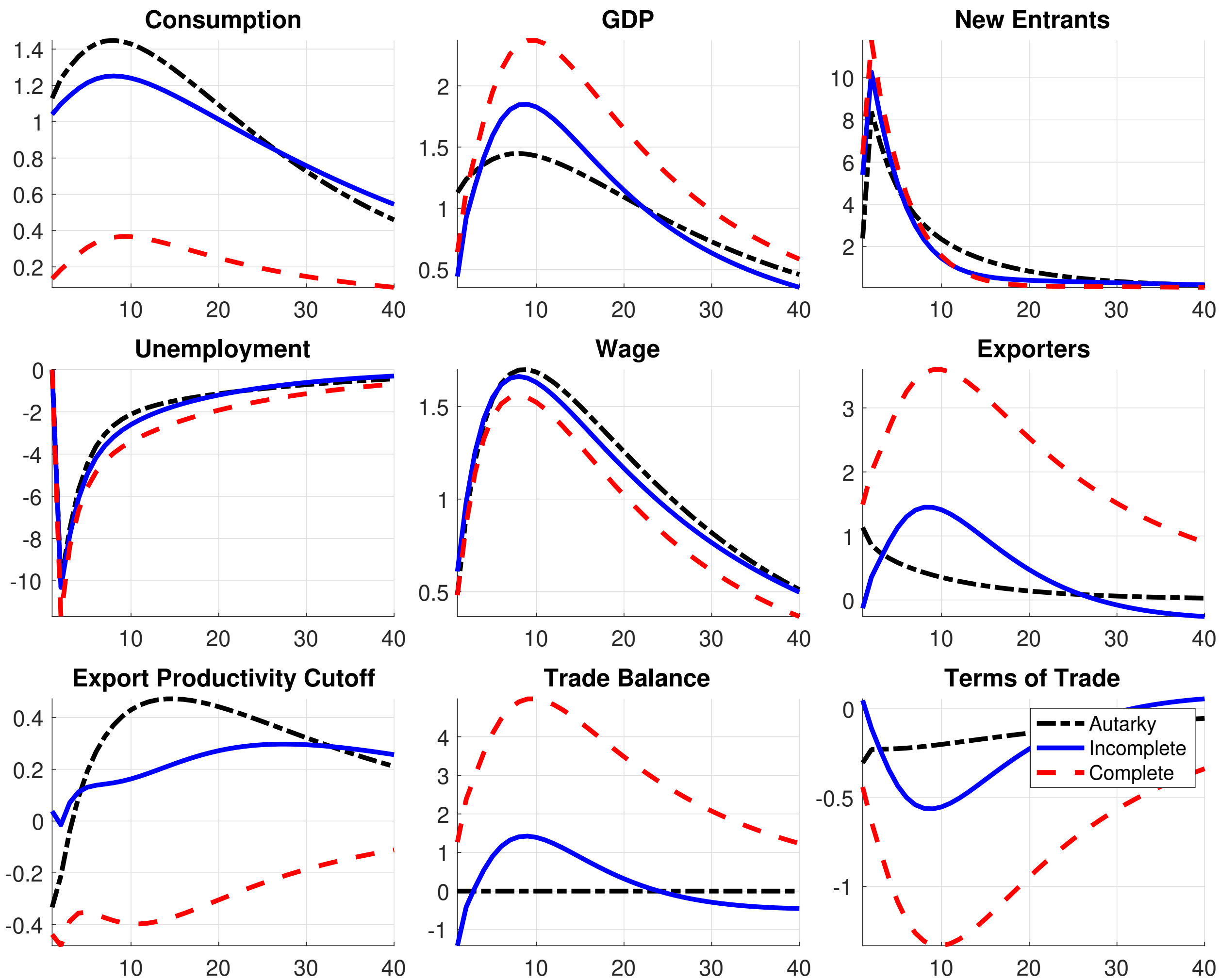


Figure 1.2. Home productivity shock, flexible exchange rates, incomplete markets (solid lines), financial autarky (dash-dotted lines), complete markets (dashed lines). Responses show percentage deviations from steady state. Unemployment and trade balance are in deviations from steady state.

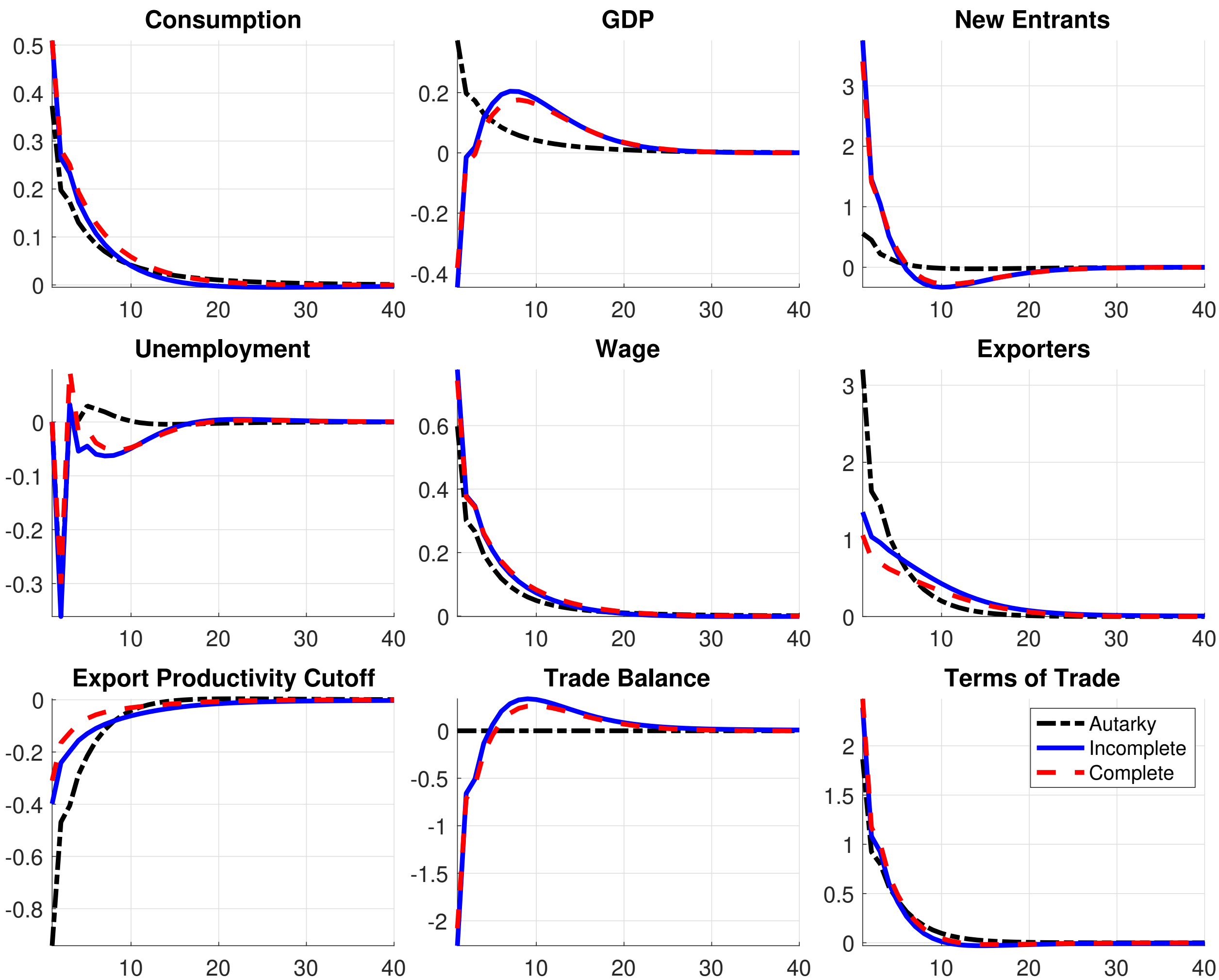


Figure 1.3. Terms of trade shock, flexible exchange rates, incomplete markets (solid lines), financial autarky (dash-dotted lines), complete markets (dashed lines). Responses show percentage deviations from steady state. Unemployment and trade balance are in deviations from steady state.

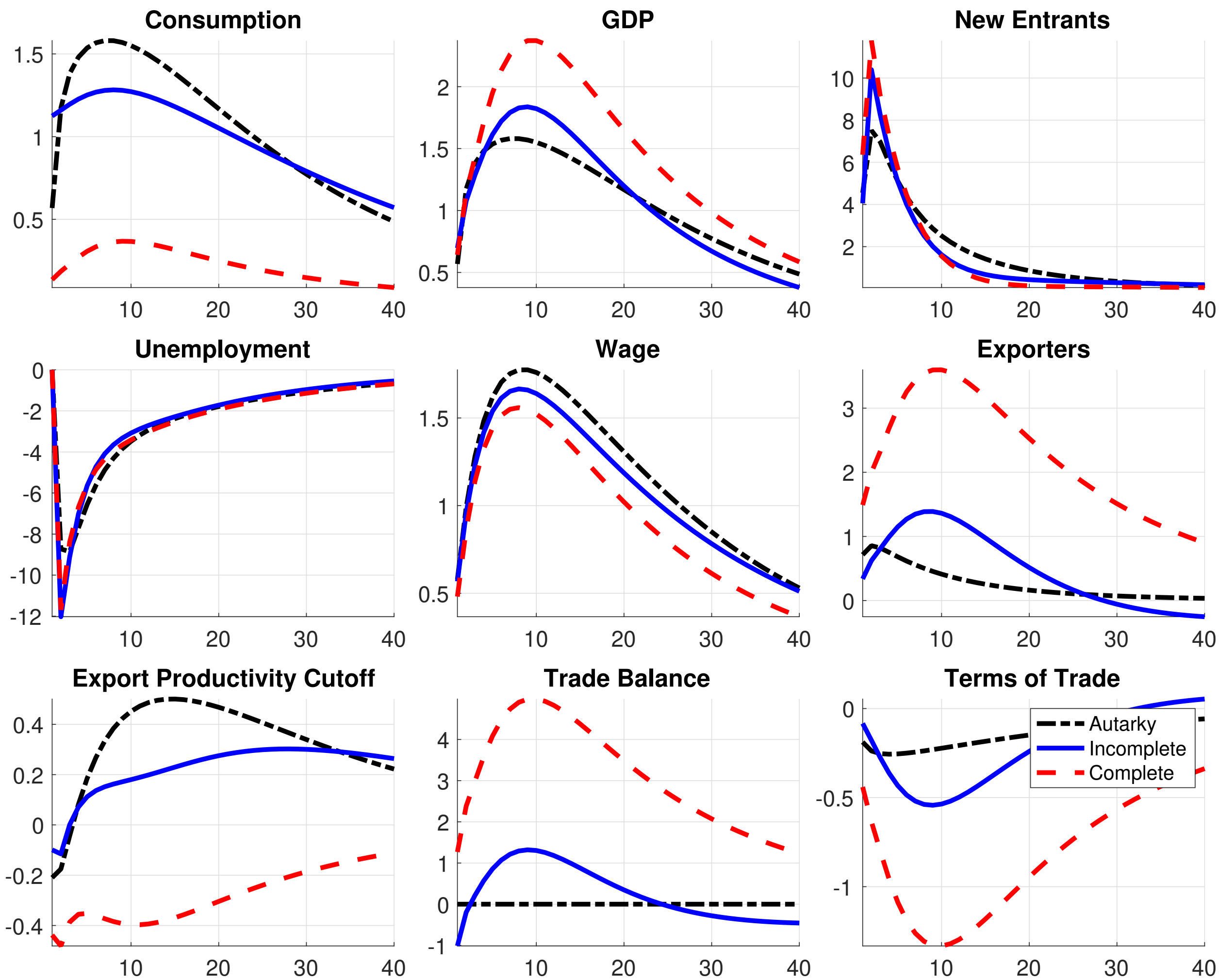


Figure 1.4. Productivity shock under different asset market and exchange rate policy assumptions: financial autarky and fixed exchange rate (dash-dotted lines), incomplete markets and fixed exchange rate (solid lines), complete markets and flexible exchange rates (dashed lines). Responses show percentage deviations from steady state. Unemployment and trade balance are in deviations from steady state.

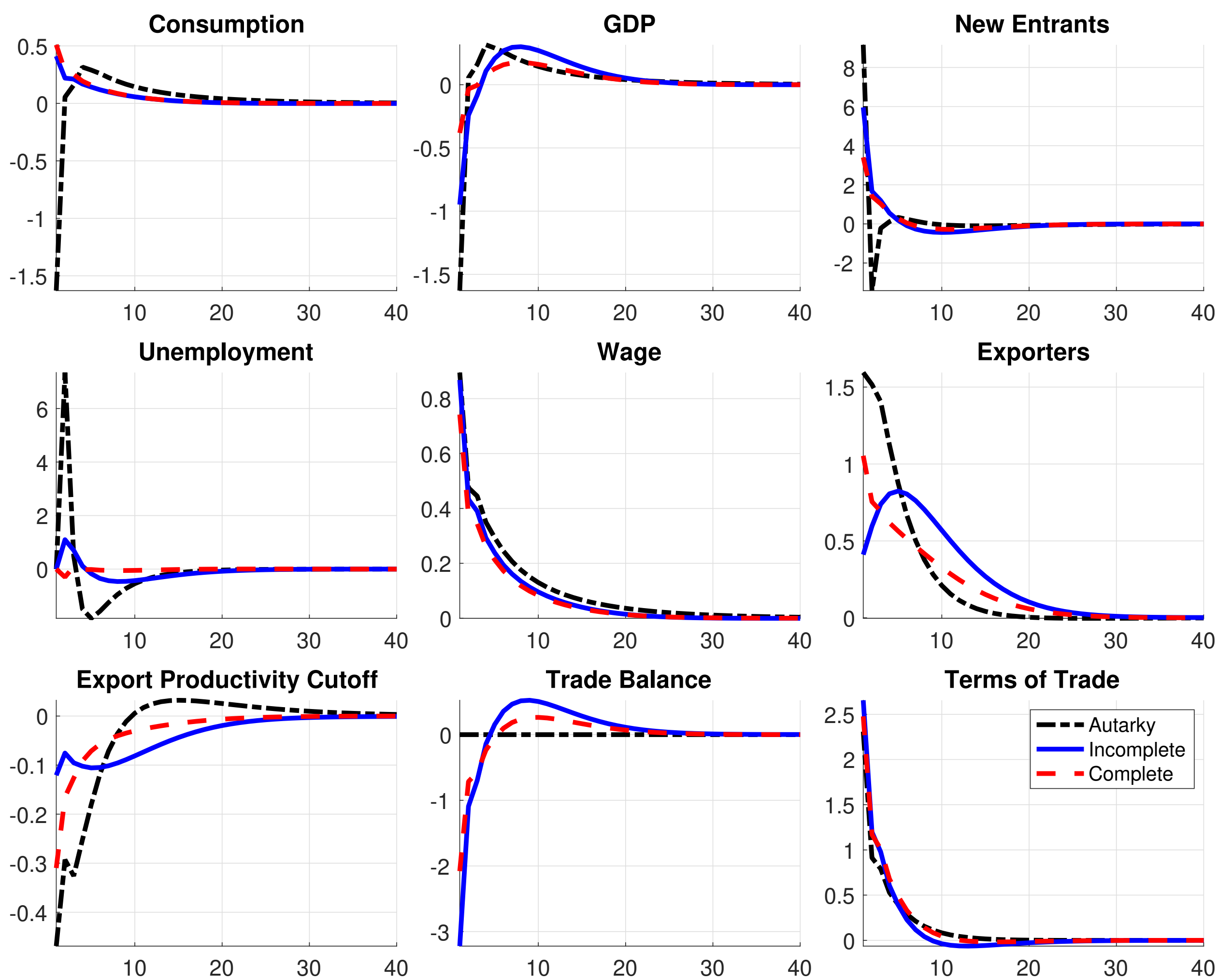


Figure 1.5. Terms of trade shock under different asset market and exchange rate policy assumptions: financial autarky and fixed exchange rate (dash-dotted lines), incomplete markets and fixed exchange rate (solid lines), complete markets and flexible exchange rates (dashed lines). Responses show percentage deviations from steady state. Unemployment and trade balance are in deviations from steady state.

Chapter 2

EXCESSIVE FIRM TURNOVER IN THE SHADOW OF UNEMPLOYMENT

2.1 Introduction

Although the role of large firms as drivers of aggregate fluctuations and potential source of market distortions has been receiving increasing attention in academic and policy literature (Azar et al., 2017; Di Giovanni and Levchenko, 2012; Gabaix, 2011), very small firms still represent a significant portion of the economy's labor market and employ a large total number of workers in many countries (Figure 2.1). While small in terms of output, these small businesses play an important role in labor market dynamics.[1] This is becoming more relevant thanks to the recent rise of a "gig economy" in which technology allows individuals to become "solopreneurs" quite easily. In the United States, "a mix of technology, economic necessity and adventure is leading more Americans to found companies that plan to stay very small" (Wall Street Journal, 2016).

Self-employment includes both startups (the successful ones that grow into large entities not being my focus) and small mom-and-pop businesses. The latter type of firms, which are more focused on monetary benefits and less on job creation or growth, exist in large numbers in both advanced and developing economies (Figure 2.2a). In the US, around a third of business owners report having no better choice of work[2] or maintaining income as their main

[1]Nonemployer firms take up 81% of all firms and yet they contribute slightly over 3% of overall receipts and sales (US Census, 2016) A nonemployer business is defined as a firm that has no paid employees, has annual receipts of over $1,000 ($1 for construction), and is subject to federal income taxes. Most of nonemployer businesses are self-employed individuals running very small and unincorporated businesses (US Census Nonemployer Statistics, 2019).

[2]The Global Entrepreneurship Monitor Adult Population Survey (GEM APS, 2019) defines them as necessity-driven businesses.

motive, and more than half respond that they view entrepreneurship as a source of income (Table 2.1). These firms operate in industries with relatively low profits and high shutdown rates. They remain small and hire no other employees; hence they do not participate in the labor market. Moreover, their number fluctuates over the cycle as conflicting forces interact: Economic expansions create more incentive to start a business due to higher demand by consumers (entrepreneurial effect) but, at the same time, expansions dampen the need of self-employment since it is easier to find work (refugee effect; Thurik et al., 2008). In the US, the entrepreneurial effect is stronger, and self-employment rises in periods of expansion (Table 2.2).

Motivated by this evidence, the goal of this paper is to study the role of solopreneurship (or self-employment) for macroeconomic dynamics, efficiency, and the outcomes of structural reforms intended to facilitate producer entry in the economy. The central concept on which I rely to accomplish my goal is that of self-employment as an occupational choice. I explore why workers have an incentive to start small businesses—despite entry costs and the risk of low profit and high chance of shutting down—and how these individual decisions can contribute to inefficient resource allocations.

I introduce self-employment as an occupational choice in a two-sector, dynamic general equilibrium model of the economy: One sector (the "hiring sector") is populated by monopolistically competitive firms that hire workers subject to search-and-matching frictions in the labor market to produce output as in Diamond (1982b) and Mortensen and Pissarides (1994). The other sector (the solopreneurs sector) consists of self-employment (one-person) firms that use the output of the first sector as input to produce their own output (think of it as services). Different from the conventional search-and-matching setup where workers always look for a job until hired, an unemployed worker can either choose to stay in the labor market and keep searching for a job or pay an entry cost and become a new solopreneur firm.[3] Solopreneurs have lower monopoly power than firms in the hiring sector, they are characterized by a different (plausibly, lower) level of average productivity, and they fail at a higher rate. New firms can be created endogenously in both sectors subject to sunk costs of business creation. These costs are a combination of technological requirements for producer entry, which a planner would take as given, and regulatory barriers to entry.

I calibrate the model to match U.S. macroeconomic and labor market, and I show that the theoretical framework results in an empirically-consistent 7.4% of employment coming from self-employment. As in U.S. data, self-employment is procyclical: Even though an economic boom implies a higher job finding probability for the unemployed, the potential profit from entrepreneurship also rises. Consequently, we observe a shift in the composition of total employment toward self-employment. For hiring firms, it becomes harder to fill vacancies since much labor has exited the unemployment pool and joined the market as enterprises, while hired workers benefit from a further increase in wages. Total household income rises as wages are higher and more family members are employed in one or the other sector.[4] Consumption and output increase by more when the economy features self-employment than without, and unemployment falls by more as some household members escape unemployment by becoming business owners. However, this results in increased volatility of the economy as the size of the self-employment sector rises, and a larger welfare cost of business cycles.

By comparing the outcome of the decentralized economy to that chosen by a benevolent social planner, I show that additional inefficiency wedges emerge along the margins of job creation and product creation in both sectors relative to a model without self-employment. Decentralized occupational choice introduces additional sources of inefficiency because the self-employed do not take into account the impact they have on labor market tightness when

[3] Only the unemployed's choice of self-employment is mentioned here because under reasonable calibration, the model endogenously shows that the employed would not want to give up their current job and switch to self-employment.

[4] As in Andolfatto (1996) and Merz (1995), I assume that there is a representative household with members employed by hiring firms, self-employed members, and unemployed members. Household members pool their incomes so they all have the same consumption.

entering nor the effect they have on consumption when using hiring sector goods as input. Moreover, the hiring firms, when posting vacancies, do not consider the present discounted value of self-employment. In other words, self-employment as a decentralized occupational choice becomes an additional source of distortions and inefficiency.

Incorporating the concepts of regulatory barriers and solopreneurship as occupational choice in my model also allows me to study the role of self-employment for the outcomes of structural reforms intended to facilitate business creation. Among others, calls for such reforms to boost feeble economic growth especially after the 08-09 global financial crisis have been made in multiple occasions by former ECB President Mario Draghi or by the IMF—for instance, in its April 2016 and October 2019 World Economic Outlook. The standard argument is that lowering barriers to entry in product markets should improve economic performance by leading to more competition and lower prices, along with more demand for labor and a fall in structural unemployment. Abundant literature has studied the topic[5], but—to the best of my knowledge—no one yet has studied the dynamic consequences and welfare effects of facilitating entry in the "gig economy," or how the consequences of this reform would compare to those of reforms of the hiring sector. The final part of this paper shows that success of product market reforms depends on whether the targeted firms hire actively and produce differentiated enough goods.

Specifically, I show that cutting red tape that interferes with entry by hiring firms is more effective than facilitating entry by soloprenuers, as creation of hiring firms has a larger impact on total job creation and employment. Deregulation of the solopreneur sector is more effective when its productivity is relatively lower, because the associated increase in demand of hiring sector output to produce a given amount of solopreneur output is larger. Deregulation of both sectors is more effective when solopreneurs are able to produce more distinctive outputs and therefore have sufficiently high monopoly power. Finally, labor market reforms that facilitate job creation in the hiring sector are more beneficial than solopreneurship deregulation.

[5] See Section 2.2 for more details.

The rest of the paper is organized as follows. Section 2.2 reviews related previous research. Section 2.3 presents the model. Section 2.4 analyzes the sources of inefficiency in the model by comparing its decentralized outcome to the solution of the social planner problem. Section 2.5 discusses the calibration. Section 2.6 studies the implied business cycle dynamics. Section 2.7 discusses the implications of various structural reforms. Section 2.8 concludes.

2.2 Related Literature

My paper relates to the recent literature on occupational choice with entrepreneurship as a selection. I expand on a dynamic stochastic general equilibrium model with endogenous entry and search and matching frictions to explore its impact on the business cycle dynamics. To my knowledge, incorporating firm creation as an occupational choice in a dynamic framework and focusing on its macroeconomic impact has been scarce, which is where my contribution lies in. This paper also adds to the discussion on structural reforms by accounting for the existence of self-employment and how it influences the effectiveness of the relevant policies.

One of the popular theoretical models for explaining entrepreneurship is that of occupational choice. The workforce becomes divided into two groups as some "choose" to become business owners, whether it is to make use of their entrepreneurial abilities (Lucas, 1978), exploit business opportunities (Holmes and Schmitz, 1990), or to trade off risk and returns (Kihlstrom and Laffont, 1979, following Knight, 1921). Instead of focusing on the business owner's personal characteristics as done by Schumpeter (1911), Knight (1921), and Oxenfeldt (1943), in my paper the choice is based on comparing wage earned as paid employee and the future expected profit as a business owner (Creedy and Johnson, 1983; Acs and Audretsch, 1989; Geroski, 1995). However, due to the existence of search and matching frictions, the choice is dependent on the endogenous probability of being matched as a paid worker in the labor market (Fonseca et al., 2001; Poschke, 2013, 2018). As a result, I focus more on what Lucas (1978) refers to as "marginal entrepreneur," who is indifferent between entrepreneurship and paid employment.

Switching to self-employment is costly in my model but not necessarily a binding constraint, as long as the expected future stream of profits are enough to cover the sunk entry cost. This approach differs from papers that explore the entrepreneurial choice under financial constraints, stemming from Fazzari et al. (1988) to Evans and Jovanovic (1989), Ghatak et al. (2001), Banerjee and Newman (1993), and Shapiro and Mandelman (2016), to name a few. However, this does not imply entrepreneurs inherently struggle to obtain credit, as shown by Levenson and Willard (2000) and Parker and van Praag (2004). I follow the latter stream of thought for two reasons. First, technology allows individuals to become business owners at a low cost, as mentioned in the introduction. Furthermore, the relationship between entrepreneurship and getting credit is modest as shown by Figure 2.2b. By allowing the possibility of being hired in the labor market, this paper explains how there still might be competing incentives for business creation, despite high costs for entry or difficulties of obtaining credit. It also helps explain the puzzle of empirically observing high entry barriers along with high entry rates, posed by Geroski (1995).

Many empirical papers have touched on the cyclicality of self-employment but with no set consensus. Positive changes in the returns and environment of entrepreneurship boosts firm entry (entrepreneurial effect; Rees and Shah, 1986; Rampini, 2004; Fonseca et al., 2001). At the same time, lower employment from an economic boom implies lower motivation for workers to start their own business (refugee effect; Koellinger and Thurik, 2011; Thurik et al., 2008). Thus, the cyclicality of self-employment depends on which effect dominates, also shown by the empirical evidence from Table 2.2. By introducing a DSGE framework, this paper shows both forces in effect, but that the entrepreneurship effect dominates when calibrated for the US economy, consistent with the data.

The theoretical model used here follows the recent thread of literature in macroeconomics and international economics that stem from microeconomic foundations to study short-run business cycle fluctuations (Bilbiie et al., 2012; Cacciatore and Fiori, 2016; Ghironi and Melitz, 2005). Search and matching frictions in the labor market are introduced following Diamond (1982b) and Mortensen and Pissarides (1994) as real business cycle models do not focus on unemployment. The joint modeling of endogenous entry and labor market frictions is along the lines of Cacciatore (2014). Using this theoretical framework, my paper presents how a significant amount of employment coming from self-employment can induce a more volatile business cycle dynamics and inefficiency in the aggregate economy.

Lastly, this paper contributes to the ongoing discussion on structural reforms by considering different types of entrepreneurship when evaluating the effectiveness of deregulation in labor and product markets. The consequence of structural reforms depend on various factors such as type of reforms, timing, and relationship with other policies (Campos et al., 2017). Blanchard and Giavazzi (2003) shows that such deregulation leads to lower unemployment in the long run, although for labor market deregulation there can be a trade-off in the short run, which is also supported by Cacciatore et al. (2016) and Cacciatore and Fiori (2016). Everaert and Schule (2008) suggest that coordinating reforms across markets and countries can be beneficial. Fiori et al. (2007) looks at the relationship between product and labor market deregulations. I add to the literature by showing how reforms have a larger effect when they target actively hiring firms or those that produce more differentiated goods.

2.3 The Model

To focus on the unemployed's choice between continuing to look for a hired job and starting one's own business, I construct a closed economy model where two sectors exist. The hiring sector consists of firms that hire workers from the labor market to produce. Thus these firms are subject to search and matching frictions. The other sector has self-employed firms that do not hire any other employees and produce using the basket of standard sector goods as intermediate goods. Variables related to the standard sector are denoted by subscript h (for *hiring*) and variables from the self-employment sector are denoted by subscript s (for *self-employment*). All contracts and prices are written in nominal terms and prices are flexible. Thus I solve for real variables and money is only a unit-of-account as in the cashless economy of Woodford (2003).

2.3.1 Households

There exists a unit mass of atomistic, identical households. Each household is considered as a large extended family with a continuum of members along a unit interval. Whether how many family members work in equilibrium depends on the labor matching process and the free entry condition in self-employment. Once each family member earns some type of income, they pool all their earnings and there is full consumption sharing between employed and unemployed members (Andolfatto, 1996).

The representative household maximizes the expected intertemporal utility function:

$$\mathbb{E}_t \sum_{j=t}^{\infty} \beta^{j-t} \left[\frac{C_j^{1-\gamma}}{1-\gamma} \right] \tag{2.1}$$

where $\beta \in (0,1)$ is the discount factor and $1/\gamma$ is the intertemporal elasticity of substitution. The representative household's composite consumption basket C_t is an Armington aggregator of goods produced in two sectors – hiring sector ($C_{H,t}$) and self-employed sector ($C_{S,t}$):

$$C_t = \left[(1-\alpha)^{\frac{1}{\phi}} C_{H,t}^{\frac{\phi-1}{\phi}} + \alpha^{\frac{1}{\phi}} C_{S,t}^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}} \tag{2.2}$$

where $(1-\alpha) \in (0,1)$ is the degree of bias towards goods from hiring sector and $\phi > 0$ refers to the elasticity of substitution between $C_{H,t}$ and $C_{S,t}$.

By defining output as sum of price times quantity from both sectors, the corresponding price index is given as:

$$P_t = \left[(1-\alpha) P_{H,t}^{1-\phi} + \alpha P_{S,t}^{1-\phi} \right]^{\frac{1}{1-\phi}} \tag{2.3}$$

where $P_{H,t}$ and $P_{S,t}$ refer to price of sectoral output.

The sectoral output bundle consists of a continuum of goods – H and S – from each sector respectively in a Dixit-Stiglitz fashion, where $\theta_S > \theta_H > 1$ is the elasticity of substitution across different varieties:

$$C_{H,t} = \left[\int_{h \in H} y_t(h)^{\frac{\theta-1}{\theta}} dh \right]^{\frac{\theta}{\theta-1}}, \quad C_{S,t} = \left[\int_{s \in S} y_t(s)^{\frac{\theta-1}{\theta}} ds \right]^{\frac{\theta}{\theta-1}} \tag{2.4}$$

Note that θ_S is set greater than θ_H to incorporate the relatively weaker monopoly power in the self-employment sector.

At any period, while the household wants to consume goods in H and S, only a subset of goods $H_t \in H$ and $S_t \in S$ is available in each sector. Therefore, the price of each sectoral output bundle, or the price sub-index, is given as:

$$P_{H,t} = \left[\int_{h \in H_t} p_t(h)^{1-\theta_H} dh \right]^{\frac{1}{1-\theta_H}}, \quad P_{S,t} = \left[\int_{s \in S_t} p_t(s)^{1-\theta_S} ds \right]^{\frac{1}{1-\theta_S}} \tag{2.5}$$

where $p_t(h)$ and $p_t(s)$ are the prices of each variety in hiring and self-employment sector respectively.

The household's demand for the hiring sector's good h and the self-employed sector's good s is given by:

$$y_t(h) = (1-\alpha) \left(\frac{p_t(h)}{P_{H,t}} \right)^{-\theta_H} \left(\frac{P_{H,t}}{P_t} \right)^{-\phi} Y_t \tag{2.6}$$

$$y_t(s) = \alpha \left(\frac{p_t(s)}{P_{S,t}} \right)^{-\theta_S} \left(\frac{P_{S,t}}{P_t} \right)^{-\phi} Y_t \tag{2.7}$$

Real prices can be defined at both the firm level and the sectoral level as:

$$\rho_{h,t} \equiv p_t(h)/P_{H,t} \qquad \rho_{s,t} \equiv p_t(s)/P_{S,t} \tag{2.8}$$

$$\boldsymbol{\mathcal{P}}_{H,t} \equiv P_{H,t}/P_t \qquad \boldsymbol{\mathcal{P}}_{S,t} \equiv P_{S,t}/P_t \tag{2.9}$$

which then can be used to simplify the expressions for the demand functions as $y_t(h) = (1-\alpha)\rho_{h,t}^{-\theta_H} \boldsymbol{\mathcal{P}}_{H,t}^{-\phi} Y_t$ and $y_t(s) = \alpha \rho_{s,t}^{-\theta_S} \boldsymbol{\mathcal{P}}_{S,t}^{-\phi} Y_t$. This also allows me to write the model equations in real variables only.

2.3.2 Hiring Sector Firms

There is a continuum of monopolistically competitive firms in the standard hiring sector. Each produces a different variety h and are all subject to idiosyncratic sectoral productivity shock $Z_{H,t}$ respectively. For simplicity I assume there is no heterogeneity in firms' productivity. This implies that all firms are identical to each other and I can drop the index h.

Hiring firms follow a linear production function that requires only labor, hired from the labor market: $y_t(h) = Z_{H,t} l_{h,t}$, where $Z_{H,t}$ is the aggregate productivity of the hiring sector. A firm produces goods that are sold at a real price $\rho_{h,t}$. To produce, the firm requires workers, coming from either the pool of incumbent workers or from new matches it obtains from posting vacancies.

Labor Market

Job creation is subject to searching frictions in the labor market. The matching function is given as $M(U_t, V_t) = \chi U_t^{\xi} V_t^{1-\xi}$, where χ shows the efficiency of the matching process and $0 < \xi < 1$ is the matching elasticity. This constant-returns-to-scale function converts aggregate vacancies and aggregate unemployed workers into aggregate matches. The probability of a firm filling a vacancy is defined as $q(\theta_t) \equiv M_t/V_t$. The probability of an unemployed worker being matched to a firm is given as $\iota(\theta_t) \equiv M_t/U_t$. This implies that I can rewrite them as a function of labor market tightness, $\theta_t \equiv V_t/U_t$. If the labor market is tighter (higher θ_t), it implies that workers have an easier time finding a job.

The amount of workers that produces each period depends on the exogenous firing rate $\lambda \in (0, 1)$ and the number of vacancies that are filled. In every period, a fixed fraction λ of workers is fired. To hire new workers, a firm posts vacancies of v_t, out of which only $q_t v_t$ are actually filled. Following Krause and Lubik (2007), the newly hired matches become productive immediately. This gives the law of motion for employment in each firm:

$$l_{h,t} = (1-\lambda) l_{h,t-1} + q_t v_t \tag{2.10}$$

In sum, in each period, a firm chooses real price of the good ($\rho_{h,t}$), labor ($l_{h,t}$), and number of vacancies to post (v_t) to maximize its intertemporal stream of profits subject to equations (2.6), (2.10), and the production function:

$$\mathbb{E}_t \sum_{j=t}^{\infty} \beta_{t,j} \left\{ \rho_{h,j} \boldsymbol{\mathcal{P}}_{H,t} \, y_j(h) - w_j l_{h,j} - \kappa v_j \right\} \tag{2.11}$$

Out of the revenue that the firm obtains, $\rho_{h,j} y_j(j)$, it pays the workers the wage and the real cost of posting a vacancy, κ, for each vacancy posted. $\beta_{t,j}$ is the stochastic discount factor, defined as $\beta_{t,j} \equiv \beta^{j-t} \left(u_{C,j} / u_{C,t} \right)$.

Solving for the first-order conditions with respect to $l_{h,t}$ and v_t yields the following equation:

$$\frac{\kappa}{q_t} = \varphi_{h,t} Z_{H,t} - w_t + (1-\delta_H)(1-\lambda) \, \mathbb{E}_t \, \beta_{t,t+1} \frac{\kappa}{q_{t+1}} \tag{2.12}$$

where $\varphi_{h,t}$ is the real marginal cost of production. This is the job creation equation of a firm. Each firm posts vacancies and hires workers until the marginal cost of posting a vacancy equals its marginal benefit. By hiring one extra worker, the firm enjoys marginal revenue product ($\varphi_{h,t} Z_{H,t}$) net of the wage it pays. It also saves the vacancy cost next period if the match survives the exogenous firing rate, shown by the last term on the right- hand side of the equation.

Furthermore, the first-order condition gives the optimal pricing equation of the hiring firms, $\rho_{h,t} = \left(\frac{\theta_H}{\theta_H - 1} \right) \frac{\varphi_{h,t}}{\mathcal{P}_{H,t}}$, which shows firms putting constant markup over the real marginal cost. Consequently, the real profit of the hiring firm can be written as:

$$
\begin{aligned}
d_{h,t} &= \left(\rho_{h,t} \mathcal{P}_{H,t} - \varphi_{h,t}\right) y_t(h) \\
&= \frac{1}{\theta_H} \left[(1-\alpha) \rho_{h,t}^{1-\theta_H} \mathcal{P}_{H,t}^{1-\phi} Y_t + \rho_{h,t}^{1-\theta_H} \mathcal{P}_{H,t} M_{s,t} N_{S,t} \right]
\end{aligned}
\tag{2.13}
$$

Endogenous Firm Entry

The number of products available is endogenously determined every period. To create a new variety, the entrant has to pay a sunk entry cost of $f_{EH,t}$. The entry cost has three components – regulation cost (f_{rh}), technological cost for business creation (f_{Th}), and cost of posting vacancies to hire enough workers to start producing. The latter cost is due to the entrants needing to build up initial stock of workers to produce. Thus the entry cost for a hiring firm is $f_{EH,t} \equiv f_{rh} + f_{Th} + \kappa v_{E,t}$, where $v_{E,t}$ is the number of vacancies posted by new entrants. Since the new entrants are identical to the incumbent firms, the stock of labor needed is also $l_{h,t}$. Combined with the timeline of firms, the vacancies posted by new entrants, $v_{E,t}$, is equal to $l_{h,t}/q_t - v_t$. Due to labor market tightness being time dependent, the entry cost for new entrants in the hiring sector changes over time. There is no time-to-build lag and new entrants start producing in the same period.

Prospective entrants are forward-looking and calculate their expected post-entry value of becoming an entrepreneur based on future stream of profits and exogenous exit rate, $\delta_H \in (0,1)$. Then the value of a hiring firm is:

$$
e_{h,t} = d_{h,t} + \mathbb{E}_t \left[\sum_{j=t+1}^{\infty} (1-\delta_H)^{j-t} \beta_{t,j} d_{h,j} \right] \tag{2.14}
$$

Entrants enter only when this value of firm is enough to cover the sunk entry costs, leading to the free entry condition $f_{EH,t} = e_{h,t}$. Once they enter, they continue to produce until they are hit by the death shock, δ_H, and exit. This gives rise to the law of motion for hiring firms:

$$N_{H,t} = (1 - \delta_H) N_{H,t-1} + N_{HE,t} \tag{2.15}$$

where the number of producing firms is determined by the number of incumbents that survive the death shock and new entrants in the period.

2.3.3 Self-Employment Sector Firms

Firms in the self-employment sector are assumed to stay small with no other employees. Therefore, they do not participate in the labor market. Instead, they use the basket of goods from the hiring sector as intermediate goods for production: $y_t(s) = Z_{S,t} M_{s,t}$. $Z_{S,t}$ is the aggregate productivity of self-employed sector and $M_{s,t}$ is the amount of of hiring sector goods basket used as intermediate goods.

The self-employed chooses $\rho_{s,t}$ to maximize profits each period:

$$\max \rho_{s,t} \boldsymbol{\mathcal{P}}_{S,t}\, y_t(s) - \boldsymbol{\mathcal{P}}_{H,t}\, M_{s,t} \tag{2.16}$$

The profit maximization problem for these firms is a static one since these businesses do not have a stock of labor as the hiring firms. From the first-order condition, the optimal pricing equation is obtained:

$$\rho_{s,t} = \left(\frac{\theta_S}{\theta_S - 1} \right) \frac{\boldsymbol{\mathcal{P}}_{H,t}}{\boldsymbol{\mathcal{P}}_{S,t}\, Z_{S,t}} \tag{2.17}$$

where $\boldsymbol{\mathcal{P}}_{H,t} / Z_{s,t}$ is the real marginal cost of the self-employed, defined as $\varphi_{s,t}$. As a result, the real profit for the self-employed is given by:

$$\begin{aligned} d_{s,t} &= (\rho_{s,t} \boldsymbol{\mathcal{P}}_{S,t} - \varphi_{s,t})\, y_t(s) \\ &= \frac{1}{\theta_S} \alpha \rho_{s,t}^{1-\theta_S} \boldsymbol{\mathcal{P}}_{S,t}^{1-\phi}\, Y_t \end{aligned} \tag{2.18}$$

Endogenous Firm Entry

Like hiring firms, self-employed firms enter until one-time entry cost is equal to the future stream of benefits. The value of a self-employed firm is the current and future expected stream of profits:

$$e_{s,t} = d_{s,t} + \mathbb{E}_t \left[\sum_{j=t+1}^{\infty} (1-\delta_S)^{j-t} \beta_{t,j} d_{s,j} \right] \tag{2.19}$$

Only when this value of self-employment is enough to cover the entry costs will an unemployed worker enter the market. Thus the free entry condition for necessity-driven enterprises is $f_{rs} + f_{Ts} \equiv f_{ES} = e_{s,t}$. Notice that for the self-employed, the entry cost only consists of the regulation cost and technology cost since they do not participate in the labor market.

Similar to the hiring firms, the self-employed become productive in the same period they enter. Once the entrepreneurs start a business, they continue to produce until hit by the death shock $\delta_S \in (0,1)$. Empirical evidence suggests that the necessity-driven businesses are more likely to choose industries prone to low entry barriers and high exit rates. To incorporate this characteristic, the exit rate for the self-employed sector is set higher than that of the hiring sector.

There is no endogenous choice by the incumbent self-employed to exit the market. Even if business owners are allowed to do so voluntarily and join the unemployment pool, under reasonable calibration the surplus from continuing as an entrepreneur is always larger that that of exiting and searching for hired work. Then the law of motion for self-employment is:

$$N_{S,t} = (1-\delta_S)N_{S,t-1} + N_{SE,t} \tag{2.20}$$

Because of the assumption of one-man firm that I made earlier, the law of motion of employment for the self-employed is equivalent to the law of motion for firms in the self-employment sector.

The timing of events is as the following. In any given period t, at the start of the period matches are exogenously separated and are added to the existing unemployment pool. Aggregate shocks are realized in both sectors. The new entrants pay sunk entry cost and enter. Standard sector firms post vacancies and matching occurs. After the hiring round, all active firms in both sectors produce. Finally, a portion of the firms are hit by the relevant death shocks and ceases to exist.

2.3.4 Labor Market

The labor market in this paper has three states for the worker: employed, unemployed, and self-employed. The employment status for a family member in each period is determined endogenously. This process is described in Figure 2.3. If a worker is employed this period, he either continues to be employed next period or is fired. As an unemployed worker, one can choose between searching for a wage-paying job and self-employment. If already self-employed, he is exposed to the same death shock as any other firm.

It is possible to depict the same figure using Bellman equations. The value for a worker from employment can be written as:

$$W_t = w_t + \mathbb{E}_t\, \beta_{t,t+1}\Big[(1-\delta_H)(1-\lambda)W_{t+1} + \{1-(1-\delta_H)(1-\lambda)\}\max(U_{u,t+1}, -f_{ES} + S_{t+1})\Big] \tag{2.21}$$

If employed, the worker gains wage and the discounted continuation value of being employed next period only if he is not fired and the firm survives the death shock. What happens if the worker is fired? In the standard Diamond-Mortensen-Pissarides model, the worker is added to the pool of unemployed workers. However, here the unemployed can choose between staying in the labor market and keep searching for hired work or paying sunk entry cost to become an entrepreneur. Which option the worker chooses depends on the value of unemployment and starting self-employment. The value of unemployment is written as the following:

$$U_{u,t} = u_b + \mathbb{E}_t\,\beta_{t,t+1}\Big[(1-\delta_H)\iota_{t+1}W_{t+1} + \big\{1-(1-\delta_H)\iota_{t+1}\big\}\max(U_{u,t+1}, -f_{ES}+S_{t+1})\Big] \tag{2.22}$$

If a worker is unemployed, she receives unemployment benefits of u_b. With probability ι_{t+1} next period, the worker is matched to a firm and gains value from employment. If not matched, the worker again faces the possibility of switching to self-employment.

Since I assume that the self-employed becomes productive right away, if the unemployed decides to start one's own business, she pays the entry cost and earns the value from self-employment beginning today $(-f_{ES}+S_t)$. The value of being self-employed is determined by the expected future stream of profits and the probability of exiting the market, δ_S:

$$S_t = d_{s,t} + \mathbb{E}_t\,\beta_{t,t+1}\Big[(1-\delta_S)S_{t+1} + \delta_S(1-\delta_H)\iota_{t+1}W_{t+1} + \big\{1-\delta_S(1-\delta_H)\iota_{t+1}\big\}\max(U_{u,t+1}, -f_{ES}+S_{t+1})\Big] \tag{2.23}$$

After earning profit $d_{s,t}$ from the business, she continues as a business owner if she is not hit by the death shock. Once the self-employed is hit by the death shock, she joins the pool of unemployed workers right away. In this case, she can try to be matched to a hiring firm. If this is unsuccessful, it is again up to the worker's decision to either stay in the labor market as an unemployed worker or start one's own firm again.

Wage Setting

The worker's surplus for being matched is defined as $S_t^W \equiv W_t - \max(U_{u,t}, -f_{ES}+S_t)$, depending on the outside option of the worker. Because both the unemployed and self-employed exist in the economy, $U_{u,t} = -f_{ES}+S_t$ needs to be satisfied in equilibrium. This implies the surplus of a match for the worker can be simply written as $S_t^W \equiv W_t - U_{u,t}$.

Then the expression for worker's surplus becomes:

$$S_t^W = w_t - \bar{\omega}_{h,t} + (1 - \delta_H)(1 - \lambda)\,\mathbb{E}_t\,\beta_{t,t+1} S_{t+1}^W \tag{2.24}$$

where the worker's outside option is the sum of unemployment benefits today and expected value coming from the possibility of being matched next period: $\bar{\omega}_{h,t} = u_b + (1 - \delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}\iota_{t+1} S_{t+1}^W$.

If a hiring firm successfully fills a vacancy by being matched to a worker, the surplus it obtains can be written as the following:

$$S_t^F = \varphi_{h,t} Z_{H,t} - w_t + (1 - \delta_H)(1 - \lambda)\,\mathbb{E}_t\,\beta_{t,t+1} S_{t+1}^F \tag{2.25}$$

Once a worker is hired, the firm gains marginal revenue product and pays real wage. Surplus from the match continues next period only if the worker survives through the exogenous firing rate λ.

I assume Nash bargaining as the wage setting rule. Once a firm and a worker are matched, they split the joint surplus $(S_t^W)^\eta (S_t^F)^{1-\eta}$ according to their bargaining power. Put differently, the Nash bargaining maximizes the joint surplus with respect to w_t. Then the first order condition implies the bargaining solution is $\eta S_t^F = (1 - \eta) S_t^W$, where $\eta \in (0, 1)$ is the worker's bargaining power. From this I obtain the bargained wage, which is a weighted average of the marginal revenue product and the worker's outside option:

$$w_t = \eta \varphi_{h,t} Z_{H,t} + (1 - \eta)\bar{\omega}_{h,t} \tag{2.26}$$

Note that a hired worker has no incentive to switch to self-employment, as long as the surplus from the match is positive. Since in equilibrium the value of unemployment is equal to that of self-employment, the surplus from being matched for an unemployed worker (S_t^W) is equal to the surplus from the match for the newly self-employed ($S_t^S \equiv W_t - \{-f_{ES} + S_t\}$). As long as $S_t^W > 0$, value of employment is always greater than that of becoming self-employed.

Budget Constraint of the Household

The extended family in the representative household have three types of family members: hired in the standard sector ($L_{h,t}$), self-employed ($N_{S,t}$), and unemployed. The employed members in the hiring sector earn real wage w_t. The self-employed earns profits $d_{s,t}$ as their income. Both the hired and self-employed are considered as employed: $L_t \equiv L_{H,t} + N_{S,t} = l_{h,t}N_{H,t} + N_{S,t} \in [0,1]$. The rest, $1 - L_t$, earns unemployment benefits of u_b, financed by lump-sum taxes from the government ($T_t = (1 - L_t)u_b$). Note that because the family members are in the unit interval, L_t is equal to the employment rate.

The household starts the period with x_t shares of mutual funds of $(1-\delta_H)N_{H,t-1}$ incumbent hiring firms. The share holdings can be sold for $e_{h,t}$. Thus $e_{h,t}x_t(1-\delta_H)N_{H,t-1}$ enters the budget constraint as income. During the same period, the household purchases shares for the next period, x_{t+1}, by paying $e_{h,t}$ to finance entry and continued production in the hiring sector. Since new entrants become productive in the same period, all existing firms pay dividends, $d_{h,t}x_{t+1}N_{H,t}$. Note that there is no shareholdings for self-employed firms but the household still pays the entry costs.

Out of the total income that the household members earn through different channels, some are used to pay taxes and finance the entry cost of entrants in both sectors. The rest goes towards consumption. Then the budget constraint of the household can be written as the following:

$$\begin{aligned} & C_t + T_t + e_{h,t}N_{H,t}x_{t+1} + f_{ES}N_{SE,t} \\ & \quad = w_t l_{h,t} N_{H,t} + d_{s,t}N_{S,t} + u_b(1-L_t) + e_{h,t}x_t(1-\delta_H)N_{H,t-1} + d_{h,t}x_{t+1}N_{H,t} \end{aligned} \tag{2.27}$$

The first order condition with respect to x_t gives the Euler equations for the value of the hiring firm:

$$e_{h,t} = d_{h,t} + (1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}e_{h,t+1} \tag{2.28}$$

The expressions for $e_{h,t}$ in (2.14) can be obtained through forward iteration of the Euler equation above if we do not allow any speculative bubbles.[6]

2.3.5 Closing the Model

Once the sectoral basket of goods ($Y_{H,t}$ and $Y_{S,t}$) are produced, perfectly competitive retailers combine them to produce a final good Y_t. This final good is written as the following:

$$Y_t = \left[(1-\alpha)^{\frac{1}{\phi}} Y_{H,t}^{\frac{\phi-1}{\phi}} + \alpha^{\frac{1}{\phi}} Y_{S,t}^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}} \tag{2.29}$$

Aggregate output is used for consumption after financing entry costs in both sectors and vacancy posting costs:

$$Y_t = C_t + \kappa V_t + (f_{rs} + f_{Ts}) N_{SE,t} + (f_{rh} + f_{Th}) N_{HE,t} \tag{2.30}$$

where vacancies are posted by both incumbents and entrants in the hiring sector ($V_t = v_t N_{H,t} + v_{E,t} N_{HE,t}$). Unemployment in the economy is:

$$U_t \equiv 1 - (1-\lambda) L_{h,t} - N_{S,t} \tag{2.31}$$

In equilibrium, aggregate price index satisfies:

$$1 = (1-\alpha) \boldsymbol{\mathcal{P}}_{H,t}^{1-\phi} + \alpha \boldsymbol{\mathcal{P}}_{S,t}^{1-\phi} \tag{2.32}$$

where:

$$\boldsymbol{\mathcal{P}}_{H,t} = \left(\frac{p_t(h)}{P_t} \right) N_{H,t}^{\frac{1}{1-\theta_H}}, \quad \boldsymbol{\mathcal{P}}_{S,t} = \left(\frac{p_t(s)}{P_t} \right) N_{S,t}^{\frac{1}{1-\theta_S}} \tag{2.33}$$

[6] There are no share holdings for the self-employed firms. However, one can assume there is a mutual fund of the self-employed and solve for the first order condition to find the Euler equation for the value of a self-employed firm.

In each sector, supply of goods should equal the demand for those goods. While the self-employment sector only serves the household, the hiring sector supplies to both the household (through consumption) and the self-employed (through intermediate goods). Thus output clearing in each sector is written as:

$$Z_{H,t}l_{h,t} = (1-\alpha)\rho_{h,t}^{-\theta_H}\boldsymbol{\mathcal{P}}_{H,t}^{-\phi}Y_t + \rho_{h,t}^{-\theta_H}M_{s,t}N_{S,t} \tag{2.34}$$

$$Z_{S,t}M_{s,t} = \alpha\rho_{s,t}^{-\theta_S}\boldsymbol{\mathcal{P}}_{S,t}^{-\phi}Y_t \tag{2.35}$$

Aggregate number of posted vacancies are $V_t = v_t$ – vacancies only come from the standard sector since entrepreneurs out of necessity do not hire any other workers. Productivity shocks in both sectors follow AR(1) processes in logs:

$$Z_{H,t} = \rho_H Z_{H,t-1} + \epsilon_{ZH,t},\ \ \epsilon_{ZH,t} \sim N(0, \sigma_{ZH}^2) \tag{2.36}$$

$$Z_{S,t} = \rho_S Z_{S,t-1} + \epsilon_{ZS,t},\ \ \epsilon_{ZS,t} \sim N(0, \sigma_{ZS}^2) \tag{2.37}$$

Table 2.3 summarizes the main equations of the model. The model is a system of 33 equations and 33 variables: C_t, $l_{h,t}$, U_t, V_t, $N_{S,t}$, $N_{SE,t}$, $N_{H,t}$, $N_{HE,t}$, $v_{E,t}$, v_t, $e_{h,t}$, $d_{h,t}$, $e_{s,t}$, $d_{s,t}$, w_t, $\bar{\omega}_{h,t}$, $\bar{\omega}_{s,t}$, $\varphi_{h,t}$, $\varphi_{s,t}$, $f_{eh,t}$, $\rho_{h,t}$, $\rho_{s,t}$, $\boldsymbol{\mathcal{P}}_{H,t}$, $\boldsymbol{\mathcal{P}}_{S,t}$, $y_{h,t}$, $y_{s,t}$, $Y_{H,t}$, $Y_{S,t}$, Y_t, $M_{s,t}$, M_t, ι_t, q_t.

Data-Consistent Variables

While in the model the household prefers consuming various goods, this variety effect is not included in the actual data. To correct for this, I follow a similar approach as Cacciatore et al. (2017) and set up a data-consistent price index $\tilde{P}_t$ using deflator Ω_t:

$$\tilde{P}_t \equiv \Omega_t^{\frac{1}{\phi-1}} P_t \tag{2.38}$$

$$\Omega_t \equiv (1-\alpha)N_{H,t}^{\frac{1-\phi}{1-\theta_H}} + \alpha N_{S,t}^{\frac{1-\phi}{1-\theta_S}} \tag{2.39}$$

Then for any real variable X_t in units of consumption, the equivalent data-consistent real variable can be constructed as $\tilde{X}_t \equiv P_t X_t / \tilde{P}_t = X_t \Omega_t^{\frac{1}{1-\phi}}$. The second moments of the model are found using the data-consistent variables.

2.4 The Planner's Solution and the Determinants of Inefficiency

To discuss efficiency of the decentralized economy, one needs to compare it to a first-best allocation. This is done by looking at the hypothetical centralized economy where a benevolent social planner chooses the allocation that maximizes social welfare.

As explained in detail in Appendix G, the social planner chooses $\{C_{H,j}, C_{S,j}, L_{H,j}, N_{S,j}, M_{S,j}, V_j\}_{j=t}^{\infty}$ to maximize the intertemporal utility function (eq. (2.1)) subject to the following constraints:

$$L_{H,t} = (1-\lambda)L_{H,t-1} + \chi(1-(1-\lambda_t)L_{H,t} - N_{S,t})^{\xi} V_t^{1-\xi} \tag{2.40}$$

$$\begin{aligned} Y_t = C_t + \kappa V_t &+ (f_{rh} + f_{Th})\{N_{H,t} - (1-\delta_H)N_{H,t-1}\} \\ &+ (f_{rs} + f_{Ts})\{N_{S,t} - (1-\delta_S)N_{S,t-1}\} \end{aligned} \tag{2.41}$$

$$\rho(N_{H,t})Z_{H,t}L_{H,t} = C_{H,t} + M_{s,t}N_{s,t} \tag{2.42}$$

$$\rho(N_{S,t})Z_{S,t}M_{s,t}N_{S,t} = C_{S,t} \tag{2.43}$$

where expressions for C_t and Y_t are

$$C_t = \left[(1-\alpha)^{1/\phi} C_{H,t}^{\frac{\phi-1}{\phi}} + \alpha^{1/\phi} C_{S,t}^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}} \tag{2.44}$$

$$Y_t = \left[(1-\alpha)^{1/\phi}(Z_{H,t}L_{H,t})^{\frac{\phi-1}{\phi}} + \alpha^{1/\phi}(\rho_{s,t}N_{S,t}Z_{S,t}M_{s,t})^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}} \tag{2.45}$$

The efficient allocations are determined by the four equations below – each representing the marginal rate of substitution between two sector goods, job creation, and free entry condition for hiring and self-employed sector respectively – derived from the first-order conditions:

$$\frac{\xi_{H,t}}{\xi_{S,t}} = \left(\frac{\alpha C_{H,t}}{(1-\alpha)C_{S,t}}\right)^{-1/\phi} \tag{2.46}$$

$$\begin{aligned}\frac{\kappa}{q_t} &= (1-\xi)\rho(N_{H,t})Z_{H,t}\left[A_t\left(\frac{C_{H,t}}{(1-\alpha)C_t}\right)^{-1/\phi} + \left(\frac{\rho(N_{H,t})Z_{H,t}L_{H,t}}{(1-\alpha)Y_t}\right)^{-1/\phi}\right] \\ &\quad - (1-\lambda)\xi\iota_t\frac{\kappa}{q_t} + (1-\lambda)(1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}\left(\frac{1+A_t}{1+A_{t+1}}\right)\frac{\kappa}{q_{t+1}}\end{aligned} \tag{2.47}$$

$$\begin{aligned}f_{rh} + f_{Th} &= \frac{\theta_H}{\theta_H - 1}\rho(N_{H,t})Z_{H,t}l_{h,t}\left[A_t\left(\frac{C_{H,t}}{(1-\alpha)C_t}\right)^{-1/\phi} + \left(\frac{\rho(N_{H,t})Z_{H,t}L_{H,t}}{(1-\alpha)Y_t}\right)^{-1/\phi}\right] \\ &\quad + (1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}\left(\frac{1+A_t}{1+A_{t+1}}\right)(f_{rh} + f_{Th})\end{aligned} \tag{2.48}$$

$$\begin{aligned}f_{rs} + f_{Ts} &= \frac{\theta_S}{\theta_S - 1}\rho(N_{S,t})Z_{S,t}M_{s,t}\left[A_t\left(\frac{C_{S,t}}{\alpha C_t}\right)^{-1/\phi} + \left(\frac{\rho(N_{S,t})N_{S,t}Z_{S,t}M_{s,t}}{\alpha Y_t}\right)^{-1/\phi}\right] \\ &\quad - A_t\left(\frac{C_{H,t}}{(1-\alpha)C_t}\right)^{-1/\phi}M_{s,t} - \frac{\xi}{1-\xi}\iota_t\frac{\kappa}{q_t} + (1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}\left(\frac{1+A_t}{1+A_{t+1}}\right)(f_{rs} + f_{Ts})\end{aligned} \tag{2.49}$$

where A_t is defined as:

$$A_t \equiv \left(\frac{C_{S,t}}{\alpha Y_t}\right)^{1/\phi}\left[\frac{1}{\rho(N_{S,t})Z_{S,t}}\left(\frac{C_{H,t}}{(1-\alpha)C_t}\right)^{-1/\phi} - \left(\frac{C_{S,t}}{\alpha C_t}\right)^{-1/\phi}\right] \tag{2.50}$$

This A_t is zero when the marginal product from self-employed is equal to the marginal rate of substitution between hiring and self-employed sector goods ($\rho(N_{S,t})Z_{S,t} = (\alpha C_{H,t}/(1-\alpha)C_{S,t})^{1/\phi}$). This result stems from the fact that one more unit of hiring sector good utilized as intermediate goods implies one less unit available for final goods consumption of the household.

There are three possible margins where inefficiency wedges can arise: job creation margin and product creation margin in hiring and self-employed sectors. Margins for both the decentralized and centralized economies are described in Table 2.6. The wedges can be analytically found by subtracting the right-hand side of allocation conditions of the social planner from that of the decentralized economy. As a result, the inefficiency wedge along the job creation margin is written as:

$$\Sigma_{JC,t} = \frac{q_t}{\kappa}\left[(\varphi_{h,t}Z_{H,t} - w_t) - (1-\xi)\rho(N_{H,t})Z_{H,t}\left\{A_t\left(\frac{C_{H,t}}{(1-\alpha)C_t}\right)^{-1/\phi} + \left(\frac{\rho(N_{H,t})Z_{H,t}L_{H,t}}{(1-\alpha)Y_t}\right)^{-1/\phi}\right\}\right]$$
$$+ (1-\lambda)\xi\iota_t + (1-\delta_H)(1-\lambda)\,\mathbb{E}_t\,\beta_{t,t+1}\left(1 - \frac{1+A_t}{1+A_{t+1}}\right)\frac{q_t}{q_{t+1}} \tag{2.51}$$

Similarly, the inefficiency wedges along the product creation margins in hiring ($\Sigma_{PCH,t}$) and self-employed ($\Sigma_{PCS,t}$) sectors are:

$$\Sigma_{PCH,t} = \frac{1}{f_{rh}+f_{Th}}\left\{\frac{1}{\theta_H}\rho(N_{H,t})\boldsymbol{\mathcal{P}}_{H,t}\,Z_{H,t}l_{h,t} - \kappa\left(\frac{l_{h,t}}{q_t} - v_t\right)\right.$$
$$\left. - \frac{\theta_H}{\theta_H - 1}\rho(N_{H,t})Z_{H,t}l_{h,t}\left[A_t\left(\frac{C_{H,t}}{(1-\alpha)C_t}\right)^{-1/\phi} + \left(\frac{\rho(N_{H,t})Z_{H,t}L_{H,t}}{(1-\alpha)Y_t}\right)^{-1/\phi}\right]\right\}$$
$$+ (1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}\left(\frac{e_{h,t+1}}{f_{rh}+f_{Th}} - \frac{1+A_t}{1+A_{t+1}}\right) \tag{2.52}$$

$$\Sigma_{PCS,t} = \frac{1}{f_{rs}+f_{Ts}}\frac{1}{\theta_S}\rho(N_{S,t})\boldsymbol{\mathcal{P}}_{S,t}\,Z_{S,t}M_{s,t}\left\{1 - \frac{\theta_S^2}{\theta_S - 1}\frac{\rho_{S,t}Z_{S,t}M_{s,t}}{\boldsymbol{\mathcal{P}}_{S,t}}\right.$$
$$\left.\times\left[A_t\left(\frac{C_{S,t}}{\alpha C_t}\right)^{-1/\phi} + \left(\frac{\rho(N_{S,t})Z_{S,t}M_{s,t}}{\alpha Y_t}\right)^{-1/\phi}\right]\right\} + \frac{1}{f_{rs}+f_{Ts}}\frac{\xi}{1-\xi}\iota_t\frac{\kappa}{q_t}$$
$$+ (1-\delta_S)\,\mathbb{E}_t\,\beta_{t,t+1}\left(1 - \frac{1+A_t}{1+A_{t+1}}\right) \tag{2.53}$$

What is noticeable here is that even if we assume that the Hosios condition holds ($\eta = \xi$), there exists no monopoly power in both sectors ($\rho_{k,t} = \varphi_{k,t}$ for $k \in \{h,s\}$), and no unemployment benefits ($u_b = 0$), the decentralized economy is not equal to that of the social planner. For the job creation margin wedge, only when A_t is equal to zero and $1-\alpha$ fraction of output is from the hiring sector is real wage determined as:

$$w_t = \xi\rho_{h,t}Z_{H,t} + (1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}\iota_{t+1}\frac{\xi}{1-\xi}\frac{\kappa}{q_{t+1}} + \xi\kappa\theta_t \tag{2.54}$$

and the inefficiency wedge is zero.

This is due to three additional factors stemming from self-employment that exist in the wedges. First, the self-employed do not take into account the impact they have on the labor market tightness when entering. If an unemployed worker starts one's own business, there is going to be a shrink in the unemployment pool, raising job finding rate and lowering vacancy filling rate. They also do not consider the impact on the final goods consumption when using hiring sector goods as intermediates to produce goods in the self-employment sector. Furthermore, when hiring firms post vacancies, they do not consider the present discounted value of self-employment that could have been created if the worker had not been matched to the firm.

2.5 Calibration

I use quarters as periods and set certain parameters according to the standard literature. Discount factor β is set at 0.99, which is interpreted as an annual real interest rate of 4%. Following Ghironi and Melitz (2005), elasticity of substitution across varieties for the hiring sector, θ_H, is equal to 3.8. For the self-employed sector, θ_S is set to 6.38. This reflects the relatively low markup in industries (53-68% of manufacturing sector's markup) the self-employed often select into, which are transportation, retail trade, and services such as accommodation and restaurants (Christopoulou and Vermeulen (2012)). The risk aversion coefficient γ is set at 2. Measuring elasticity of substitution between goods from hiring sector and self-employed sector is difficult. However, empirical evidence suggests that the majority of the self-employed produce nontradable service goods and serve only the domestic market. Thus I use the elasticity of substitution between tradables and nontradables for ϕ. This parameter is set at 0.5, following Mendoza (1992). The share of hiring sector goods, $1-\alpha$, is given as 0.3 to reflect the relatively smaller output generated by the self-employed.

To capture the characteristics of the product and labor market, I calibrate parameters according to the US economy for 1977:Q1 - 2007:Q4. Elasticity of the matching function ξ is set at 0.5 to match the midpoint of the estimates in Blanchard and Diamond (1989). Bargaining power of the worker η is equal to 0.5 to satisfy the Hosios condition. This ensures that the competitive equilibrium in this economy is efficient. Exogenous separation rate λ and exit rate for the hiring sector δ_H are calculated to match the total separation rate. λ^{tot} is set at 0.077, which is slightly higher than the estimates by Hall (2005), to capture the fact that separation rates are higher for smaller firms (Hobijn and Sahin (2009)).

The exit rates of industries that the self-employed select into most (transportation and services for the US) are higher compared to the manufacturing sector[7]. The probability of exiting is also much higher for smaller firms, around 16% for firms with less than 5 employees compared to 3-4% for larger sized firms (US Census Business Dynamics Statistics (2016)). To reflect this, exogenous exit rate δ_S for the self-employed is set at 0.1, which is twice as high compared to the hiring sector. Value from unemployment is equal to 90% of steady-state wage, which includes the average replacement rate of 0.54 of the US reported by OECD (2019) and the constant disutility from labor. Following Ebell and Haefke (2009b), the fixed portion of the entry cost (regulation and technological cost) for the hiring sector is calculated as 5.2 months of lost output. To incorporate the empirical evidence that the self-employed largely select into industries with lower entry to barrier and produce goods already available in the economy (Hurst and Pugsley (2012)), the entry cost for the self-employed is lower at 2 months of lost output.

Following the literature, I calibrate the values of matching efficiency χ and cost of posting vacancies κ to match the unemployment rate and probability of filling a vacancy. The job finding probability (ι) is set at 0.75 since the median unemployment duration is 6 weeks, consistent with the findings in Hobijn and Sahin (2009). Probability of filling a vacancy (q) is set at 0.9, which is in line with Andolfatto (1996). This yields the steady-state level of self-employed at 7.4% of total employment and the unemployment rate of 9.6%.

Finally, the exogenous aggregate productivity shock for the hiring sector (Z_H) and the self-employed sector (Z_S) follow an AR(1) process in logs with persistence of 0.95 and standard deviation of 0.0072, following the common RBC literature. The benchmark calibration

[7] In 2016, the exit rates of transportation, communications, electric, gas, and sanitary services sector and services sector were 10.3% and 8.9% respectively, compared to 6.8% for the manufacturing sector.

is summarized in Table 2.4.

2.6 Business Cycle Properties

2.6.1 Impulse Responses

Figure 2.4 depicts the response of the economy after a positive temporary productivity shock in the hiring sector of size one standard deviation (blue solid line). For comparison purposes, I construct an alternative economy with same parameter values except for the dynamics of self-employment. Put differently, the number of self-employed stays at the steady-state level with no entry and exit, similar to the traditional Diamond-Pissarides-Mortensen (DMP) model. Having such two setups allows me to explicitly observe the change that arises after including subsistence business as an occupational choice. The responses of this economy without fluctuations in self-employment is denoted with orange dashed lines. All variables are in percentage deviations from the steady state except unemployment, which is in deviations from the steady state.

It is possible to observe the opposite forces on self-employment at work from the impulse responses. As expected, after an increase in hiring sector's productivity, output rises. This gives more incentive to the firms in the standard sector to hire more workers by posting more vacancies. Because the labor market is tighter, workers have an easier time finding jobs, as shown by the higher job finding rate. This dampens the refugee effect of self-employment. However, after the positive productivity shock, more self-employed enterprises are created due to the environment being more favorable to business creation in general. Put differently, expected future stream of profits is higher for the self-employed, making it easier for them to enter. In sum, the entrepreneurial effect is stronger, leading to a procyclical self-employment.

Compared to the case where self-employment channel is shut down, in my benchmark model, relatively more workers choosing into business creation decreases the unemployment pool available to the hiring firms. This additional source of firm entry contributes to the overall volatility of active firms in the economy. It also increases vacancy posting costs and hiring firms post vacancies relatively less. At the same time, entry into self-employment sector pushes demand for hiring sector goods further through the entrepreneurs' demand for intermediate goods.

As a result, employment in the standard sector increases by less and wages for the hired workers end up being higher. Nonetheless unemployment rate falls relatively more since more workers are employed in the economy – but in the self-employment sector. In other words, a shift of employment between sectors is observed. As a result, consumption increases by more under the economy with self-employment.

Figure 2.5 shows the impulse responses after the same positive productivity shock of size one standard deviation but in the self-employed sector. Overall the magnitudes are smaller since the self-employed sector is smaller. The effect on the labor market variables are also more modest due to the self-employed firms being solopreneurs with no other employees. This will have an effect on the structural reforms (more details in Section 2.7).

2.6.2 Steady State Analysis

For a better understanding of self-employment, it is beneficial to investigate the link between self-employment and unemployment (more details can be found in Appendix F). In steady state, the total separation rate is $\lambda^{tot} = [\delta_H + \lambda(1 - \delta_H)](1 - N_S/L)$, where N_S/L is the self-employment rate as a fraction of total employment. While lower exit rate in the hiring sector and exogenous separation rate contribute to a lower separation rate in total, a higher self-employment rate also leads to a lower λ^{tot} $(\partial\lambda^{tot}/\partial(N_S/L) < 0)$.

Since in steady state the number of new matches equals the number of separations in the labor market, using the relationship $\lambda^{tot}L = \iota U$, I can solve for the steady-state expression of unemployment rate as the following:

$$U = \frac{\lambda^{tot}\{\delta_H + \lambda(1 - \delta_H)\}}{(\iota + \lambda^{tot})\{\delta_H + \lambda(1 - \delta_H)\} - \iota\lambda\lambda^{tot}} \tag{2.55}$$

Since $\partial U/\partial\lambda^{tot} > 0$, combined with the result on total separation rate, I can show that higher self-employment rate brings a lower unemployment rate ($\partial U/\partial(N_S/L) < 0$). This relationship is due to the unemployed being able to start producing as self-employed in the same period, unlike workers in the labor market who need to be matched with probability ι.

The free entry condition for the self-employed states that firms will enter when the value of the firm is enough to cover the sunk entry cost, where the value of a self-employed firm is:

$$e = \frac{d_s}{1 - \beta(1 - \delta_S)} \tag{2.56}$$

Here, only the profit and exit rate matter because free entry depends on accounting profits, not economic profits. Specifically, higher profits with less probability to go out of business give more incentive to become entrants in the self-employment sector. Nonetheless, exploring economic profits is beneficial since it displays how labor market tightness is closely related to worker's surplus from self-employment. Defined as the difference between the value as self-employment and that of unemployment, surplus from self-employment ($S_t^S \equiv S_t - U_{u,t}$) in steady state is:

$$S^S = \frac{1}{1 - \beta(1 - \delta_S)} \left\{ d_s - \left(u_b + \frac{\beta(1 - \delta_S)(1 - \delta_H)\eta\kappa\theta}{1 - \eta} \right) \right\} \tag{2.57}$$

where the expression in the square brackets is the outside option of the self-employed. Since the unemployed have an easier time finding hired work under a tighter labor market, the surplus from switching to having one's own business depends negatively on the labor market tightness. Unemployment benefits also affect the unemployed's choice to stay in the labor market since a worker is no longer considered unemployed once he starts out as a business owner (this is explored in more detail in the policy exercises done in Section 2.7).

2.6.3 Comparison with Data

Under the calibration described above, Table 2.5 compares the second moments for the main macroeconomic aggregate variables to those from the US data for the period 1977:Q1 -

2007:Q4[8], omitting the global financial crisis. Data for vacancy filling rate is shorter than other variables since the Job Openings and Labor Turnover Survey (JOLTS) is only available from 2001. All the data used here are logged, then HP-filtered with smoothing parameter 1600 for quarterly data. In the table, Model I refers to the benchmark model where workers are allowed to select into self-employment. Model II is the scenario where entry and exit in the self-employed sector are shut down. As described in Equation 2.3.5, data-consistent variables are used to find the model-generated second moments (denoted with tildes).

Overall, the second moments generated by the model match those of the main macroeconomic variables fairly closely, with output, consumption, employment, and job finding rate correctly being procyclical and countercyclical vacancy filling rate. The job finding rate and vacancy filling rate are not as volatile as what data suggests. Compared to the model without self-employment, the benchmark model does better in matching the data more closely.

2.6.4 Welfare Cost of Business Cycles

Table 2.7 calculates the welfare cost of business cycles under different economies. I compute the percentage of steady-state consumption that the household would be willing to give up to move to a deterministic economy, denoted as Δ_{BC}. Higher Δ_{BC} implies higher welfare cost from business cycle dynamics. As documented by Schmitt-Grohé and Uribe (2004), second-order approximation to the policy functions is used to correctly evaluate welfare under different economies. This is due to the expected value of each variable being equal to its non-stochastic steady state values. Therefore, to assess the effects of business cycles, higher order is required. Welfare is calculated as the following:

$$\mathbb{E}_t \sum_{j=t}^{\infty} \beta^{j-t} U(C_j) = \frac{1}{1-\beta} U\left[\left(1 - \frac{\Delta_{BC}}{100}\right) C\right] \tag{2.58}$$

As shown in Table 2.7, the welfare cost from business cycles is always higher under the

[8] The series for the job finding rate is slightly shorter, ending at 2004:Q4.

existence of self-employment dynamics (entry and exit) under both sectoral and aggregate shocks. Put differently, in the presence of productivity shocks in the hiring sector, the household in the benchmark model is willing to give up 1.189% of its consumption to move to an economy with a completely smooth consumption schedule. Such difference comes from both the mean and variance of consumption and unemployment under the presence of self-employment. The unemployment pool changes more dynamically due to not only workers being matched and separated but also from workers entering and exiting through the self-employed sector. This leads to higher volatility in wages which, combined with profits of the self-employed, ends up at consumption being more volatile.

2.7 Structural Reforms when Solopreneurs Matter

2.7.1 Product and Labor Market Reforms

Utilizing the model introduced in Section 2.3, it is possible to conduct difference labor market- and product market-related reforms and study their effects. This is relevant in the current climate where the debate on structural reforms is still ongoing and solopreneurs are on the rise (see chapter 3 of World Economic Outlook (2019) for more details on structural reforms). I examine four possible policies: deregulation in hiring sector and self-employed sector, a decrease in unemployment benefits and worker's bargaining power. Here, deregulation is defined as a permanent reduction in regulation costs in each sector. All policy changes are permanent and perfectly observed by the household. Periods are still in quarters. In all cases, variables reach 80% of the changes by 15 years (60 quarters) and are at 90-95% of the new steady-states by 20 years (100 quarters) after the reform.

The results of the policy exercises are depicted in Figure 2.6 through Figure 2.9. Figure 2.6 and Figure 2.7 show that the direction of impact from deregulation in hiring and self-employed sectors is similar, since both lead to more firm entry. One major difference is in the profits of the self-employed. The relative size of the increase in the self-employed firms is large in Figure 2.7 – in fact, so large that this increased competition makes profits fall.

In general, the size of changes in the self-employed sector is more modest since the whole industry is relatively smaller. Additionally, having more firms in the hiring sector increases demand for labor and thus employment in the standard sector. As a result, deregulation in the hiring sector has a greater effect on all accounts including consumption and output.

Since business creation is an occupational option for the workers, labor market policies also affect the self-employment sector (Figure 2.8 and Figure 2.9). Both the decrease in unemployment benefits and worker's bargaining power give more incentive towards firm creation in the self-employed sector. Nonetheless, the effect is more sizable in the case of unemployment benefits since it affects the value of unemployment today directly. On the other hand, worker's bargaining power affects wages, which is relevant only when hired by a firm, subject to the job finding probability. Unemployment falls by a lot more since staying unemployed is no longer as attractive as before. Whether it is through hiring sector or self-employment, more unemployed workers will try to switch to employment.

The results point towards policy implications in various angles. First, the effect of reforms varies depending on what fraction of the economic agents are affected. This is shown in Figure 2.10, where all four reforms are compared. Reducing entry cost of the self-employed has the smallest impact due to the sector itself being small with no other employees. A decrease in worker's bargaining power follows as it primarily affects wage earners. What is most interesting is the reduction in unemployment benefits being the most effective in boosting consumption in the short run but gradually being caught up by deregulation in the hiring sector in the long run. This reversal is due to unemployment benefits having an immediate impact on workers' value of being unemployed, giving rise to higher incentive for them to find a job, both through the standard labor market and self-employment. In comparison, a decrease in regulation cost for the hiring firms promotes entry of firms, which then hire workers to produce. Not only do workers benefit from higher employment and wages in the hiring sector but the self-employed also gain from relatively lower price of inputs. This whole process occurs gradually, with unemployment falling less but wage and profits rising by more, leading to consumption and output reaching higher levels.

The adequacy of government-funded subsidies for new entrants is also dependent on the type of firms affected from the said policies. For economies where obtaining capital is difficult, government programs such as the Entrepreneurs' Law (*Ley de Emprendedores*) that passed recently in Argentina are considered a hopeful push towards building a better entrepreneurial ecosystem. However, if all the government is doing is fueling the excessive entry of necessity-driven entrepreneurs, the economy also has a possibility to end up allocating resources inefficiently. Another example of this is the South Korean government using $1.6 billion to offer better credit to the self-employed in 2016. This particular policy resulted in the number of new entrepreneurs increasing by 33% compared to the year before. At the same time, even more firms exited the market, reaching a new record since 2011.

Furthermore, labor market-specific policies that affect compensation during unemployment or duration of unemployment becomes relevant to firm entry. If the unemployed are offered better unemployment benefits or if it is relatively easier to find a job, it reduces the incentive for these workers to become entrepreneurs. Meanwhile, it warns us of the drawback from blindly using unemployment rate as a measure of the labor market. As it becomes more difficult to be matched with a firm as a hired worker, there is a higher chance that the unemployed will become "employed" through entrepreneurship, leading to a relatively lower unemployment rate.

2.7.2 Effect of Relative Sector Productivity and Monopoly Power on Deregulation

Relative Sector Productivity Z_S/Z_H

Along the lines of deregulation in markets, one can ask if the effects of such structural reforms would vary if the average productivity of two sectors differs. For easier comparison, I define the (sectoral) productivity ratio as Z_S/Z_H and only vary Z_S while keeping Z_H constant at 1. If the consequences of policy reforms depend on relative productivity differences, this becomes an important question as we do observe concentration of self-employment in certain industries in reality.

Figure 2.11 and Figure 2.12 show the results of the same permanent 1% decrease in regulation cost in the self-employed and hiring sector respectively, but under varying sectoral productivity ratios. From comparing Figure 2.11 and Figure 2.12, it is observed that the magnitude of reforms is greater under deregulation of the hiring sector. This is mainly due to the participation of hiring firms in the labor market. A decrease in entry cost of the hiring sector allows more new entrants who stay in the market for longer due to lower exit rates. This increase in hiring firms implies more job creation. Combined with this change in demand for labor, the number of solopreneurs also rise as more final goods are demanded by the household. As a result, unemployment falls by more, and consumption and output rises by more compared to deregulation in the hiring sector. This points to structural reforms being much more effective if done to firms that actively hire employees, rather than soloprenuers. On the other hand, the degree of effectiveness does not vary much according to the productivity ratio since the major changes are through the hiring sector.

In comparison, the effect of deregulation in the self-employed sector is greater as productivity ratio is lower. Due to low productivity, the entry cost of self-employment is already low. Decreasing the cost of entry even more allows more new entrants to enter the market, as the threshold of switching to self-employment is lower. Since more workers become employed through firm creation, household income and consumption rise. This leads to a positive spillover effect on the hiring sector through an increase in demand for both final and intermediate goods, but more so for lower productivity ratio case since the solepreneurs require using more intermediate goods. Unemployment falls by more for low Z_S/Z_H as more workers are absorbed by both sectors. Income rises but by less for low Z_S/Z_H because the relative lower increase in wages has a greater effect than the relatively lower decrease in profits (much more family members are hired by the hiring sector than the self-employed sector). Thus the impact of deregulation is larger in the hiring side as self-employment's sectoral productivity is lower.

In both cases, what drives the effectiveness of deregulation are the hiring firms and their impact on the job creation margin. Deregulation in the hiring sector is more effective than that in the self-employed sector by two magnitudes. Even when lowering the entry cost of solopreneurs, the reform works better when productivity ratio Z_S/Z_H is lower since the greater positive spillover effect on the hiring sector dominates.

Monopoly Power in Self-Employed Sector θ_S

Instead of productivity ratios, I also test whether monopoly power of the solopreneurs affects the policy reform results. Lower θ_S implies greater monopoly power and higher markups. θ_S of 6.38, 5, 3.8, and 2.9 imply 112%, 100%, 92%, and 87% of hiring sector's markup respectively. The benchmark was 87% following empirical evidence. The result of the exercise is described in Figure 2.13 and Figure 2.14. Since the structural reform itself is same as before (1% decrease in regulation cost), the direction of the reforms is not very different. However, now in both cases of hiring and self-employed sectors, the policies are more effective when the solopreneurs have higher monopoly power and are able to put higher markups. This indicates that solopreneurs are more important for reforms if they have a relatively higher monopoly power and are able to produce more differentiated products.

2.8 Conclusion

Motivated by the rise of very small firms in the recent years, this paper explores how the existence of necessity-driven businesses can impact macroeconomic dynamics, efficiency, and the outcomes of structural reforms. To do so, I develop a two-sector, dynamic stochastic general equilibrium model with endogenous producer entry and search and matching frictions. By doing so, I contribute towards a deeper understanding of firm creation, which usually have been focused on large firms with active employment. I shed light on how having necessity-driven businesses can lead to macroeconomic inefficiency and higher welfare costs. Furthermore, under this extra channel of employment present, structural reforms on either labor or product markets vary in terms of effectiveness, with deregulation on the hiring sector being the most effective in boosting consumption and output. Firms' relative productivity and monopoly power also matter since the same structural reform is more successful when the self-employed are less productive or when firms produce more differentiated products.

The main message of the paper is that firm creation as an occupational choice can make firm dynamics be more closely related to the state of the labor market. Once I allow for the unemployed to use entrepreneurship as an occupational choice, excessive entry to self-employment occurs. Since employment occurs in both sectors, as hired workers and self-employed, unemployment falls by more initially and consumption is higher. However, this leads to higher welfare cost from business cycles. More factors also contribute to inefficiency as neither hiring firms nor workers internalize the effect of their choices on the aggregate economy. As a result, understanding what type of firms are targeted matters when analyzing the effectiveness of structural reforms.

There exist possible extensions that one can continue to explore. First is opening up the economy and allowing international trade. It is observed in the data that the self-employed are mostly skewed towards industries that produce non-traded service goods. Thus, if there is more entry in the self-employed sector, it would imply an asymmetric impact on tradables versus nontradables. This concentration is even more evident in some small open economies such as Korea. Extending the model to an open economy setting will allow me to analyze such issues in detail.

Additionally, while in this paper I have the self-employed use goods from the other sector as intermediate goods, it might be more plausible to include hours of work as the cost for the self-employed. This is in line with the empirical evidence that there is more intensive margin rather than extensive margin in small businesses, mostly due to extra costs that arise when hiring employees. Put differently, it is easier for the entrepreneur to put in extra hours of work rather than hiring another worker for the firm. I leave these extensions for future work.

Table 2.1. Main motive for starting one's own business in the U.S. Data for TEA, averaged over 2010-2015. TEA: Total Early Stage Entrepreneurship; involved in a nascent firm or young firm or both. Mixed motivation includes a combination of opportunity and necessity and having a job but seeking better opportunities. Source: GEM APS, World Bank World Development Index. [cited on page 51]

Necessity or maintain income	Increasing income	Being independent	Mixed motivations
27.6%	36.3%	26.9%	9.1%

Table 2.2. Cyclical correlation of self-employment with output. Source: author's calculations. Self-employment refers to own-account workers and business owners with less than 5 employees, as share of the working-age population. All series are annual, logged, and HP-filtered with smoothing parameter 100 for annual. [cited on page 51]

	USA	Korea	Italy	Turkey
$Corr(SE_t, Y_t)$	0.06	0.29	-0.23	-0.68

Table 2.3. Model summary [cited on page 77]

Description	Equation
Matching function	$M_t = \chi U_t^{\xi} V_t^{1-\xi}$
Job finding probability	$\iota_t = M_t/U_t$
Vacancy filling probability	$q_t = M_t/V_t$
Unemployment	$U_t = 1 - (1-\lambda) l_{h,t} N_{H,t} - N_{S,t}$
Law of motion	$l_{h,t} = (1-\lambda) l_{h,t-1} + q_t v_t$
Law of motion for firms	$N_{S,t} = (1-\delta_S) N_{S,t-1} + N_{SE,t}$
	$N_{H,t} = (1-\delta_H) N_{H,t-1} + N_{HE,t}$
Free entry condition	$f_{rs} = e_{s,t}$
	$f_{eh,t} = e_{h,t}$
Entry cost for H firms	$f_{eh,t} = f_{rh} + \kappa v_{E,t}$
Value of H firm	$e_{h,t} = d_{h,t} + (1-\delta_H)\, \mathbb{E}_t\, \beta_{t,t+1} e_{h,t+1}$
Value of SE firm	$e_{s,t} = d_{s,t} + (1-\delta)\, \mathbb{E}_t\, \beta_{t,t+1} e_{s,t+1}$
Profits of H firm	$d_{h,t} = \frac{1}{\theta_H}(1-\alpha)\rho_{h,t}^{1-\theta_H} \mathcal{P}_{H,t}^{-\phi} Y_t$
Profits of SE firm	$d_{s,t} = \frac{1}{\theta_S}\alpha\rho_{s,t}^{1-\theta_S} \mathcal{P}_{S,t}^{-\phi} Y_t$
Job creation	$\frac{\kappa}{q_t} = \varphi_{h,t} Z_{H,t} - w_t + (1-\delta_H)(1-\lambda)\, \mathbb{E}_t\, \beta_{t,t+1} \frac{\kappa}{q_{t+1}}$
Real wage	$w_t = \eta \varphi_{h,t} Z_{H,t} + (1-\eta)\bar{\omega}_t$
Outside option	$\bar{\omega}_t = u_b + (1-\delta_H)\frac{\eta}{1-\eta}\, \mathbb{E}_t\, \beta_{t,t+1}\iota_{t+1}\frac{\kappa}{q_{t+1}}$
Vacancies by H entrants	$v_{E,t} = l_{h,t}/q_t - v_t$
Aggregate vacancies	$V_t = v_t N_{H,t} + v_{E,t} N_{HE,t}$
Marginal costs	$\rho_{h,t} = \frac{\theta_H}{\theta_H - 1}\varphi_{h,t}$
	$\rho_{s,t} = \frac{\theta_S}{\theta_S - 1}\varphi_{s,t}$
Real prices	$\rho_{h,t} = N_{H,t}^{\frac{1}{\theta_H - 1}}$
	$\rho_{s,t} = N_{S,t}^{\frac{1}{\theta_S - 1}}$
Price sub-indices	$\varphi_{s,t} = \mathcal{P}_{H,t}/Z_{s,t}$
	$1 = (1-\alpha)\mathcal{P}_{H,t}^{1-\phi} + \alpha \mathcal{P}_{S,t}^{1-\phi}$
Production functions	$y_t(h) = Z_{H,t} l_{h,t}$
	$y_t(s) = Z_{S,t} M_{s,t}$
Sectoral output	$Y_{h,t} = (1-\alpha)\mathcal{P}_{H,t}^{-\phi} Y_t$
	$Y_{s,t} = \alpha \mathcal{P}_{S,t}^{-\phi} Y_t$
Output clearing	$Z_{H,t} l_{h,t} = (1-\alpha)\rho_{h,t}^{-\theta_H} \mathcal{P}_{H,t}^{-\phi} Y_t + \rho_{h,t}^{-\theta_H} M_{s,t} N_{S,t}$
	$Z_{S,t} M_{s,t} = \alpha \rho_{s,t}^{-\theta_S} \mathcal{P}_{S,t}^{-\phi} Y_t$
Aggregate demand	$Y_t = C_t + \kappa V_t + f_{rs} N_{se,t} + f_{rh} N_{he,t}$

Table 2.4. Calibration [cited on page 75]

Parameter		Value	Parameter		Value
Discount factor	β	0.99	Matching elasticity	ξ	0.5
Intertemporal elasticity of substitution	γ	2	Matching efficiency	χ	0.82
Elasticity of substitution for variety (H)	θ_H	3.8	Total unemployment benefits	u_b/w	0.9
Elasticity of substitution for variety (S)	θ_S	6.38	Vacancy filling rate	q	0.9
Elasticity of substitution bet. sectors	ϕ	0.5	Worker matching rate	ι	0.75
Share of goods from SE sector	α	0.3	Regulation cost (H)	f_{rh}	0.42
Firm exit rate (H)	δ_H	0.05	Regulation cost (S)	f_{rs}	0.68
Firm exit rate (S)	δ_S	0.1	Vacancy cost	κ	0.06
Exogenous separation rate	λ	0.035	Persistence of TFP shock	ρ_Z	0.95
Worker's bargaining power	η	0.5	Std. of TFP shock	σ_Z	0.0072

Table 2.5. Business cycle statistics, benchmark, and model with no self-employment dynamics. Data = US 1977:Q1 - 2007:Q4 (1977:Q1 - 2004:Q4 for job finding rate, 2001:Q1 - 2007:Q4 for JOLTS), logged and HP-filtered with smoothing parameter 1600; Model I = benchmark with self-employment; Model II = no entry/exit in self-employment. Data-consistent variables used for model-generated moments. Source: US FRED, BLS, JOLT, and data constructed by Robert Shimer (for additional details, please see Shimer (2012) and his webpage http://home.uchicago.edu/~shimer/data/flows/). [cited on page 77]

	σ_X			σ_X/σ_Y			$corr(X,Y)$		
Var	Data	Model I	Model II	Data	Model I	Model II	Data	Model I	Model II
$\tilde{Y}$	1.35	1.42	1.44	1.00	1.00	1.00	1.00	1.00	1.00
$\tilde{C}$	1.05	0.76	0.54	0.77	0.53	0.54	0.85	0.99	0.99
L	0.74	0.38	0.36	0.55	0.27	0.25	0.86	0.94	0.94
ι	9.17	3.87	3.74	6.77	2.73	2.59	0.80	0.99	0.99
q	16.31	4.65	4.49	12.06	3.28	3.11	-0.33	-0.99	-0.99

Table 2.6. Comparison of margins between decentralized and centralized economies. [cited on page 71]

	Decentralized
Job Creation	$1 = \frac{q_t}{\kappa}\left(\varphi_{h,t} Z_{H,t} - w_t\right) + (1-\lambda)(1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}\frac{q_t}{q_{t+1}}$
Product Creation (H)	$1 = \frac{1}{(f_{rh}+f_{Th})}\left[\frac{1}{\theta_H}\rho_{h,t}\mathcal{P}_{H,t}\,Z_{H,t} l_{h,t} - \kappa v_{E,t}\right] + (1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}\frac{e_{h,t+1}}{f_{rh}}$
Product Creation (S)	$1 = \frac{1}{(f_{rs}+f_{Ts})}\left[\frac{1}{\theta_S}\rho_{s,t}\mathcal{P}_{S,t}\,Z_{S,t} M_{S,t} + (1-\delta_S)\,\mathbb{E}_t\,\beta_{t,t+1} e_{s,t+1}\right]$

	Social Planner
Job Creation	$1 = \frac{q_t}{\kappa}(1-\xi)\rho(N_{H,t})Z_{H,t}\left[A_t\left(\frac{C_{H,t}}{(1-\alpha)C_t}\right)^{-\frac{1}{\phi}} + \left(\frac{\rho(N_{H,t})Z_{H,t}L_{H,t}}{(1-\alpha)Y_t}\right)^{-\frac{1}{\phi}}\right]$ $-(1-\lambda)\xi\iota_t + (1-\lambda)(1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}\left(\frac{1+A_t}{1+A_{t+1}}\right)\frac{q_t}{q_{t+1}}$
Product Creation (H)	$1 = \frac{1}{(f_{rh}+f_{Th})}\left[\frac{\theta_H}{\theta_H-1}\rho(N_{H,t})Z_{H,t} l_{h,t}\left\{A_t\left(\frac{C_{H,t}}{(1-\alpha)C_t}\right)^{-\frac{1}{\phi}} + \left(\frac{\rho(N_{H,t})Z_{H,t}L_{H,t}}{(1-\alpha)Y_t}\right)^{-\frac{1}{\phi}}\right\}\right]$ $+(1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}\left(\frac{1+A_t}{1+A_{t+1}}\right)$
Product Creation (S)	$1 = \frac{1}{(f_{rs}+f_{Ts})}\left[\frac{\theta_S}{\theta_S-1}\rho(N_{S,t})Z_{S,t}M_{S,t}\left\{A_t\left(\frac{C_{S,t}}{\alpha C_t}\right)^{-\frac{1}{\phi}} + \left(\frac{\rho(N_{S,t})N_{S,t}Z_{S,t}M_{s,t}}{\alpha Y_t}\right)^{-\frac{1}{\phi}}\right\}\right.$ $\left.-A_t\left(\frac{C_{H,t}}{(1-\alpha)C_t}\right)^{-\frac{1}{\phi}} M_{S,t} - \frac{\xi}{1-\xi}\iota_t\frac{\kappa}{q_t}\right] + (1-\delta_S)\,\mathbb{E}_t\,\beta_{t,t+1}\left(\frac{1+A_t}{1+A_{t+1}}\right)$

Table 2.7. Welfare cost under different scenarios. Δ_{BC} = welfare cost of business cycles (% of steady-state consumption in benchmark model). [cited on page 78]

	Δ_{BC}	
Shock	Benchmark	No Entry/Exit in SE
H sector	1.189%	0.046%
S sector	0.050%	0.046%
Both sectors	1.237%	1.065%

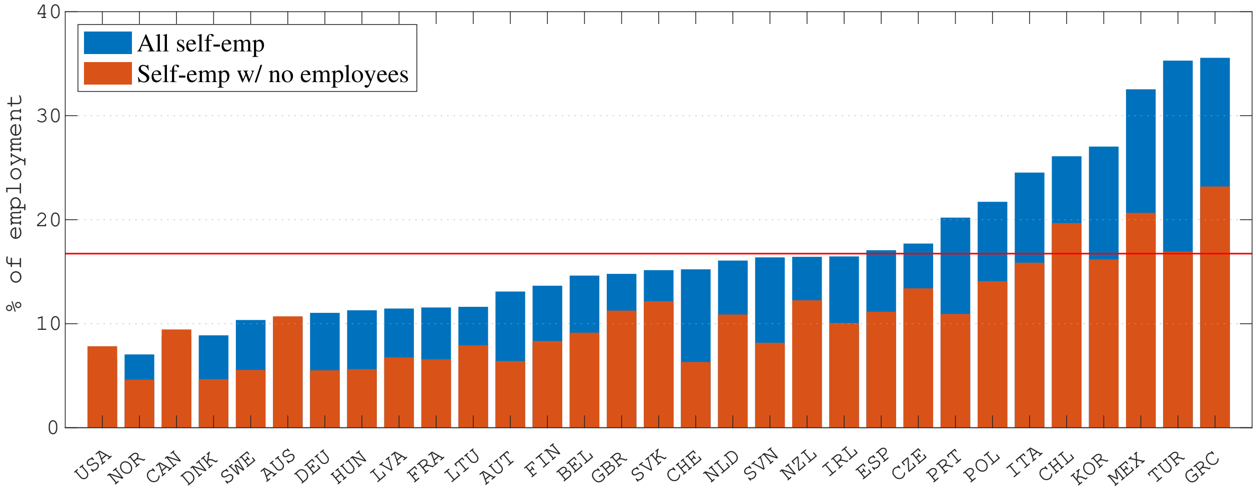
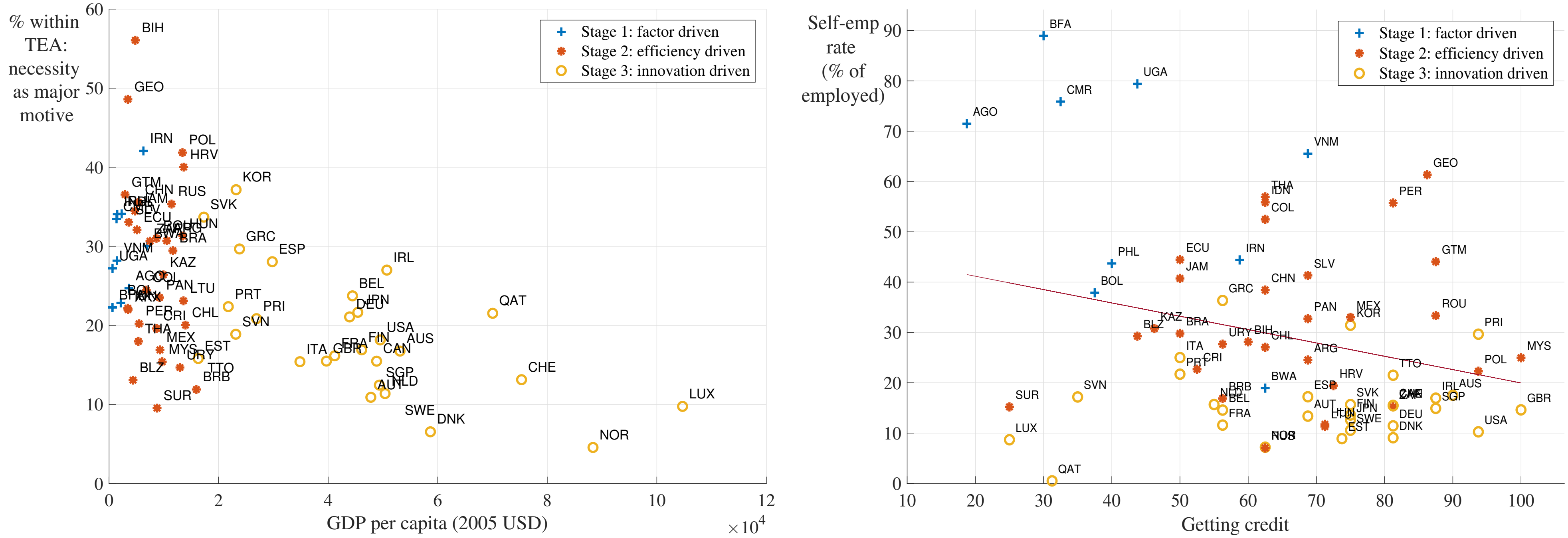


Figure 2.1. Self-employment rates (as % of total employment). Average of annual data for 2010-2017. Source: OECD (2019). [cited on page 50]



(a) Necessity-driven businesses by GDP per capita

(b) Necessity-driven businesses by Getting Credit index

Figure 2.2. Self-employment, necessity-driven business, and their relationship with other factors. **Factor-driven**: least developed, mostly subsistence agriculture and extraction businesses, with heavy reliance on (unskilled) labor and natural resources; **Efficiency-driven**: increasingly competitive, with more-efficient production processes and increased product quality; **Innovation-driven**: most developed, businesses more knowledge-intensive, and the service sector expands. **Getting credit index** measures (i) strength of legal rights index, (ii) depth of credit information index, (iii) credit bureau coverage (% of adults), and (4) credit registry coverage (% of adults). Higher values indicate ease of getting credit. Source: GEM APS, WB World Development Index (2010-2014). [cited on page 50]

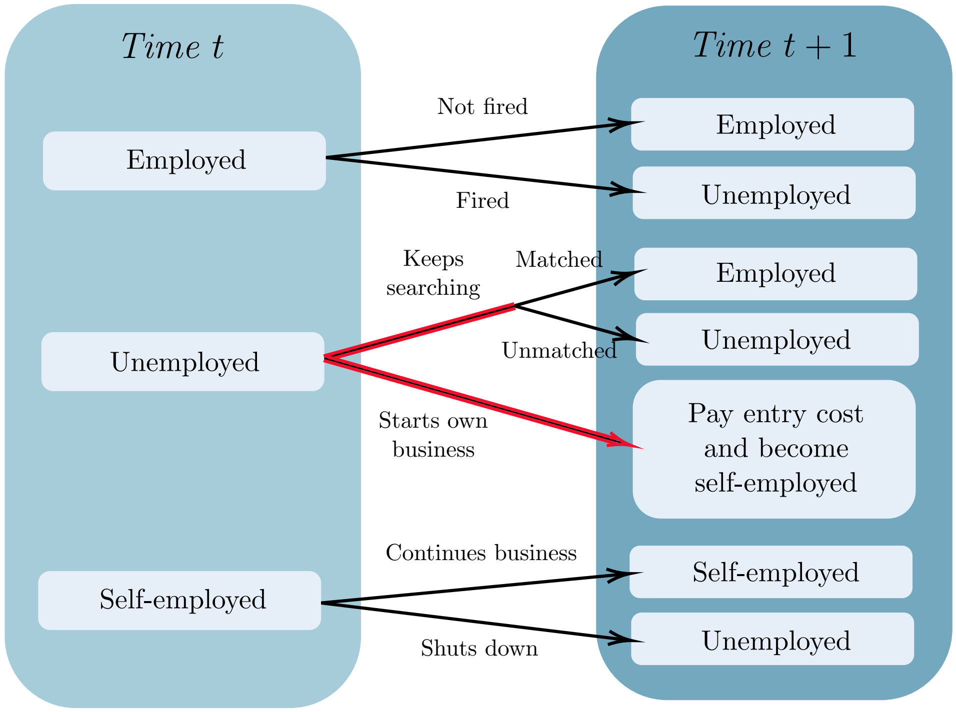


Figure 2.3. Three-state labor market [cited on page 64]

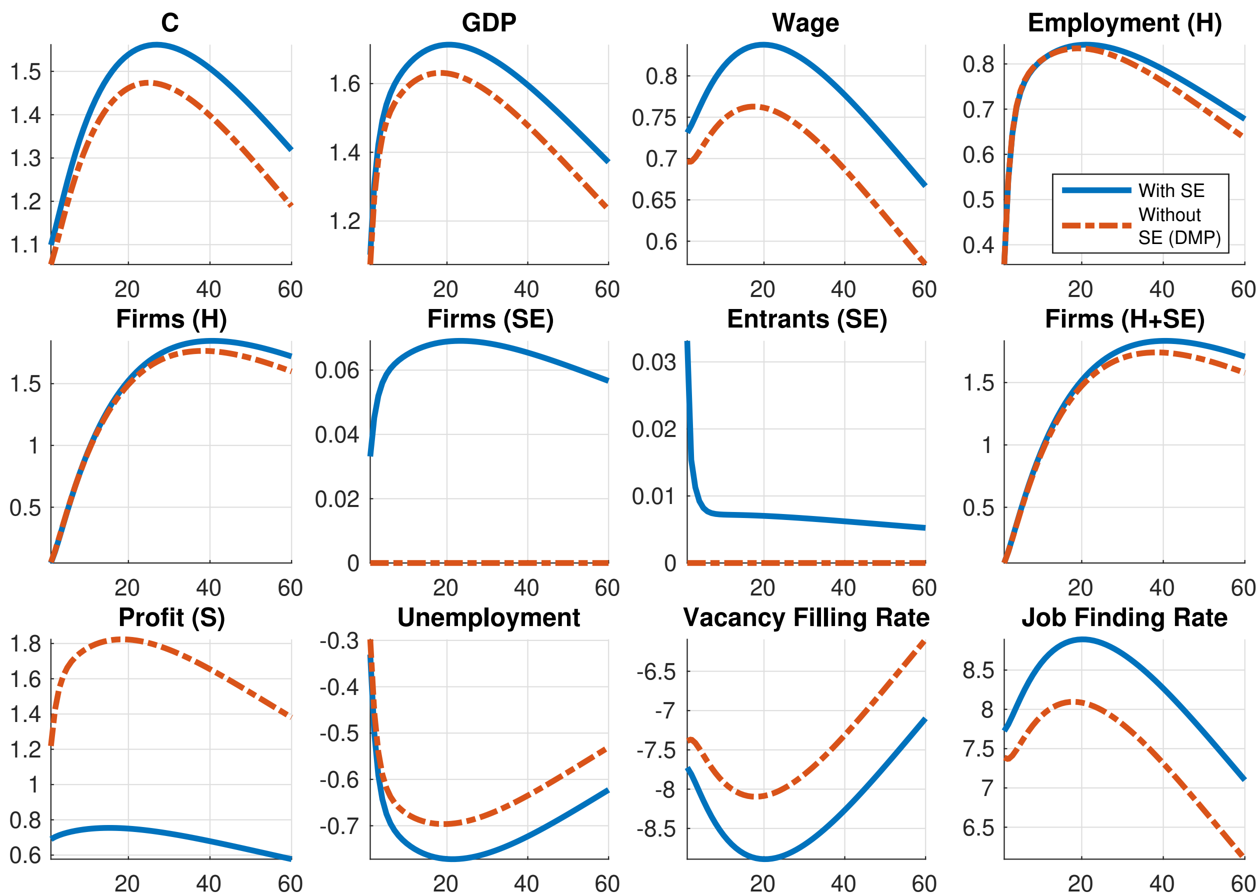


Figure 2.4. Productivity shock in the hiring sector. Responses show percentage deviations from steady state after a one standard deviation productivity shock. Unemployment is in deviations from steady state. [cited on page 75]

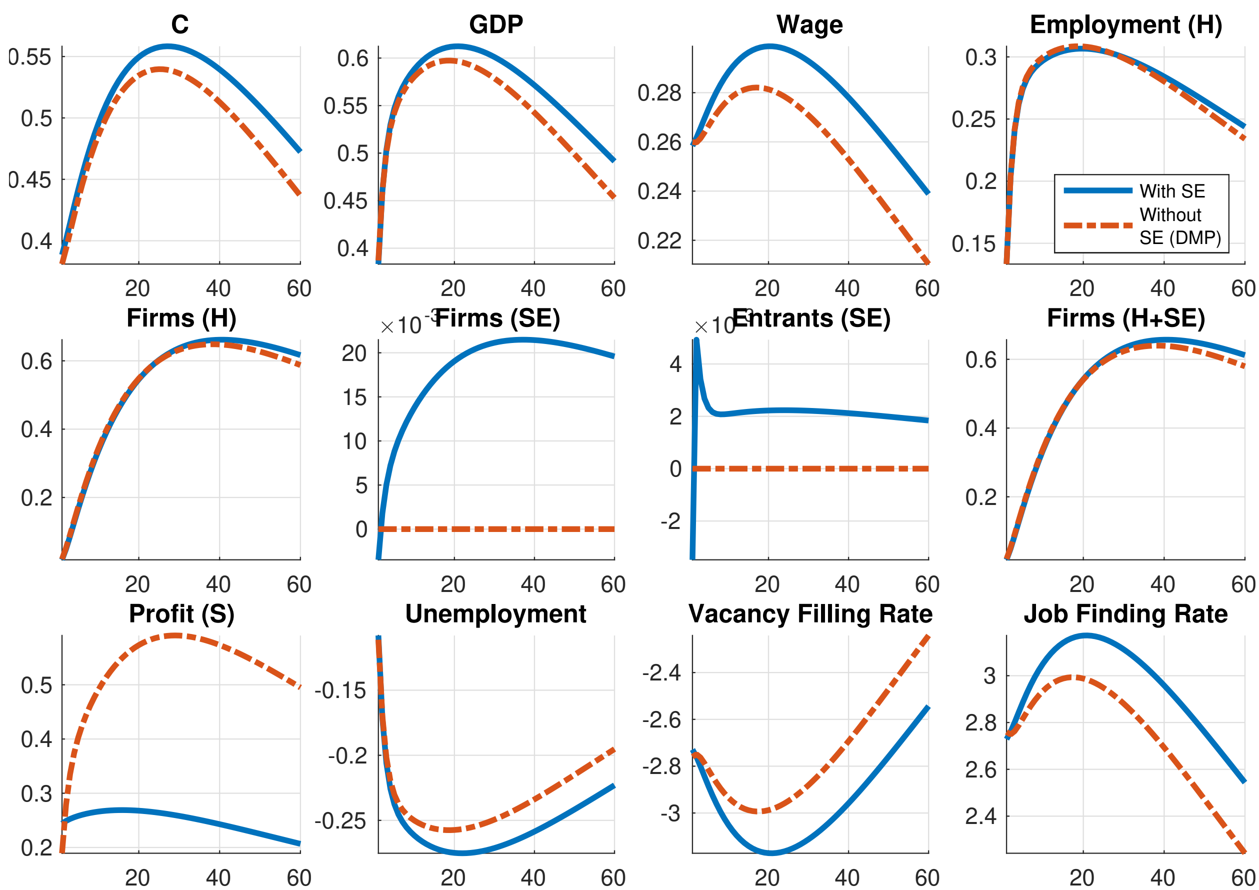


Figure 2.5. Productivity shock in the self-employed sector. Responses show percentage deviations from steady state after a one standard deviation productivity shock. Unemployment is in deviations from steady state. [cited on page 76]

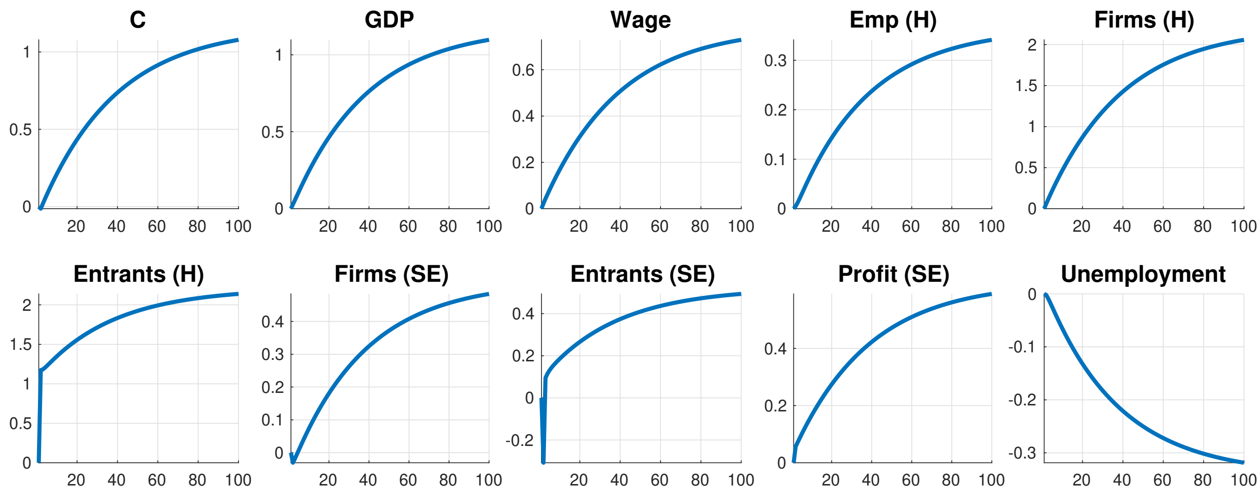


Figure 2.6. Permanent 1% decrease in regulation cost for the hiring sector. [cited on page 79]

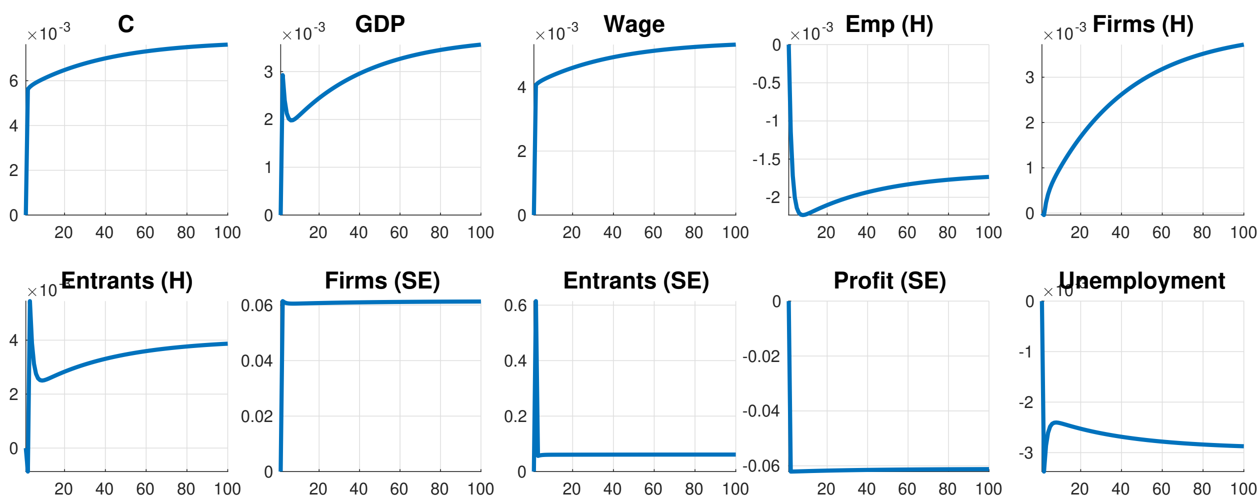


Figure 2.7. Permanent 1% decrease in regulation cost for the self-employment sector. [cited on page 79]

Responses show percentage deviations from steady state after the respective permanent policy change. Unemployment is in deviations from steady state.

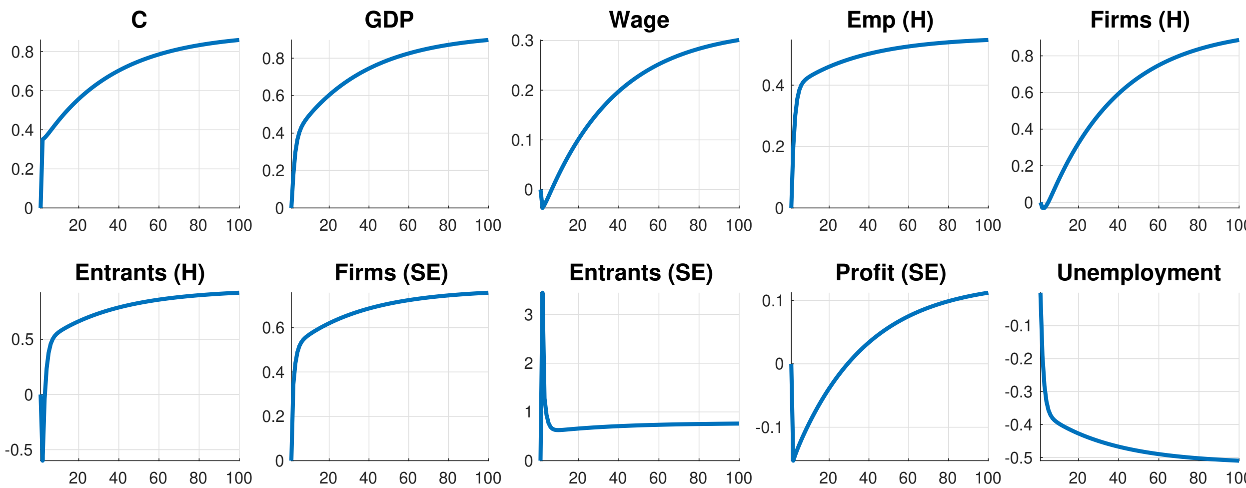


Figure 2.8. Permanent 1% decrease in unemployment benefits. [cited on page 80]

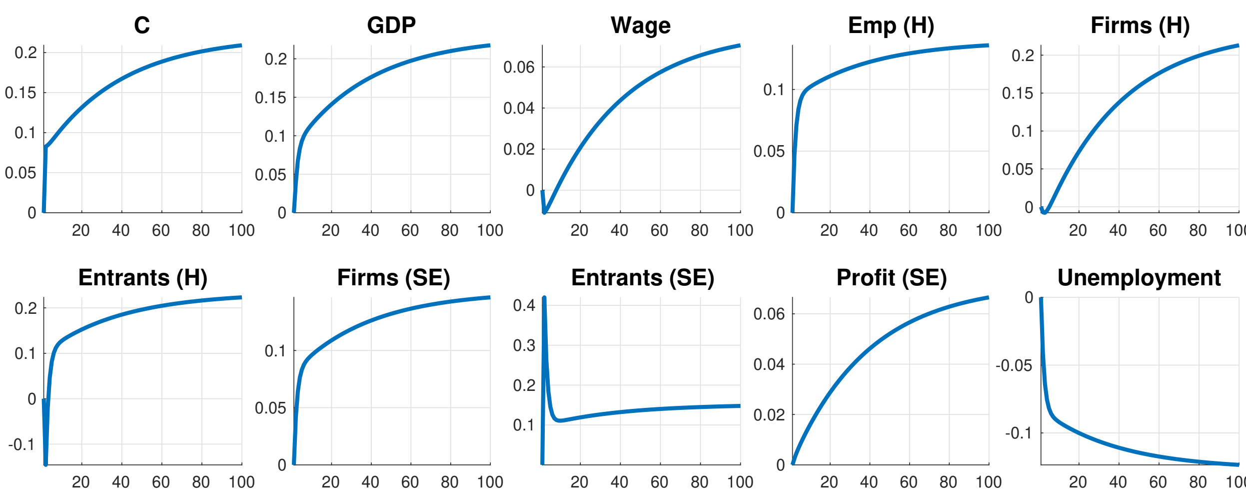


Figure 2.9. Permanent 1% decrease in worker's bargaining power. [cited on page 80]

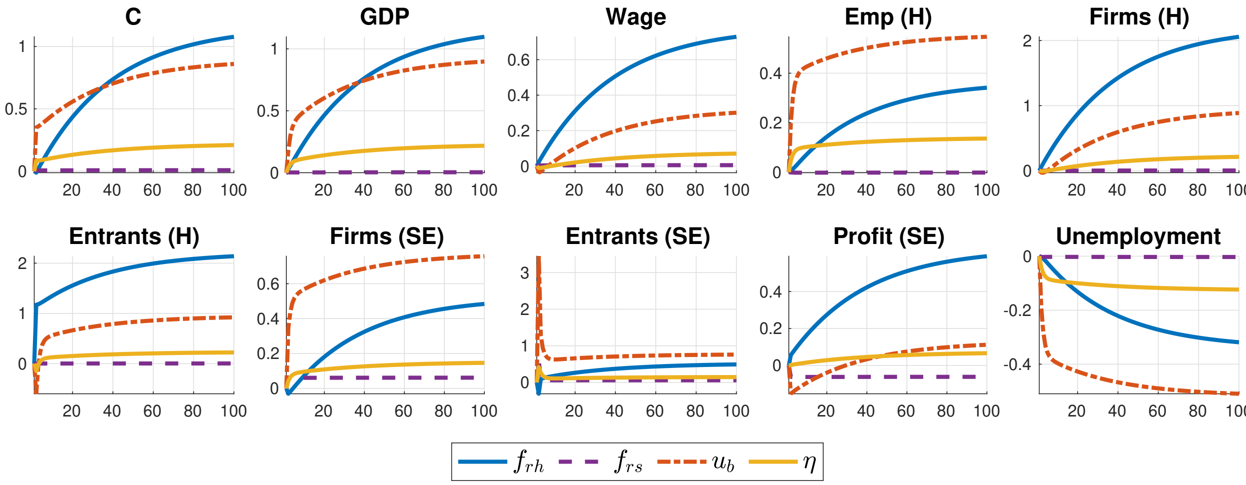


Figure 2.10. Comparison of four reforms: two product market policies (1% decrease in regulation cost in hiring and self-employed sectors) and two labor market policies (1% decrease in unemployment benefits and worker's bargaining power). [cited on page 80]

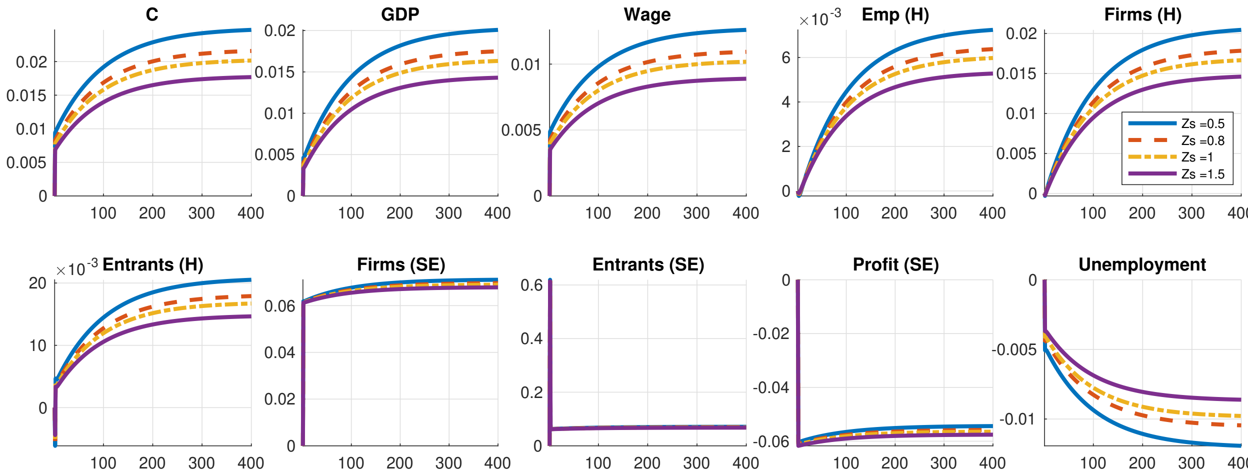


Figure 2.11. Permanent 1% decrease in regulation cost for the self-employment sector. [cited on page 82]

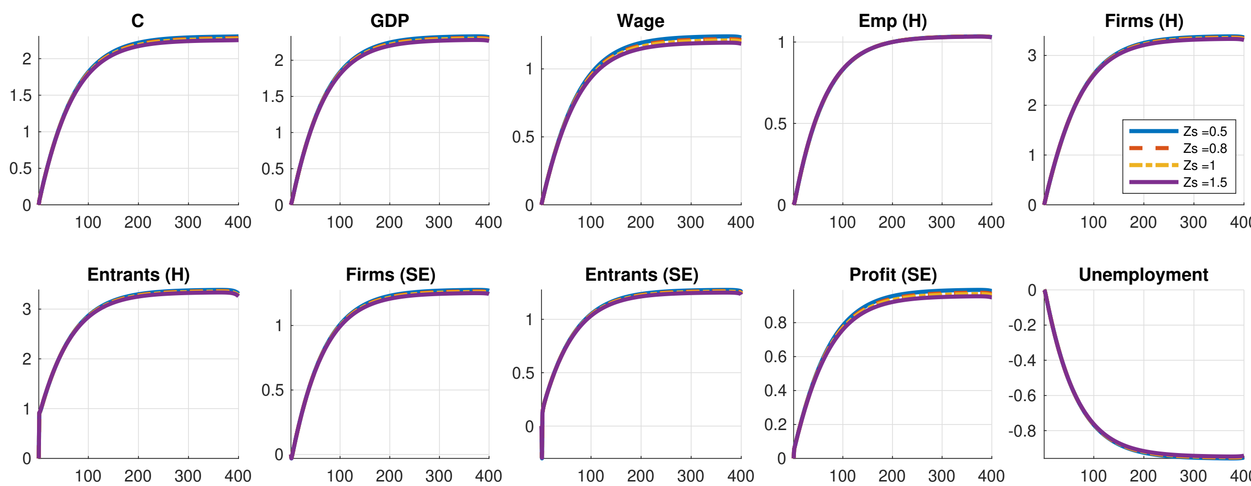


Figure 2.12. Permanent 1% decrease in regulation cost for the hiring sector. [cited on page 82]

Responses show percentage deviations from steady state after the respective permanent policy change. Unemployment is in deviations from steady state.

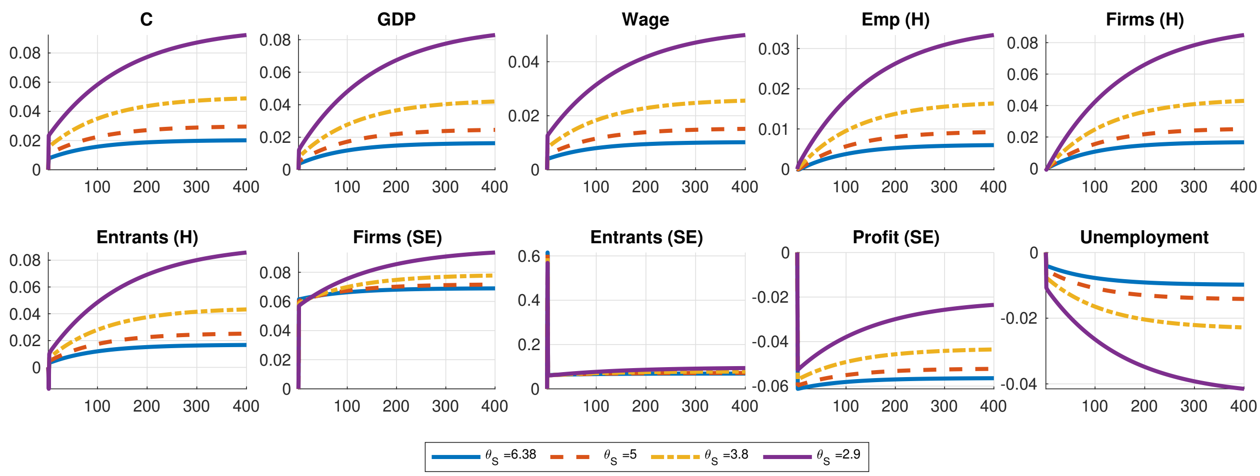


Figure 2.13. Permanent 1% decrease in regulation cost for the self-employment sector. [cited on page 83]

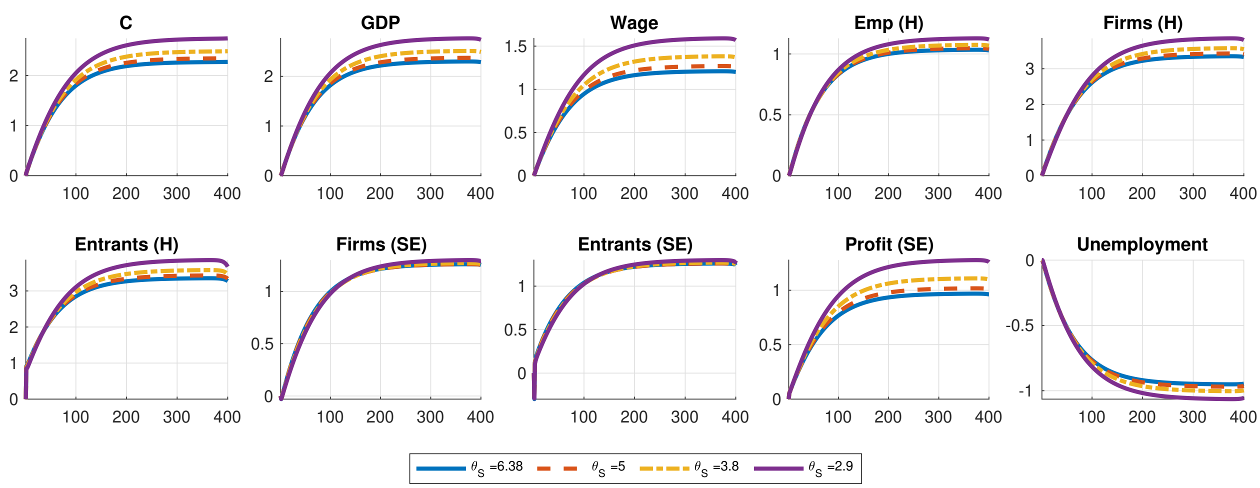


Figure 2.14. Permanent 1% decrease in regulation cost for the hiring sector. [cited on page 83]

Responses show percentage deviations from steady state after the respective permanent policy change. Unemployment is in deviations from steady state. Higher θ_S implies less monopoly power and smaller markup in S sector (112%, 100%, 92%, and 87% of H sector markup respectively).

Chapter 3

TRADE LIBERALIZATION AND STRUCTURAL REFORMS UNDER SELF-EMPLOYMENT

3.1 Introduction

Self-employment is much more prominent in small open economies. As seen earlier in Figure 2.1, compared to the U.S. with 8% of self-employment, economies such as Chile, Korea, and Mexico show 25-32% of employment coming from the self-employed. On the other hand, while more developed economies tend to have relatively less self-employment, this is not always the case. For instance, in Figure 2.2a, one can see multiple economies along different levels of development being clustered around self-employment of 20%.

One of the distinctive characteristics of self-employment that I take into account in this chapter is the skewness in the industries the self-employed selects into. As Figure 3.1 shows, self-employment is extremely concentrated in nontraded service sector goods, with 'accommodation and food services' and 'wholesale and retail trade' taking up more than half of self-employment. Not surprisingly, they are also sectors that do not require very high skill sets or productivity, with relatively low barrier to entry.

The empirical pattern mentioned above is why I construct a two-sector dynamic, general equilibrium model in a small open economy framework, where the self-employed firms produce nontradable goods. They enjoy relatively lower monopoly power and are subject to higher exit rates compared to firms that hire workers and produce tradable goods. This mechanism implies that more entry into self-employment would have a disproportionate effect on nontradable goods, ending up in impacting the exchange rate and terms of trade as well.

This small open economy model allows me to ask interesting questions on the consequences of trade liberalization and its effect on the wage inequality under the presence of self-employment. Not much focus has been put on the analysis of the relationship between open economy policies and self-employment so far. The closest would be the existing literature on the impact of trade liberalization on informal versus formal employment that was studied extensively especially after the trade reforms in the 1980s-90s in Latin American countries, though it did not always end in a consensus. Goldberg and Pavcnik (2003) shows that trade reforms lead to a rise in informal employment in Colombia but not for Brazil, while Menezes-Filho and Muendler (2011) argues otherwise. Heid et al. (2013) discusses how the expansion of the export sector in Mexico had limited effects on informal employment. Some existing papers also look at the impact of such reforms on the wage gap, although again there are conflicting results. Ferreira et al. (2007) uses the example of Brazil to show a decrease in wage inequality as a result, while Feliciano (2001) and Cragg and Epelbaum (1996) use Mexico's case to argue otherwise. I contribute to the discussion by incorporating both the effect of self-employment on the outcomes of reforms and the impact of reforms on the labor market composition.

The rest of the chapter is organized as the following. Section 3.2 gives a description of the theoretical framework. Section 3.3 discusses the calibration used for the model and the resulting business cycle dynamics. Section 3.5 concludes.

3.2 The Model

I construct a two sector dynamic, general equilibrium model for a small open economy. One sector – which I call the hiring sector – produces tradable goods by using workers hired through the labor market, subject to search and matching frictions. The other sector consists of self-employed firms that produce nontradable goods by using hiring sector goods as inputs. h and s refer to variables related to the hiring and self-employed sector respectively. Subscript D or d denotes domestic variables, while X or x refers to exports to/imports from Rest of the World (or Foreign). All foreign variables are denoted with a star.

3.2.1 Household

The economy consists of a unit mass of atomistic, identical households. Each household is a large extended family containing a continuum of members along a unit interval. Whether a family member is employed (either through hired work or self-employment) or unemployed is endogenously determined by the labor matching process and firm entry. Following Andolfatto (1996), there is a full consumption sharing among the employed, self-employed, and unemployed family members.

A representative household maximizes the intertemporal expected utility:

$$\mathbb{E}_t \sum_{j=t}^{\infty} \beta^{j-t} \left(\frac{C_j^{1-\gamma}}{1-\gamma} \right). \tag{3.1}$$

The final consumption basket is an Armington aggregator of tradable hiring sector goods and nontradable self-employed sector goods:

$$C_t = \left[(1-\alpha_S)^{\frac{1}{\phi_S}} (C_t^H)^{\frac{\phi_S - 1}{\phi_S}} + \alpha_S^{\frac{1}{\phi_S}} (C_t^S)^{\frac{\phi_S - 1}{\phi_S}} \right]^{\frac{\phi_S}{\phi_S - 1}}, \tag{3.2}$$

where $\phi_S > 0$ is the elasticity of substitution between C_t^H and C_t^S.

The tradable consumption basket consists of sub-baskets of hiring sector goods produced domestically and in foreign (i.e. imported):

$$C_t^H = \left[(1-\alpha_X)^{\frac{1}{\phi_X}} (C_{D,t}^H)^{\frac{\phi_X - 1}{\phi_X}} + \alpha_X^{\frac{1}{\phi_X}} (C_{X,t}^{H*})^{\frac{\phi_X - 1}{\phi_X}} \right]^{\frac{\phi_X}{\phi_X - 1}}, \tag{3.3}$$

where ϕ_X is the elasticity of substitution between $C_{D,t}^H$ and $C_{X,t}^H$.

This implies that the relevant price indices for the final and tradable consumption baskets can be written as the following:

$$P_t = \left[(1-\alpha_S)(P_t^H)^{1-\phi_S} + \alpha_S(P_t^S)^{1-\phi_S}\right]^{\frac{1}{1-\phi_S}}, \tag{3.4}$$

$$P_t^H = \left[(1-\alpha_X)(P_{D,t}^H)^{1-\phi_X} + \alpha_X(P_{X,t}^{H*})^{1-\phi_X}\right]^{\frac{1}{1-\phi_X}}. \tag{3.5}$$

Each sectoral sub-basket consists of a continuum of goods - H or S depending on the sector - for both domestically produced and imported goods:

$$C_{D,t}^H = \left(\int_{h\in H} c_{d,t}(h)^{\frac{1-\theta_H}{\theta_H}} dh\right)^{\frac{\theta_H}{\theta_H-1}}, \quad C_{X,t}^{H*} = \left(\int_{h\in H} c_{x,t}^*(h)^{\frac{1-\theta_H}{\theta_H}} dh\right)^{\frac{\theta_H}{\theta_H-1}}, \tag{3.6}$$

$$C_t^S = \left(\int_{s\in S} c_t(s)^{\frac{1-\theta_S}{\theta_S}} ds\right)^{\frac{\theta_S}{\theta_S-1}}. \tag{3.7}$$

$\theta_S > \theta_H > 1$ is the elasticity of substitution across different varieties, where θ_S is set greater to allow the relatively weaker monopoly power of the self-employed sector.

At any period, only a subset of goods $H_t \in H$ and $S_t \in S$ out of all the goods the household wants to consume is available in each sector. Thus the price of each sectoral sub-basket, or the sectoral price sub-index, is written as:

$$P_{D,t}^H = \left(\int_{h\in H_t} p_{d,t}(h)^{1-\theta_H} dh\right)^{\frac{1}{1-\theta_H}}, \quad P_{X,t}^{H*} = \left(\int_{h\in H_t} p_{x,t}^*(h)^{1-\theta_H} dh\right)^{\frac{1}{1-\theta_H}}, \tag{3.8}$$

$$P_t^S = \left(\int_{s\in S_t} p_t(s)^{1-\theta_S} ds\right)^{\frac{1}{1-\theta_S}}. \tag{3.9}$$

where $p_{d,t}(h)$ is price of H sector good sold domestically (in Home currency) and $p_{x,t}^*(h)$ is price of the imported H sector good (also in Home currency).

Under the structure of the consumption baskets and price indices described above, the domestic household's demand for each sectoral bundle is given as:

$$C_t^H = (1-\alpha_S)\left(\frac{P_t^H}{P_t}\right)^{-\phi_S} C_t, \qquad C_t^S = \alpha_S\left(\frac{P_t^S}{P_t}\right)^{-\phi_S} C_t, \tag{3.10}$$

and the demand for domestically produced and foreign produced traded bundle are:

$$C^H_{D,t} = (1-\alpha_X)\left(\frac{P^H_{D,t}}{P^H_t}\right)^{-\phi_X} C^H_t, \qquad C^{H*}_{X,t} = \alpha_X \left(\frac{P^{H*}_{X,t}}{P^H_t}\right)^{-\phi_X} C^H_t. \tag{3.11}$$

Domestic demand for Home's H sector variety, export demand for Home's H sector variety, and domestic demand for Home's S sector variety are found as the following respectively:

$$c_{d,t}(h) = \left(\frac{p_{d,t}(h)}{P^H_{D,t}}\right)^{-\theta_H} C^H_{D,t}, \quad c_{x,t}(h) = \left(\frac{p_{x,t}(h)}{P^H_{X,t}}\right)^{-\theta_H} C^H_{X,t}, \tag{3.12}$$

$$c_t(s) = \left(\frac{p_t(s)}{P^S_t}\right)^{-\theta_S} C^S_t. \tag{3.13}$$

By defining the real prices of each variety as $\rho_{d,t} \equiv p_{d,t}(h)/P_t$, $\rho_{x,t} \equiv p_{x,t}(h)/P^*_t$, and $\rho_{s,t} \equiv p_t(s)/P_t$, the demand for domestically produced variety is rewritten as:

$$c_{d,t}(h) = (1-\alpha_X)(1-\alpha_S)\rho_{d,t}^{-\theta_H} \left(\frac{P^H_{D,t}}{P_t}\right)^{\theta_H-\phi_X} \left(\frac{P^H_t}{P_t}\right)^{\phi_X-\phi_S} C_t, \tag{3.14}$$

$$c_{x,t}(h) = \alpha_X(1-\alpha_S)\rho_{x,t}^{-\theta_H} \left(\frac{P^H_{X,t}}{P^*_t}\right)^{\theta_H-\phi_X} \left(\frac{P^H_t}{P^*_t}\right)^{\phi_X-\phi_S} C^*_t, \tag{3.15}$$

$$c_t(s) = \alpha_S \rho_{s,t}^{-\theta_S} \left(\frac{P^S_t}{P_t}\right)^{\theta_S-\phi_S} C_t. \tag{3.16}$$

Assuming producer currency pricing and law of one price implies $p_{x,t}(h) = \tau_t \epsilon_t^{-1} p_{d,t}(h)$, where ϵ_t is the nominal exchange rate, defined as units of Home currency per one unit of Foreign currency. This relationship also holds in real variables: $\rho_{x,t}(h) = \tau_t Q_t^{-1} \rho_{d,t}(h)$, where the real exchange rate is defined as $Q_t \equiv \epsilon_t P^*_t / P_t$.

3.2.2 Production

Hiring Firms

The hiring sector is composed of a continuum of monopolistically competitive firms of measure zero that produce variety h that are imperfect substitutes. Firms follow a linear production function $y_t(h) = Z_{H,t} l_{h,t}$, where $Z_{H,t}$ is the sectoral productivity. As firms hire workers from the labor market, they are subject to search and matching frictions following Diamond (1982b) and Mortensen and Pissarides (1994).

Search and Matching

Job creation is subject to the search and matching frictions in the labor market. The matching function $M(U_t, V_t) = \chi U_t^{\xi} V_t^{1-\xi}$ combines aggregate unemployed workers U_t and aggregate vacancies V_t into matches. The job finding rate ι_t and the vacancy filling rate q_t are endogenously determined as $\iota_t \equiv M_t/U_t$ and $q_t \equiv M_t/V_t$. This implies that both rates are endogenously determined by the labor market tightness, $\theta_t \equiv V_t/U_t$: if the labor market becomes tighter (θ_t rises), workers have an easier time finding jobs.

Once matched, all workers are subject to an exogenous rate of separation, λ. Following Krause and Lubik (2007), the newly created matches become productive right away. This gives the law of motion for employment at hiring firms, where the amount of currently hired workers depends on the incumbent workers surviving firing and newly filled vacancies:

$$l_{h,t} = (1 - \lambda) l_{h,t-1} + q_t v_t. \tag{3.17}$$

Profit Maximization

Each firm in the hiring sector chooses the amount of labor to hire ($l_{h,t}$), vacancies to post (v_t), and the price of the good ($\rho_{h,t}$) to maximize the following intertemporal profit function, subject to the production function and the law of motion for employment:

$$\mathbb{E}_t \sum_{j=t}^{\infty} \beta_{t,j}(1-\delta_H)^{j-t} \left\{\rho_{d,j}(h)y_j(h) - w_j l_{h,j} - \kappa v_j\right\}. \tag{3.18}$$

Note that for hiring firms, they will face demand from three sources: domestic and foreign households as final consumption goods and self-employed firms as inputs ($y_t(h) = y_{d,t}(h) + y_{x,t}(h) + m_{s,t}(h)N_{S,t}$).

The first order conditions give rise to the job creation equation and the optimal price setting rule:

$$\frac{\kappa}{q_t} = \varphi_{h,t} Z_{H,t} - w_t + (1-\delta_H)(1-\lambda)\, \mathbb{E}_t\, \beta_{t,t+1} \frac{\kappa}{q_{t+1}}, \tag{3.19}$$

$$\rho_{d,t}(h) = \left(\frac{\theta_H}{\theta_H - 1}\right) \varphi_{h,t}. \tag{3.20}$$

Eq. (3.19) equates the marginal cost of posting a vacancy (κ/q_t) to its marginal benefit, which is the marginal revenue product created by the extra worker minus the wage, and the future savings from not needing to post a vacancy if the match survives. Eq. (3.20) shows that the firm will charge a fixed markup over marginal cost.

Total revenue for the hiring firm is $\rho_{d,t}(h)y_{d,t}(h) + Q_t\rho_{x,t}(h)y_{x,t}(h) + \rho_{d,t}(h)m_{s,t}(h)N_{S,t}$ and total cost is $\varphi_{h,t}(y_{d,t}(h) + \tau_t y_{x,t}(h) + m_{s,t}(h)N_{S,t})$. Then the period profit of the firm can be written as:

$$d_{h,t} = \frac{1}{\theta_H}\rho_{d,t}(h)\left\{y_{d,t}(h) + \tau_t y_{x,t}(h) + m_{s,t}(h)N_{S,t}\right\}. \tag{3.21}$$

Free Entry Condition

As a new entrant, the hiring firm needs to pay for the regulation cost (f_{rh}), technology cost (f_{Th}), and build up a stock of labor needed for production. Hence the total entry cost faced by a new firm is:

$$f_{eh,t} = \underbrace{f_{rh} + f_{Th}}_{\equiv f_{RH}} + \kappa v_{E,t}, \tag{3.22}$$

where $v_{E,t} = \frac{l_{h,t}}{q_t} - v_t$ is the vacancies posted by new entrants.

Firms enter until this entry cost is equal to the value of the hiring firm, which is the present (since firms become productive right away) and future stream of profits:

$$e_{h,t} = d_{h,t} + \mathbb{E}_t \sum_{j=t+1}^{\infty} (1-\delta_H)^{j-t} \beta_{t,j} d_{h,j}. \tag{3.23}$$

Therefore, the free entry condition becomes $f_{eh,t} = e_{h,t}$. This equation pins down the law of motion for hiring firms:

$$N_{H,t} = (1-\delta_H) N_{H,t-1} + N_{HE,t}, \tag{3.24}$$

where the number of hiring firms is determined by the incumbent firms that survives the probability of shutting down, $\delta_H \in (0,1)$, plus the new entrants.

Self-Employed Firms

The self-employment sector also consists of a continuum of monopolistically competitive firms with each producing a variety s. The self-employed are subject to a linear production function, but uses a basket of hiring sector goods as inputs instead of labor as they are one-man firms: $y_t(s) = Z_{S,t} M_{s,t}$. The first order condition from the profit maximization problem gives rise to the optimal price setting rule:

$$\rho_{s,t} = \left(\frac{\theta_S}{\theta_S - 1} \right) \varphi_{s,t}, \tag{3.25}$$

where $\varphi_{s,t} = \frac{(P_t^H / P_t)}{Z_{S,t}}$ is the real marginal cost for the self-employed. Then the period profits can be written as:

$$d_{s,t} = \frac{1}{\theta_S} \alpha_S \rho_{s,t}^{1-\theta_S} \left(\frac{P_t^S}{P_t} \right)^{\theta_S - \phi_S} Y_t. \tag{3.26}$$

For the firms in the self-employed sector, the expression for profits is much simpler as their only source of demand is from the domestic household.

Free Entry Condition

Similar to the hiring sector, new entrants enter until the entry cost is equal to the value of the firm ($f_{RS} = e_{s,t}$), where $e_{s,t}$ is the present and future stream of profits for the self-employed:

$$e_{s,t} = d_{s,t} + \mathbb{E}_t \sum_{j=t+1}^{\infty} (1 - \delta_S)^{j-t} \beta_{t,j} d_{s,j}. \tag{3.27}$$

Different from the hiring sector, the self-employed do not hire any other employees; thus, its entry cost only consists of the regulation and technology costs ($f_{RS} = f_{rs} + f_{Ts}$). This also gives rise to the law of motion for self-employment firms:

$$N_{S,t} = (1 - \delta_S) N_{S,t-1} + N_{SE,t}. \tag{3.28}$$

The self-employed are also subject to shutdown rates of $\delta_S \in (0, 1)$ each period. However, following the empirical evidence of small firms in industries where self-employment is skewed towards showing higher exit rates, I set δ_S larger than δ_H. Note that since the self-employed are one-man firms, the law of motion for employment in the self-employed sector is exactly same as the law of motion for self-employment sector firms.

The timeline of the events in period t is described in Figure 3.2. At the start of the period, some matches cease to continue due to exogenous separation, which join the unemployment pool immediately. After shocks are realized in each sector, new entrants enter in both the hiring and self-employed sectors. All hiring firms post vacancies, in which some are filled through matching. All active firms in both sectors produce, and the period ends with some firms exiting due to exogenous rates of shutting down.

3.2.3 Labor Market

Under the given setup, a worker can be in one of the three following states in the labor market: employed (i.e. has a wage-paying job), unemployed, and self-employed (where income depends on the profits from running a business). Both the employed and the self-employed count towards total employment: $L_t = l_{h,t} N_{H,t} + N_{S,t}$.

As a wage-paid worker in period t, the value of being employed is the sum of wage one earns today and the discounted value of the future state. Which state the employed worker would be in depends on the exogenous firing rate (λ), the shutdown rate for the hiring sector (δ_H), and the worker's choice between staying in the unemployment pool and starting one's own business ($\max(U_{u,t+1}, -f_{RS} + S_{t+1})$):

$$W_t = w_t + \mathbb{E}_t\, \beta_{t,t+1} \Big[(1-\delta_H)(1-\lambda) W_{t+1} + \big\{1 - (1-\delta_H)(1-\lambda)\big\} \max(U_{u,t+1}, -f_{RS} + S_{t+1}) \Big]. \tag{3.29}$$

An unemployed worker receives unemployment benefits today and is either matched next period or needs to choose again between unemployment and self-employment:

$$U_{u,t} = u_b + \mathbb{E}_t\, \beta_{t,t+1} \Big[(1-\delta_H)\iota_{t+1} W_{t+1} + \big\{1 - (1-\delta_H)\iota_{t+1}\big\} \max(U_{u,t+1}, -f_{RS} + S_{t+1}) \Big]. \tag{3.30}$$

Once a worker decides to pay the entry cost and switches to running one's own business, he no longer receives unemployment benefits but starts earning profits from the new business. Whether this person continues with the business or not in the next period depends on the exogenous shutdown rates and probability of matching:

$$S_t = d_{s,t} + \mathbb{E}_t\, \beta_{t,t+1}\Big[(1-\delta_S)S_{t+1} + \delta_S(1-\delta_H)\iota_{t+1}W_{t+1} + \big\{1-\delta_S(1-\delta_H)\iota_{t+1}\big\}\max(U_{u,t+1}, -f_{RS}+S_{t+1})\Big]. \tag{3.31}$$

Worker's surplus from match is defined as $S_t^W \equiv W_t - \max(U_{u,t}, -f_{RS} + S_t$. Since both unemployment and self-employment exist in equilibrium, the equilibrium condition states that $U_{u,t} = -f_{RS} + S_t$. Using this condition, the worker's surplus can be rewritten as:

$$S_t^W = w_t - \bar{\omega}_{h,t} + (1-\delta_H)(1-\lambda)\,\mathbb{E}_t\,\beta_{t,t+1}S_{t+1}^W, \tag{3.32}$$

where $\bar{\omega}_{h,t} \equiv u_b + (1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}\iota_{t+1}S_{t+1}^W$ is the worker's outside option.

Firm's surplus from the match (S_t^F) comes from the extra marginal revenue product from the extra match less the wage paid, and the future discounted benefit of the match if it survives the separation:

$$S_t^F = \varphi_{h,t}Z_{H,t} - w_t + (1-\delta_H)(1-\lambda)E_t\beta_{t,t+1}S_{t+1}^F. \tag{3.33}$$

Nash bargaining implies real wage as the following:

$$w_t = \eta\varphi_{h,t}Z_{H,t} + (1-\eta)\bar{\omega}_{h,t}. \tag{3.34}$$

3.2.4 Household's Intertemporal Problem

The representative household faces the following budget constraint:

$$C_t + T_t + e_{h,t}N_{H,t}x_{h,t+1} + f_{RS}N_{SE,t} = w_t l_{h,t}N_{H,t} + d_{s,t}N_{S,t} + u_b(1-L_t) + e_{h,t}x_{h,t}(1-\delta_H)N_{H,t-1} + d_{h,t}x_{h,t+1}N_{H,t}, \tag{3.35}$$

where $x_{h,t}$ is the shares of mutual fund in hiring sector held by the household and unemployment benefits (u_b) are financed by lump-sum taxes (T). First order condition respect to $x_{h,t}$ gives the Euler equation for shareholdings, $e_{h,t} = d_{h,t} + (1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}e_{h,t+1}$.

3.2.5 Closing the Model

In equilibrium, the aggregate price index satisfies:

$$1 = (1-\alpha_S)\left(\frac{P_t^H}{P_t}\right)^{1-\phi_S} + \alpha_S\left(\frac{P_t^S}{P_t}\right)^{1-\phi_S}, \tag{3.36}$$

where

$$\frac{P_t^S}{P_t} = N_{S,t}^{\frac{1}{1-\theta_S}}\rho_{s,t}, \tag{3.37}$$

$$\frac{P_t^H}{P_t} = \left[(1-\alpha_X)N_{H,t}^{\frac{1-\phi_X}{1-\theta_H}}\rho_{d,t}^{1-\phi_X} + \alpha_X(N_{H,t}^*)^{\frac{1-\phi_X}{1-\theta_H}}(\rho_{x,t}^*)^{1-\phi_X}\right]^{\frac{1}{1-\phi_X}}. \tag{3.38}$$

Aggregate demand is written as $Y_t = C_t + \kappa V_t + f_{RS}N_{SE,t} + f_{RH}N_{HE,t}$ and aggregate unemployment rate is $U_t = 1-(1-\lambda)l_{h,t}N_{H,t} - N_{S,t}$. Output clearing for each sector implies the following:

$$Z_{H,t}l_{h,t} = (1-\alpha_S)N_{H,t}^{\frac{\theta_H-\phi_X}{1-\theta_H}}\left[(1-\alpha_X)\rho_{d,t}^{-\phi_X}\left(\frac{P_t^H}{P_t}\right)^{\phi_X-\phi_S}Y_t \right.$$
$$\left. +\alpha_X\rho_{x,t}^{-\phi_X}\left(\frac{P_t^H}{P_t^*}\right)^{\phi_X-\phi_S}Y_t^*\right] + (1-\alpha_X)N_{S,t}^{\frac{1-\phi_X}{1-\theta_H}}\rho_{h,t}^{-\phi_X}\left(\frac{P_t^H}{P_t}\right)^{\phi_X}M_{s,t}, \tag{3.39}$$

$$Z_{S,t}M_{s,t} = \alpha_S\rho_{s,t}^{-\theta_S}\left(\frac{P_t^S}{P_t}\right)^{\theta_S-\phi_S}Y_t. \tag{3.40}$$

Terms of trade is defined as $TOT_t \equiv Q_t\rho_{x,t}^*/\rho_{x,t}$. The economy is under financial autarky and trade is balanced every period: $Q_tN_{H,t}\rho_{x,t}y_{x,t}(h) - N_{H,t}^*\rho_{x,t}^*y_{x,t}^*(h) = 0$. The model described above gives 30 endogenous variables and 30 equations as shown in Table 3.1. The foreign variables that have an effect on the Home economy are $N_{H,t}^*$, $y_{x,t}^*$, τ_t^*, $\mathcal{P}_t^{H*}$, and Y_t^*.

3.3 Calibration

I use quarters as periods and set certain parameters according to those standard in the literature. Small open economy-specific parameters are calibrated using the data from Korea. The rest of the world is assumed to be symmetric to Home. Discount factor β is set at 0.99, which is interpreted as an annual real interest rate of 4%. Following Ghironi and Melitz (2005), elasticity of substitution across varieties for the hiring sector, θ_H, is equal to 3.8. For the self-employed sector, θ_S is set to 6.38. The risk aversion coefficient γ is set at 2. Since I follow the empirical evidence that the majority of the self-employed produce nontradable service goods and serve only the domestic market, I use the elasticity of substitution between tradables and nontradables for ϕ_S, the elasticity of substitution between goods from hiring sector and self-employed sector. This parameter is set at 0.5, following Mendoza (1992). Elasticity between domestic and imported goods, ϕ_X, is set at 1.5, as is standard in the international business cycle literature. Share of hiring sector goods, $1 - \alpha_S$, is given as 0.2 to reflect the relatively smaller output generated by the self-employed. Share of imported goods, α_X, is set at 0.5, to reflect the relatively high openness of Korea. Iceberg trade costs, τ, is set to match the total trade (imports + exports) over GDP to 0.66, the average value for Korea.

To capture the characteristics of the product and labor market, I calibrate parameters according to the Korean labor market after the recent financial crisis. Elasticity of the matching function ξ is set at 0.5 to follow the calibration of the Korean economy as Schauer (2018). Bargaining power of the worker η is equal to 0.5 to satisfy the Hosios condition. This ensures that the competitive equilibrium in this economy is efficient. The exogenous exit rate δ_S for the self-employed is set at 0.2, higher than that of the hiring sector, $\delta_H = 0.05$. Due to the uniqueness of the Korean labor market, separation rate (λ) for workers differs vastly depending on whether the worker is permanent or temporary. In 2016, while only 2.4% of permanent workers left their jobs, for temporary workers the separation rate was at 18.8%. According to the classification of Ha and Lee (2013), the share of non-regular workers is estimated at 49% of total employment. Using weighted average, separation rate λ is calculated at 0.026. Unemployment benefit is equal to 51% of steady-state wage, which matches the average replacement rate u_b/w of Korea reported by OECD (2004).

Following the literature, I calibrate the values of matching efficiency χ and cost of posting vacancies κ to match the unemployment rate and probability of filling a vacancy. The job finding probability, ι, is set at 0.75 to match the median unemployment duration of 6 weeks, consistent with the findings in Hobijn and Sahin (2009). As noted in Andolfatto (1996), the probability of filling a vacancy (q) is set at 0.9. This yields the steady-state level of self-employed at 36% of total employment and the unemployment rate of 4.6%.

As for the product market, following Ebell and Haefke (2009b), the fixed portion of the entry cost (regulation and technological cost) for the hiring sector is calculated as 5.2 months of lost output. To incorporate the empirical evidence that the self-employed largely select into industries with lower entry to barrier and produce goods already available in the economy (Hurst and Pugsley (2012)), the entry cost for the self-employed is lower, with 2 months of lost output.

Finally, the exogenous aggregate productivity shock for the hiring sector (Z_H) and the self-employed sector (Z_S) follow an AR(1) process in logs with persistence of 0.95 and standard deviation of 0.0072, following the common RBC literature. The full description of calibrated parameters is given in Table 3.2. The model gives 33% of employment coming from self-employment in the steady state, which is close to what the data from Korea suggests.

3.4 Business Cycle Dynamics

Figure 3.3 shows the business cycle dynamics after a one standard deviation productivity shock in the hiring sector. Not surprisingly, more firms enter in the hiring sector - but at the same time, it lowers the cost of inputs for the self-employed, leading to a rise in their profits and thus a spillover effect in the self-employment sector as well. As a result, the number of total firms rise. While unemployment does fall, it is actually coming from the workforce shifting into self-employment, as shown by the decline in the hiring sector's employment. Higher wage and profits of self-employment on top of more workers being employed imply a rise in output and consumption as a result. Due to a rise in new firm entry in the hiring sector at Home, terms of trade depreciates. Home's exports become relatively cheaper, but due to a stronger increase in demand for foreign goods by both domestic households and the self-employed (as inputs), real exchange rate depreciates (Q_t rises). As a result, terms of trade appreciates initially, then eventually depreciates.

In contrast, Figure 3.4 shows the business cycle dynamics after a one standard deviation productivity shock in the self-employment sector. What is interesting here is that a positive productivity shock does not necessarily lead to an increase in the entry of the self-employed. Multiple factors contribute to this result. There exists a spillover effect from the self-employed sector to the hiring sector as well since hiring sector goods are used as inputs. This increased demand faced by hiring firms has a positive effect on the new entrants in the sector, allowing more workers to be employed. This dampens the workers' need for shifting into entrepreneurship and becomes the dominant impact over firm entry in the sector. While the real exchange rate and terms of trade move in the same direction due to increased entry in the hiring sector, the size is much smaller compared to the case with a positive productivity shock in the hiring sector.

Figure 3.5 compares the benchmark case (blue solid line) with the financial autarky case (orange dash-dotted line). It is possible to observe some significant differences that the opening of the financial market brings to the business cycle dynamics. As in the standard international business cycle literature, access to financial markets allows more consumption smoothing. Interestingly enough, while the international financial market should make it easier to finance firm entry, it does not lead to more firm creation. Part of this phenomenon is due to the curbing of self-employment. Due to better chances of finding wage-paying jobs for the workers, employment in the hiring sector falls by less and the unemployed have less of an incentive to shift into self-employment. This leads to terms of trade showing very different movements: while it depreciates eventually, under international borrowing, it initially appreciates first.

3.5 Conclusion

I constructed a small open economy version of the model presented in Chapter 2, incorporating certain pieces of important empirical evidence on self-employment into account. What I find is the impact of productivity shocks being disproportionate not only on the domestic economic variables but also on the real exchange rate and terms of trade. As a result, workers' endogenous decision-making for selecting into self-employment becomes more crucial for an open economy with a significant amount of employment coming from the self-employed. The policy exercise of opening up the financial market reveals a more modest movement in firm creation in both sectors, along with very distinctively different movements in terms of trade.

Table 3.1. Model summary

Var	Description	Equation
M_t	Matching function	$M_t = \chi U_t^{\xi} V_t^{1-\xi}$
ι_t	Job finding probability	$\iota_t = M_t/U_t$
q_t	Vacancy filling probability	$q_t = M_t/V_t$
U_t	Unemployment	$U_t = 1 - (1-\lambda)l_{h,t}N_{H,t} - N_{S,t}$
$l_{h,t}$	Law of motion for employment	$l_{h,t} = (1-\lambda)l_{h,t-1} + q_t v_t$
$N_{S,t}$	Law of motion for SE firms	$N_{S,t} = (1-\delta_S)N_{S,t-1} + N_{SE,t}$
$N_{H,t}$	Law of motion for H firms	$N_{H,t} = (1-\delta_H)N_{H,t-1} + N_{HE,t}$
$e_{h,t}$	Value of H firm	$e_{h,t} = d_{h,t} + (1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}e_{h,t+1}$
$e_{s,t}$	Value of SE firm	$e_{s,t} = d_{s,t} + (1-\delta_S)\,\mathbb{E}_t\,\beta_{t,t+1}e_{s,t+1}$
$N_{HE,t}$	Free entry condition (H)	$f_{RH} + \kappa(l_{h,t}/q_t - v_t) = e_{h,t}$
$N_{SE,t}$	Free entry condition (SE)	$f_{RS} = e_{s,t}$
$d_{h,t}$	Profits of H firm	$d_{h,t} = \frac{1}{\theta_H}\rho_{d,t}\left[y_{d,t}(h) + \tau_t y_{x,t}(h) + m_{s,t}(h)N_{S,t}\right]$
$d_{s,t}$	Profits of SE firm	$d_{s,t} = \frac{1}{\theta_S}\rho_{s,t}y_t(s)$
$y_{d,t}(h)$	Domestic demand for variety h	$y_{d,t}(h) = (1-\alpha_X)(1-\alpha_S)N_{H,t}^{\frac{\theta_H-\phi_X}{1-\theta_H}}\,\rho_{d,t}^{-\phi_X}\left(\mathcal{P}_t^H\right)^{\phi_X-\phi_S}Y_t$
$y_{x,t}(h)$	Export demand for variety h	$y_{x,t}(h) = \alpha_X(1-\alpha_S)N_{H,t}^{\frac{\theta_H-\phi_X}{1-\theta_H}}\left(\tau Q_t^{-1}\rho_{d,t}\right)^{-\phi_X}\left(\mathcal{P}_t^{H*}\right)^{\phi_X-\phi_S}Y_t^*$
$m_{s,t}(h)$	Demand for variety h as inputs	$m_{s,t}(h) = (1-\alpha_X)\rho_{d,t}^{-\phi_X}N_{H,t}^{\frac{\theta_H-\phi_X}{1-\theta_H}}\left(\mathcal{P}_t^H\right)^{\phi_X}M_{s,t}$
$y_t(s)$	Demand for variety s	$y_t(s) = \alpha_S\rho_{s,t}^{-\theta_S}\left(\mathcal{P}_t^S\right)^{\theta_S-\phi_S}Y_t$
v_t	Job creation	$\frac{\kappa}{q_t} = \varphi_{h,t}Z_{H,t} - w_t + (1-\lambda)(1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}\frac{\kappa}{q_{t+1}}$
w_t	Real wage	$w_t = \eta\varphi_{h,t}Z_{H,t} + (1-\eta)\left[u_b + (1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}\iota_{t+1}\frac{\eta}{1-\eta}\frac{\kappa}{q_{t+1}}\right]$
V_t	Aggregate vacancies	$V_t = v_tN_{H,t} + (l_{h,t}/q_t - v_t)N_{HE,t}$
$\varphi_{h,t}$	Marginal costs	$\rho_{d,t} = \frac{\theta_H}{\theta_H-1}\varphi_{h,t}$
$\varphi_{s,t}$		$\rho_{s,t} = \frac{\theta_S}{\theta_S-1}\varphi_{s,t}$
$\mathcal{P}_t^S$	Price sub-indices	$1 = (1-\alpha_S)(\mathcal{P}_t^H)^{1-\phi_S} + \alpha_S(\mathcal{P}_t^S)^{1-\phi_S}$
$\mathcal{P}_t^H$		$\mathcal{P}_t^H = \left[(1-\alpha_X)N_{H,t}^{\frac{1-\phi_X}{1-\theta_H}}\rho_{d,t}^{1-\phi_X} + \alpha_X(N_{H,t}^*)^{\frac{1-\phi_X}{1-\theta_H}}(\tau^*Q_t\rho_{d,t}^*)^{1-\phi_X}\right]^{\frac{1}{1-\phi_X}}$
$y_{h,t}$	Production functions	$y_{h,t} = Z_{H,t}l_{h,t}$
$y_{s,t}$		$y_{s,t} = Z_{S,t}M_{s,t}$
Y_t	Output clearing (H)	$Z_{H,t}l_{h,t} = N_{H,t}^{\frac{\theta_H-\phi_X}{1-\theta_H}}\rho_{d,t}^{-\phi_X}\Big[(1-\alpha_X)(\mathcal{P}_t^H)^{\phi_X}\big\{(1-\alpha_S)(\mathcal{P}_t^H)^{-\phi_S}Y_t$ $+ M_{s,t}N_{S,t}\big\} + \alpha_X(1-\alpha_S)(\tau Q_t)^{-\phi_X}(\mathcal{P}_t^{H*})^{\phi_X-\phi_S}Y_t^*\Big]$
$M_{s,t}$	Output clearing (SE)	$Z_{S,t}M_{s,t} = \alpha_SN_{S,t}^{\frac{\theta_S-\phi_S}{1-\theta_S}}\rho_{s,t}^{-\phi_S}Y_t$
C_t	Aggregate demand	$Y_t = C_t + \kappa V_t + f_{RH}N_{HE,t} + f_{RS}N_{SE,t}$
Q_t	RER	$Q_tN_{H,t}\rho_{x,t}y_{x,t}(h) - N_{H,t}^*\rho_{x,t}^*y_{x,t}^*(h) = 0$

Table 3.2. Calibration

Parameter		Value	Parameter		Value
Discount factor	β	0.99	Matching elasticity	ξ	0.5
Risk aversion	γ	2	Matching efficiency	χ	0.82
EOS for variety (sector H)	θ_H	3.8	Total unemp. benefits	u_b/w	0.51
EOS for variety (sector S)	θ_S	6.38	Vacancy filling rate	q	0.9
EOS bet. sectoral goods	ϕ_S	0.5	Separation rate	λ	0.05
EOS bet. domestic and imported goods	ϕ_X	1.5	Worker matching rate	ι	0.75
Share of S sector goods in C	α_S	0.2	Vacancy cost	κ	0.84
Share of imported goods in C	α_X	0.5	Worker's bargaining power	η	0.5
Firm exit rate	δ_H	0.05	Persistence of prod. shock	ρ_{Zh}	0.95
	δ_S	0.2		ρ_{Zs}	0.81
Regulation cost	f_{RH}	1.27	Std. of prod. shock	σ_{Zh}	0.0072
	f_{RS}	0.79		σ_{Zs}	0.004
Trade openness	$(IM+X)/Y$	0.66	Emp from SE	N_S/L	0.33

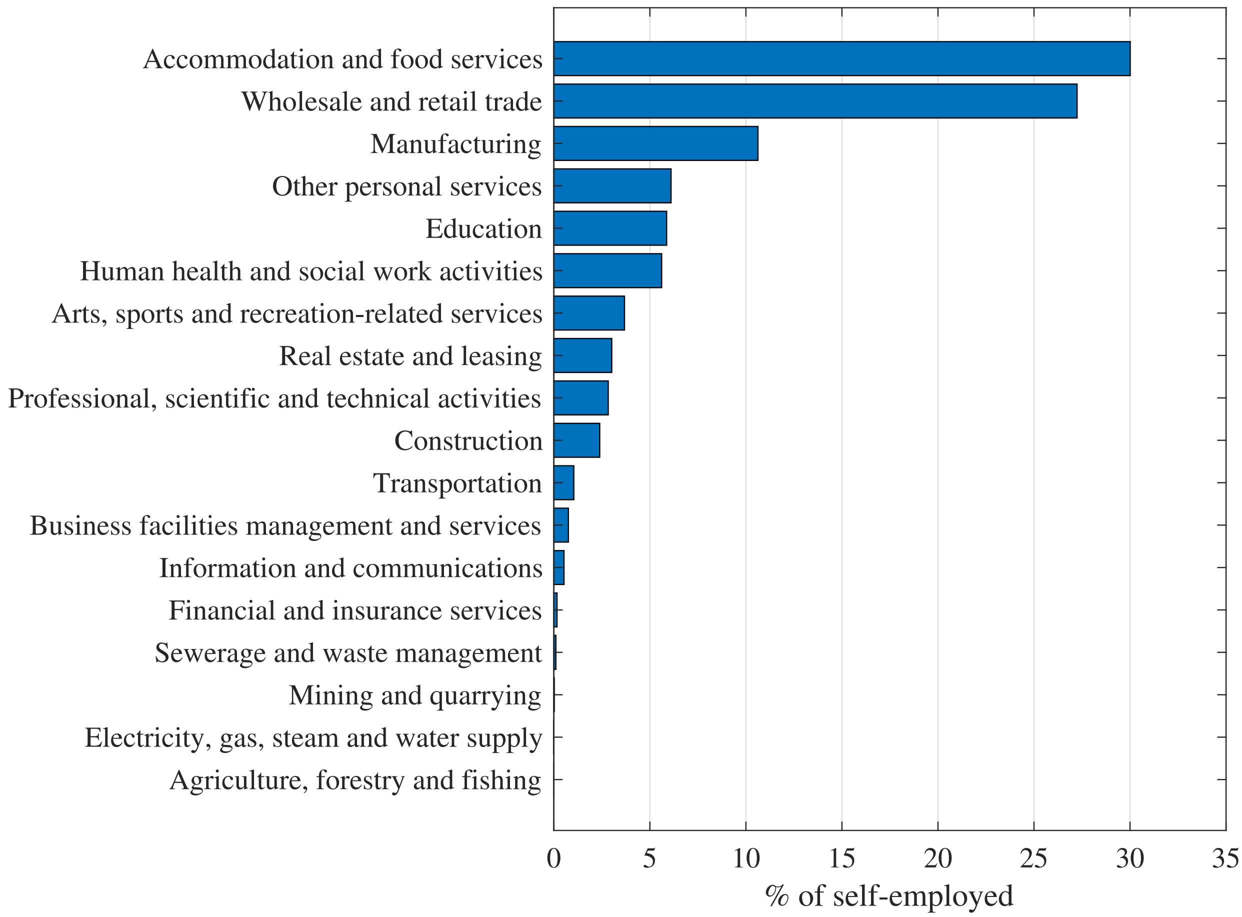


Figure 3.1. Self-employed with 1-4 workers by industry in Korea, Kostat 2007-2016 avg

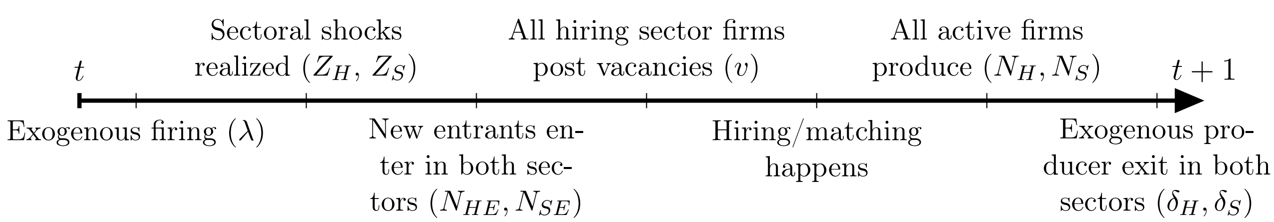


Figure 3.2. Timeline of events in a given period. [cited on page 107]

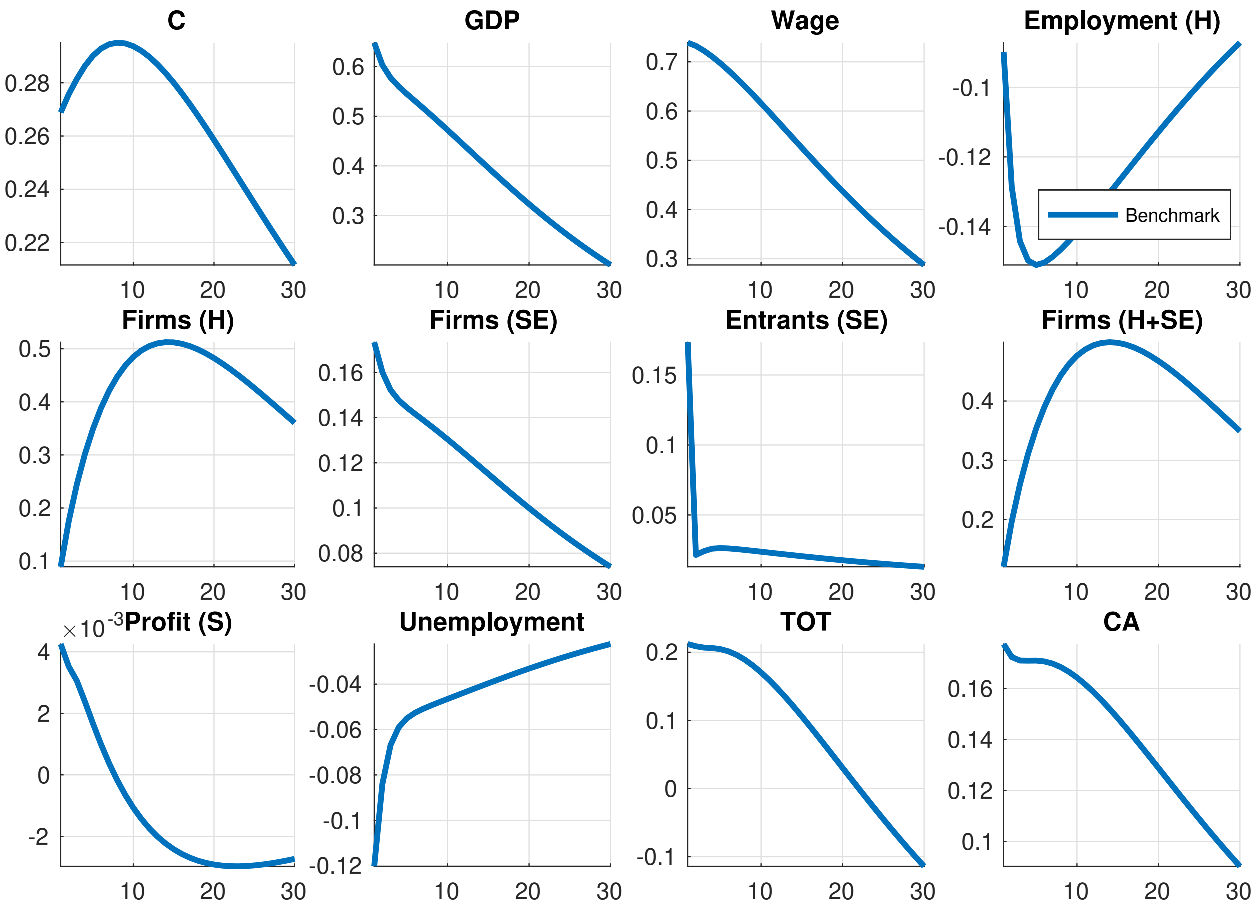


Figure 3.3. Productivity shock in the hiring sector. Responses show percentage deviations from steady state after a one standard deviation productivity shock. Unemployment is in deviations from steady state.

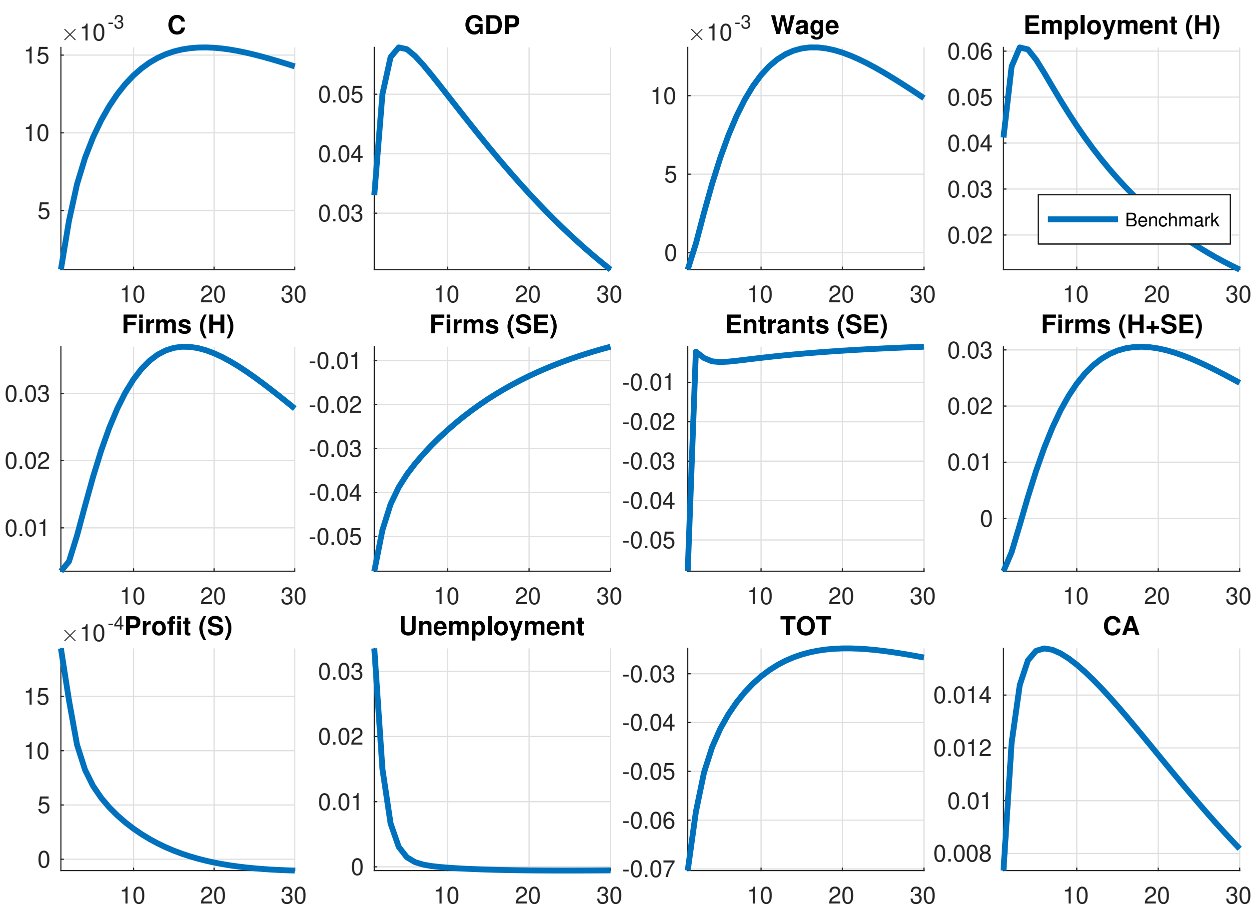


Figure 3.4. Productivity shock in the self-employed sector. Responses show percentage deviations from steady state after a one standard deviation productivity shock. Unemployment is in deviations from steady state.

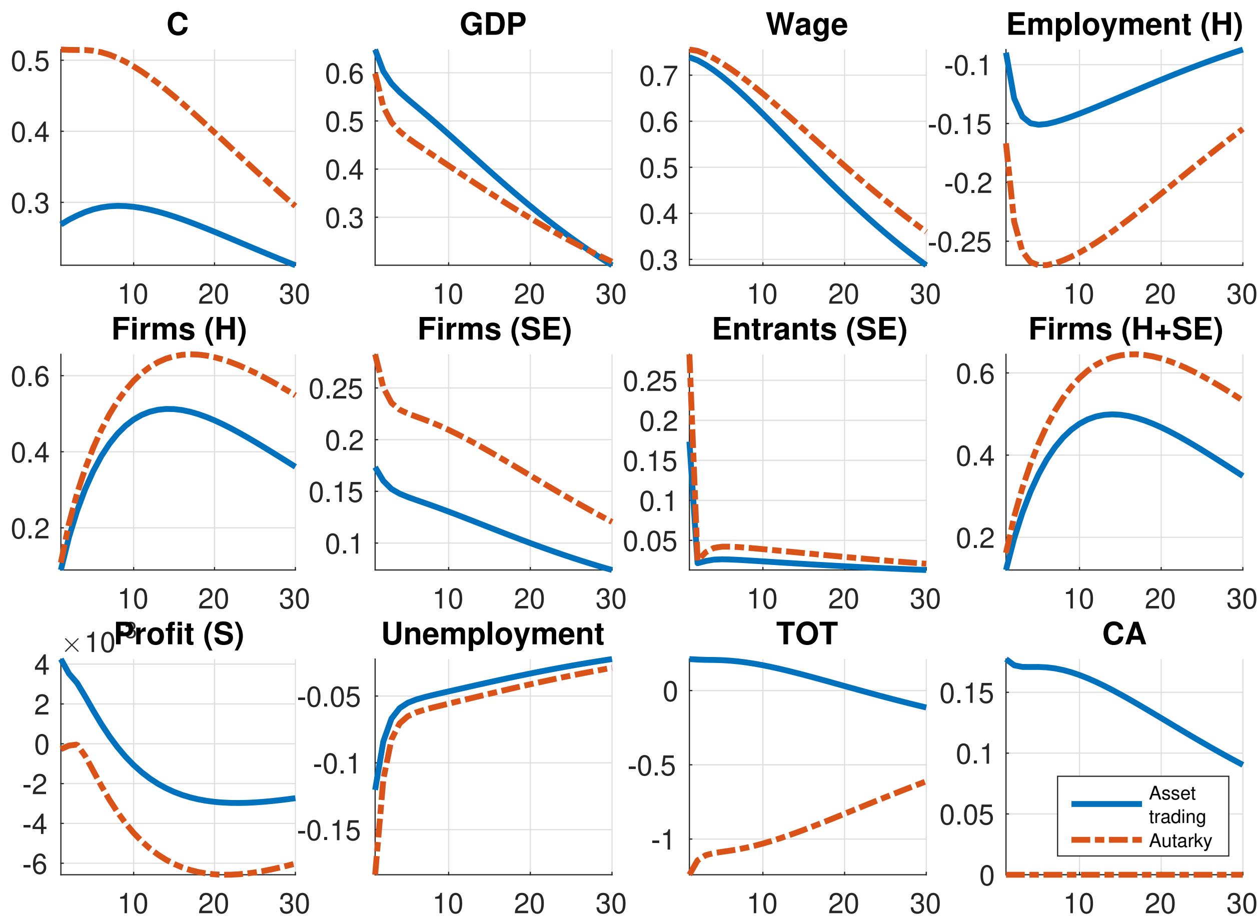


Figure 3.5. Productivity shock in the hiring sector under financial autarky (orange) and open financial markets (blue). Responses show percentage deviations from steady state after a one standard deviation productivity shock. Unemployment is in deviations from steady state.

BIBLIOGRAPHY

Daron Acemoglu. Good jobs versus bad jobs. *Journal of Labor Economics*, 19(1):1–21, 2001.

Daron Acemoglu and Robert Shimer. Efficient unemployment insurance. *The Journal of Political Economy*, 107(5):893–928, 1999.

Daron Acemoglu and Robert Shimer. Productivity gains from unemployment insurance. *European Economic Review*, 44(7):1195–1224, 2000.

Zoltan J. Acs. How is entrepreneurship good for economic growth? *Innovations*, 1(1):97–107, 2006.

Zoltan J. Acs and David B. Audretsch. Small-firm entry in US manufacturing. *Economica*, 56(222):255–265, 1989.

Philippe Aghion and Peter Howitt. A model of growth through creative destruction. *Econometrica*, 60(2):323–351, 1992.

Mark Aguiar and Gita Gopinath. Emerging market business cycles: the cycle is the trend. *Journal of political Economy*, 115(1):69–102, 2007.

George Alessandria and Horag Choi. Do sunk costs of exporting matter for net export dynamics? *The Quarterly Journal of Economics*, 122(1):289–336, 2007.

David Andolfatto. Business cycles and labor-market search. *The American Economic Review*, 86(1):112–132, 1996.

David M. Arseneau and Sanjay K. Chugh. Optimal fiscal and monetary policy with costly wage bargaining. *Journal of Monetary Economics*, 55(8):1401–1414, 2008.

Stéphane Auray and Aurélien Eyquem. Welfare reversals in a monetary union. *American Economic Journal: Macroeconomics*, 6(4):246–90, 2014.

Bee Yan Aw, Sukkyun Chung, and Mark J. Roberts. Productivity and turnover in the export market: micro-level evidence from the Republic of Korea and Taiwan (China). *The World Bank Economic Review*, 14(1):65–90, 2000.

José Azar, Ioana Marinescu, and Marshall I. Steinbaum. Labor market concentration. *No. w24147. National Bureau of Economic Research*, 2017.

Abhijit V. Banerjee and Andrew F. Newman. Occupational choice and the process of development. *Journal of Political Economy*, 101(2):274–298, 1993.

Bank of Korea. Economic Statistics System (ECOS), 2015. URL: http://ecos.bok.or.kr. Accessed in November 2015.

Gianluca Benigno and Pierpaolo Benigno. Exchange rate determination under interest rate rules. *Journal of international Money and Finance*, 27(6):971–993, 2008.

Pierpaolo Benigno. Price stability with imperfect financial integration. *Journal of Money, credit and Banking*, 41:121–149, 2009.

Andrew B. Bernard and J. Bradford Jensen. Why some firms export. *Review of economics and Statistics*, 86(2):561–569, 2004.

Andrew B. Bernard, Jonathan Eaton, J. Bradford Jensen, and Samuel Kortum. Plants and productivity in international trade. *American economic review*, 93(4):1268–1290, 2003.

Florin O. Bilbiie, Fabio Ghironi, Marc J. Melitz, Virgiliu Midrigan, and Julio J. Rotemberg. Monetary policy and business cycles with endogenous entry and product variety [with comments and discussion]. *NBER Macroeconomics Annual*, 22:299–379, 2007.

Florin O. Bilbiie, Fabio Ghironi, and Marc J. Melitz. Endogenous entry, product variety, and business cycles. *Journal of Political Economy*, 120(2):304–345, 2012.

Olivier J. Blanchard and Peter Diamond. The Beveridge curve. *Brookings Papers on Economic Activity*, 1989(1):1–51, 1989.

Olivier J. Blanchard and Francesco Giavazzi. Macroeconomic effects of regulation and deregulation in goods and labor markets. *The Quarterly Journal of Economics*, 118(3):879–907, 2003.

David G. Blanchflower. Self-employment in OECD countries. *Labour Economics*, 7(5):471–505, 2000.

Pontus Braunerhjelm. Entrepreneurship, knowledge and economic growth. *Foundations and Trends in Entrepreneurship*, 4(5):451–533, 2008.

Christian Broda. Terms of trade and exchange rate regimes in developing countries. *Journal of International economics*, 63(1):31–58, 2004.

Christian Broda and David E. Weinstein. Product creation and destruction: Evidence and price implications. *American Economic Review*, 100(3):691–723, 2010.

Matteo Cacciatore. International trade and macroeconomic dynamics with labor market frictions. *Journal of International Economics*, 93(1):17–30, 2014.

Matteo Cacciatore and Giuseppe Fiori. The macroeconomic effects of goods and labor markets deregulation. *Review of Economic Dynamics*, 20:1–24, 2016.

Matteo Cacciatore and Fabio Ghironi. Trade, unemployment, and monetary policy. Working paper, 2012.

Matteo Cacciatore, Fabio Ghironi, and Stephen J. Turnovsky. Inflation targeting and economic reforms in New Zealand. *International Journal of Central Banking*, 11(4):145–198, 2015.

Matteo Cacciatore, Romain Duval, Giuseppe Fiori, and Fabio Ghironi. Short-term pain for long-term gain: market deregulation and monetary policy in small open economies. *Journal of International Money and Finance*, 68:358–385, 2016.

Matteo Cacciatore, Romain Duval, Giuseppe Fiori, and Fabio Ghironi. Market reforms at the zero lower bound. NBER Working Papers 23960, National Bureau of Economic Research, 2017.

Nauro F. Campos, Paul De Grauwe, and Yuemei Ji. Structural reforms, growth and inequality: an overview of theory, measurement and evidence. 2017.

David Card. Intertemporal labor supply: an assessment. Working paper, National Bureau of Economic Research, 1991.

Martin A. Carree and Roy Thurik. *The impact of entrepreneurship on economic growth*. Springer, 2010.

Rebekka Christopoulou and Philip Vermeulen. Markups in the Euro area and the US over the period 1981-2004: a comparison of 50 sectors. *Empirical Economics*, 42(1):53–77, 2012.

Jaesik Chung, Yongseung Jung, and Doo Yong Yang. Optimal monetary policy in a small open economy: the case of Korea. *Journal of Asian Economics*, 18(1):125–143, 2007.

Richard Clarida, Jordi Galí, and Mark Gertler. Monetary policy rules and macroeconomic stability: evidence and some theory. *The Quarterly journal of economics*, 115(1):147–180, 2000.

Diego Comin and Mark Gertler. Medium-term business cycles. *American Economic Review*, 96(3):523–551, 2006.

Diego Comin, Norman Loayza, Farooq Pasha, and Luis Serven. *Medium-term business cycles in developing countries*. The World Bank, 2009.

Giancarlo Corsetti, Luca Dedola, and Sylvain Leduc. Optimal monetary policy in open economies. In *Handbook of monetary economics*, volume 3, pages 861–933. Elsevier, 2010.

Michael Ian Cragg and Mario Epelbaum. Why has wage dispersion grown in Mexico? is it the incidence of reforms or the growing demand for skills? *Journal of development Economics*, 51(1):99–116, 1996.

J. Creedy and P. S. Johnson. Firm formation in manufacturing industry. *Applied Economics*, 15(2):177–185, 1983.

Julian Di Giovanni and Andrei A. Levchenko. Country size, international trade, and aggregate fluctuations in granular economies. *Journal of Political Economy*, 120(6):1083–1132, 2012.

Peter A. Diamond. Aggregate demand management in search equilibrium. *Journal of political Economy*, 90(5):881–894, 1982a.

Peter A. Diamond. Wage determination and efficiency in search equilibrium. *The Review of Economic Studies*, 49(2):217–227, 1982b.

Avinash K. Dixit and Joseph E. Stiglitz. Monopolistic competition and optimum product diversity. *The American economic review*, 67(3):297–308, 1977.

Monique Ebell and Christian Haefke. Product market deregulation and the US employment miracle. *Review of Economic dynamics*, 12(3):479–504, 2009a.

Monique Ebell and Christian Haefke. Product market deregulation and the US employment miracle. *Review of Economic Dynamics*, 12(3):479–504, 2009b.

Barry J. Eichengreen. *Capital flows and crises.* MIT Press, 2004a.

Barry J. Eichengreen. Monetary and exchange rate policy in Korea: assessments and policy issues. 2004b.

Barry J. Eichengreen. *Globalizing capital: a history of the international monetary system.* Second edition, Princeton University Press, Princeton, NJ, 2008.

David S. Evans. The relationship between firm growth, size, and age: Estimates for 100 manufacturing industries. *The Journal of Industrial Economics*, 35(4):567–581, 1987.

David S. Evans and Boyan Jovanovic. An estimated model of entrepreneurial choice under liquidity constraints. *Journal of Political Economy*, 97(4):808–827, 1989.

David S. Evans and Linda S. Leighton. Some empirical aspects of entrepreneurship. *The American Economic Review*, 79(3):519–535, 1989.

Luc Everaert and Werner Schule. Why it pays to synchronize structural reforms in the euro area across markets and countries. *IMF Staff Papers*, 55(2):356–366, 2008.

Robert Fairlie and Frank Fossen. Defining opportunity versus necessity entrepreneurship: Two components of business creation, 2019.

Steven Fazzari, R. Glenn Hubbard, and Bruce Petersen. Investment, financing decisions, and tax policy. *The American Economic Review*, 78(2):200–205, 1988.

Zadia M. Feliciano. Workers and trade liberalization: the impact of trade reforms in mexico on wages and employment. *ilr Review*, 55(1):95–115, 2001.

Francisco H.G. Ferreira, Phillippe G. Leite, and Matthew Wai-Poi. *Trade liberalization, employment flows, and wage inequality in Brazil.* The World Bank, 2007.

Giuseppe Fiori, Giuseppe Nicoletti, Stefano Scarpetta, and Fabio Schiantarelli. Employment outcomes and the interaction between product and labor market deregulation: Are they substitutes or complements? Working paper, 2007.

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

Raquel Fonseca, Paloma Lopez-Garcia, and Christopher A. Pissarides. Entrepreneurship, start-up costs and employment. *European Economic Review*, 45(4):692–705, 2001.

Xavier Gabaix. The granular origins of aggregate fluctuations. *Econometrica*, 79(3):733–772, 2011.

Jordi Galí and Tommaso Monacelli. Monetary policy and exchange rate volatility in a small open economy. *The Review of Economic Studies*, 72(3):707–734, 2005.

P.A. Geroski. What do we know about entry? *International Journal of Industrial Organization*, 13:421–440, 1995.

Mark Gertler and Antonella Trigari. Unemployment fluctuations with staggered nash wage bargaining. *Journal of political Economy*, 117(1):38–86, 2009.

Mark Gertler, Luca Sala, and Antonella Trigari. An estimated monetary DSGE model with unemployment and staggered nominal wage bargaining. *Journal of Money, Credit and Banking*, 40(8):1713–1764, 2008.

Maitreesh Ghatak, Massimo Morelli, and Tomas Sjöström. Occupational choice and dynamic incentives. *The Review of Economic Studies*, 68(4):781–810, 2001.

Maitreesh Ghatak, Massimo Morelli, and Tomas Sjöström. Entrepreneurial talent, occupational choice, and trickle up policies. *Journal of Economic Theory*, 137(1):27–48, 2007.

Fabio Ghironi and Marc J. Melitz. International trade and macroeconomic dynamics with heterogeneous firms. *The Quarterly Journal of Economics*, 120(3):865–915, 2005.

Stephan J. Goetz, David A. Fleming, and Anil Rupasingha. The economic impacts of self-employment. *Journal of Agricultural and Applied Economics*, 44(3):315–321, 2012.

Pinelopi Koujianou Goldberg and Nina Pavcnik. The response of the informal sector to trade liberalization. *Journal of development Economics*, 72(2):463–496, 2003.

Douglas Gollin. Nobody's business but my own: Self-employment and small enterprise in economic development. *Journal of Monetary Economics*, 55(2):219–233, 2008.

Byung-jin Ha and Sangheon Lee. Dual dimensions of non-regular work and SMEs in the Republic of Korea. *ILO Employment Working Paper*, 148, 2013. URL https://core.ac.uk/download/pdf/51175924.pdf.

Robert E. Hall. Job loss, job finding, and unemployment in the U.S. economy over the past fifty years. *NBER Macroeconomics Annual*, 20:101–137, 2005.

John Haltiwanger, Stefano Scarpetta, and Helena Schweiger. *Assessing job flows across countries: the role of industry, firm size, and regulations*. The World Bank, 2006.

Barton H. Hamilton. Does entrepreneurship pay? An empirical analysis of the returns to self-employment. *Journal of Political Economy*, 108(3):604–631, 2000.

David M. Hart. *The emergence of entrepreneurship policy: governance, start-ups, and growth in the US knowledge economy*. Cambridge University Press, 2003.

Jonathan Heathcote and Fabrizio Perri. Financial autarky and international business cycles. *Journal of monetary Economics*, 49(3):601–627, 2002.

Jonathan Heathcote and Fabrizio Perri. Assessing international efficiency. In *Handbook of International Economics*, volume 4, pages 523–584. Elsevier, 2014.

Benedikt Heid, Mario Larch, and Alejandro Riano. The rise of the Maquiladoras: A mixed blessing. *Review of Development Economics*, 17(2):252–267, 2013.

Bart Hobijn and Aysegul Sahin. Job-finding and separation rates in the OECD. *Economics Letters*, 104(3):107–111, 2009.

Thomas J. Holmes and James A. Schmitz. A theory of entrepreneurship and its application to the study of business transfers. *Journal of Political Economy*, 98(2):265–294, 1990.

Hugo A. Hopenhayn. Entry, exit, and firm dynamics in long run equilibrium. *Econometrica*, 60(5):1127–1150, 1992.

Erik Hurst and Benjamin Wild Pugsley. What do small businesses do? *Brookings Papers on Economic Activity*, 2011(2):73–118, 2012.

International Monetary Fund. *World Economic Outlook: Too Slow for Too Long*. Washington, DC, April, 2016.

International Monetary Fund. *World Economic Outlook: Global Manufacturing Downturn, Rising Trade Barriers*. Washington, DC, October, 2019.

Job Openings and Labor Turnover Survey (JOLTS). URL: https://www.bls.gov/jlt/. Accessed in October 2019.

Peter Johnson. *The Formation and Development of Small Business: Issues and Evidence*. Routledge, 2008.

Michael Keane and Richard Rogerson. Micro and macro labor supply elasticities: A reassessment of conventional wisdom. *Journal of Economic Literature*, 50(2):464–76, 2012.

Richard E. Kihlstrom and Jean-Jacques Laffont. A general equilibrium entrepreneurial theory of firm formation based on risk aversion. *Journal of Political Economy*, 87(4):719–748, 1979.

Sangho Kim, Hyunjoon Lim, and Donghyun Park. Imports, exports and total factor productivity in Korea. *Applied Economics*, 41(14):1819–1834, 2009.

Tae Bong Kim. Monetary policy in Korea through the lense of taylor rule in DSGE model. In *2013 Meeting Papers*, number 746. Society for Economic Dynamics, 2013.

Robert G. King and Sergio T. Rebelo. Resuscitating real business cycles. *Handbook of macroeconomics*, 1:927–1007, 1999.

Frank H. Knight. *Risk, Uncertainty and Profit*. Courier Corporation, 1921.

Philipp D. Koellinger and Maria Minniti. Unemployment benefits crowd out nascent entrepreneurial activity. *Economics Letters*, 103(2):96–98, 2009.

Philipp D. Koellinger and Roy Thurik. Entrepreneurship and the business cycle. *Review of Economics and Statistics*, 94(4):1143–1156, 2011.

Maria Kontos. Self-employment policies and migrants' entrepreneurship in germany. *Entrepreneurship & Regional Development*, 15(2):119–135, 2003.

Michael U. Krause and Thomas A. Lubik. The (ir) relevance of real wage rigidity in the new keynesian model with search frictions. *Journal of Monetary Economics*, 54(3):706–727, 2007.

Aslı Leblebicioğlu. Financial integration, credit market imperfections and consumption smoothing. *Journal of Economic Dynamics and Control*, 33(2):377–393, 2009.

Alec R Levenson and Kristen L Willard. Do firms get the financing they want? measuring credit rationing experienced by small businesses in the us. *Small Business Economics*, 14 (2):83–94, 2000.

Magnus Lofstrom. Does self-employment increase the economic well-being of low-skilled workers? *Small Business Economics*, 40(4):933–952, 2013.

Robert E. Lucas. On the size distribution of business firms. *The Bell Journal of Economics*, 9(2):508–523, 1978.

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

Enrique G. Mendoza. The effects of macroeconomic shocks in a basic equilibrium framework. *Staff Papers (International Monetary Fund)*, 39(4):855–889, 1992.

Naércio Aquino Menezes-Filho and Marc-Andreas Muendler. Labor reallocation in response to trade reform. Working paper, National Bureau of Economic Research, 2011.

Monika Merz. Search in the labor market and the real business cycle. *Journal of monetary Economics*, 36(2):269–300, 1995.

Pascal Michaillat. Do matching frictions explain unemployment? Not in bad times. *American Economic Review*, 102(4):1721–50, 2012.

Fabio Milani and Sung Ho Park. The effects of globalization on macroeconomic dynamics in a trade-dependent economy: The case of Korea. *Economic Modelling*, 48:292–305, 2015.

Dale T. Mortensen and Christopher A. Pissarides. Job creation and job destruction in the theory of unemployment. *The Review of Economic Studies*, 61(3):397–415, 1994.

Makoto Nakajima. Business cycles in the equilibrium model of labor market search and self-insurance. *International Economic Review*, 53(2):399–432, 2012.

Francesc Obiols-Homs. Search and matching in the labor market without unemployment insurance. *Barcelona GSE WP*, 670, 2012.

Allan O'Connor. A conceptual framework for entrepreneurship education policy: Meeting government and economic purposes. *Journal of Business Venturing*, 28(4):546–563, 2013.

OECD. Benefits and Wages: Statistics, 2015a. URL: http://www.oecd.org/els/benefits-and-wages-statistics.htm. Accessed in November 2015.

OECD. Online OECD employment database, 2015b. URL: http://www.oecd.org/employment/emp/onlineoecdemploymentdatabase.htm#epl. Accessed in November 2015.

OECD, 2019. doi: 10.1787/fb58715e-en. URL: https://data.oecd.org. Accessed in March 2019.

Alberto Ortiz and Federico Sturzenegger. Estimating SARB's policy reaction rule. *South African Journal of Economics*, 75(4):659–680, 2007.

Alberto Ortiz, Pablo Ottonello, Federico Sturzenegger, and Ernesto Talvi. Monetary and fiscal policies in a sudden stop: Is tighter brighter? *Dealing with an International Credit Crunch, Policy Responses to Sudden Stops in Latin America*, 2009.

Jonathan D. Ostry and Carmen M. Reinhart. Private saving and terms of trade shocks: evidence from developing countries. *Staff Papers (International Monetary Fund)*, 39(3): 495–517, 1992.

Alfred Richard Oxenfeldt. *New firms and free enterprise: Pre-war and post-war aspects*. American Council on Public Affairs, 1943.

Simon C. Parker. *The economics of entrepreneurship*. Cambridge University Press, 2009.

Simon C. Parker and Mirjam van Praag. Schooling, capital constraints and entrepreneurial performance: The endogenous triangle. *SSRN Electronic Journal*, 2004.

Barbara Petrongolo and Christopher Pissarides. Scale effects in markets with search. *The Economic Journal*, 116(508):21–44, 2006.

Markus Poschke. Entrepreneurs out of necessity: a snapshot. *Applied Economics Letters*, 20 (7):658–663, 2013.

Markus Poschke. The firm size distribution across countries and skill-biased change in entrepreneurial technology. *American Economic Journal: Macroeconomics*, 10(3):1–41, 2018.

Edward C. Prescott. Theory ahead of business-cycle measurement. In *Carnegie-Rochester conference series on public policy*, volume 25, pages 11–44. Elsevier, 1986.

Adriano A. Rampini. Entrepreneurial activity, risk, and the business cycle. *Journal of Monetary Economics*, 51(3):555–573, 2004.

Hedley Rees and Anup Shah. An empirical analysis of self-employment in the U.K. *Journal of Applied Econometrics*, 1(1):95–108, 1986.

Paul Davidson Reynolds and Diana Hechavarria. Global Entrepreneurship Monitor [GEM]: Adult Population Survey Data Set, 1998-2012. ICPSR20320-v4. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2016-12-14. URL: http://optdoi.org/10.3886/ICPSR20320.v4.

Julio J. Rotemberg. Sticky prices in the United States. *Journal of Political Economy*, 90(6): 1187–1211, 1982.

Enrico Santarelli and Marco Vivarelli. Entrepreneurship and the process of firms' entry, survival and growth. *Industrial and Corporate Change*, 16(3):455–488, 2007.

Johanna Schauer. *Labor market duality in Korea.* International Monetary Fund, 2018.

Stephanie Schmitt-Grohé and Martín Uribe. Solving dynamic general equilibrium models using a second-order approximation to the policy function. *Journal of Economic Dynamics and Control*, 28(4):755–775, 2004.

Joseph A. Schumpeter. *Theorie der Wirtschaftlichen Entwicklung. Eine Untersuchung tber Unternehmergewinn, Kapital, Kredit, Zins und den Konjunkturzyklus*. Berlin: Duncker und Hublot (The Theory of Economic Development, Cambridge, MA: Harvard University Press, 1912), 1911.

Alan Finkelstein Shapiro. Self-employment and business cycle persistence: Does the composition of employment matter for economic recoveries? *Journal of Economic Dynamics and Control*, 46:200–218, 2014.

Alan Finkelstein Shapiro and Federico S. Mandelman. Remittances, entrepreneurship, and employment dynamics over the business cycle. *Journal of International Economics*, 103: 184–199, 2016.

Robert Shimer. The cyclical behavior of equilibrium unemployment and vacancies. *American Economic Review*, 95(1):25–49, 2005.

Robert Shimer. Reassessing the ins and outs of unemployment. *Review of Economic Dynamics*, 15:127–148, 2012.

Jeffrey Sparshott. Big growth in tiny businesses. *Wall Street Journal*, 2016. URL http://www.wsj.com/articles/big-growth-in-tiny-businesses-1482953786.

Statistics Korea. Korean statistical information service (kosis), 2015. URL: http://kosis.kr. Accessed in November 2015.

Lois Stevenson and Anders Lundström. *Patterns and Trends in Entrepreneurship/SME Policy and Practice in Ten Economies*, volume 3. Vällingby: Elanders Gotab, 2001.

John B. Taylor. Discretion versus policy rules in practice. In *Carnegie-Rochester conference series on public policy*, volume 39, pages 195–214. Elsevier, 1993.

Carlos Thomas. Search and matching frictions and optimal monetary policy. *Journal of Monetary Economics*, 55(5):936–956, 2008.

Roy Thurik, Martin A. Carree, André van Stel, and David B. Audretsch. Does self-employment reduce unemployment? *Journal of Business Venturing*, 23(6):673–686, 2008.

Antonella Trigari. Equilibrium unemployment, job flows, and inflation dynamics. *Journal of money, credit and banking*, 41(1):1–33, 2009.

Stephen J. Turnovsky. Domestic and foreign disturbances in an optimizing model of exchange-rate determination. *Journal of International Money and Finance*, 4(1):151–171, 1985.

U.S. Bureau of Economic Analysis. Federal Reserve Economic Data (FRED), 2015. Federal Reserve Bank of St. Louis. URL: https://research.stlouisfed.org/fred2/. Accessed in November 2015.

US Census Business Dynamics Statistics. URL: https://www.census.gov/programs-surveys/bds.html. Accessed in September 2019.

US Census Nonemployer Statistics. URL: https://www.census.gov/programs-surveys/nonemployer-statistics.html. Accessed in September 2019.

US Census Survey of Business Owners and Self Employed Persons. URL: https://www.census.gov/programs-surveys/sbo.html. Accessed in October 2019.

Marco Vivarelli. Are all the potential entrepreneurs so good? *Small Business Economics*, 23:41–49, 2004.

Sander Wennekers and Roy Thurik. Linking entrepreneurship and economic growth. *Small business economics*, 13(1):27–56, 1999.

Michael Woodford. *Interest and prices: Foundations of a theory of monetary policy*. Princeton University Press, 2003.

World Bank. Enterprise surveys - what businesses experience. URL: http://www.enterprisesurveys.org/. Accessed in February 2018.

World Bank. World Integrated Trade Solution (WITS), 2015. FURL: http://wits.worldbank.org. Accessed in November 2015.

Appendix A

WAGE DETERMINATION

This Appendix summarizes wage determination. Let J_t denote the real value of an existing productive match for the producer, then:

$$J_t = \varphi_t Z_t h_t - \frac{w_t}{P_t} h_t - \frac{\vartheta}{2}\pi_{w,t}^2 + \mathbb{E}_t\, \beta_{t,t+1}(1-\lambda) J_{t+1}. \tag{A.1}$$

That is, J_t equals the current marginal value product of the match less the wage bill inclusive of wage adjustment costs, plus the expected discounted continuation value of the match next period.

Next, let W_t denote the worker's asset value of being matched, and $U_{u,t}$ the value of being unemployed. The value of being employed at time t equals the real wage the worker receives plus the expected future value of continuing to be matched to the firm. Thus,

$$W_t = \frac{w_t}{P_t} h_t + \mathbb{E}_t \left\{ \beta_{t,t+1} \left[(1-\lambda) W_{t+1} + \lambda U_{u,t+1} \right] \right\}. \tag{A.2}$$

The value of being unemployed is:

$$U_{u,t} = \frac{\nu(h_t)}{u_{C,t}} + b + \mathbb{E}_t \left\{ \beta_{t,t+1} \left[\iota_t W_{t+1} + (1-\iota_t) U_{u,t+1} \right] \right\}, \tag{A.3}$$

which equals the utility gain from leisure in terms of consumption, plus the unemployment benefit from the government plus the expected discounted value of gaining reemployment next period (versus remaining unemployed), the probability of which occurring is $\iota_t \equiv M_t/U_t$.

Combining (A.2) and (A.3) the worker's surplus, $H_t \equiv W_t - U_{u,t}$ is thus:

$$H_t = \frac{w_t}{P_t} h_t - \left(\frac{\nu(h_t)}{u_{C,t}} + b \right) + (1 - \lambda - \iota_t)\, \mathbb{E}_t \left(\beta_{t,t+1} H_{t+1} \right). \tag{A.4}$$

The Nash bargain maximizes the joint surplus $J_t^\eta H_t^{1-\eta}$ with respect to w_t. Carrying out the optimization yields:

$$\eta_{w,t} H_t \frac{\partial J_t}{\partial w_t} + (1 - \eta_{w,t}) J_t \frac{\partial H_t}{\partial w_t} = 0, \tag{A.5}$$

where:

$$\frac{\partial J_t}{\partial w_t} = -\frac{h_t}{P_t} - \vartheta \frac{\pi_{w,t}}{w_{t-1}} + (1 - \lambda) \vartheta\, \mathbb{E}_t \left[\beta_{t,t+1} (1 + \pi_{w,t+1}) \frac{\pi_{w,t+1}}{w_t} \right], \quad \frac{\partial H_t}{\partial w_t} = \frac{h_t}{P_t}.$$

The sharing rule (A.5) can thus be written as:

$$\eta_{w,t} H_t = (1 - \eta_{w,t}) J_t, \tag{A.6}$$

where:

$$\eta_{w,t} \equiv \frac{\eta}{\eta - (1 - \eta)(\partial H_t / \partial w_t)(\partial J_t / \partial w_t)^{-1}}. \tag{A.7}$$

Combining equations (A.5) and (A.6) yields equation (1.5) of the text.

Appendix B

PRICING DECISIONS

The representative final sector firm sets the price of the output bundle for domestic sale, $P_{d,t}$, and the domestic currency price of the export bundle, $P^d_{x,t}$, letting the price in the foreign market be determined by $P_{x,t} = \tau_t P^d_{x,t}/S_t$. When choosing $P_{d,t}$ and $P^d_{x,t}$, the firm maximizes

$$\mathbb{E}_t \sum_{s=t}^{\infty} \beta_{t,t+s} \left[\left(\frac{P_{d,s}}{P_s} - \frac{P^y_{d,s}}{P_s} \right) Y_{d,s} + \left(\frac{P^d_{x,s}}{P_s} - \frac{P^y_{x,s}}{P_s} \tau_s \right) Y_{x,s} - \frac{\Gamma_{d,s}}{P_s} - \frac{\Gamma^d_{x,s}}{P_s} \right], \tag{B.1}$$

where $\Gamma_{d,s} \equiv \nu \pi^2_{d,s} P_{d,s} Y_{d,s}/2$, $\Gamma^d_{x,s} \equiv \nu (\pi^d_{x,s})^2 P^d_{x,s} Y_{x,s}/2$, $\pi_{d,s} \equiv (P_{d,s}/P_{d,s-1}) - 1$, $\pi^d_{x,s} \equiv \left(P^d_{x,s}/P^d_{x,s-1}\right) - 1$, and output bundle demands are determined by:

$$Y_{d,s} = \left(\frac{P_{d,s}}{P_s} \right)^{-\phi} Y^C_s, \quad Y_{x,s} = \left(\frac{\tau_s P^d_{x,s}}{Q_s P_s} \right)^{-\phi} Y^{C*}_s. \tag{B.2}$$

First-order optimality conditions for $P_{d,t}$ and $P^d_{x,t}$ and straightforward, though tedious, algebra yield equations (1.19)–(1.22) in the text. (To obtain (1.21)–(1.22), recall that $P_{x,t} = \tau_t P^d_{x,t}/S_t$ and $Q_t \equiv S_t P^*_t / P_t$.)

Appendix C

OTHER EQUILIBRIUM DETAILS

The aggregate stock of employed labor in the Home economy is determined by:

$$l_t = (1-\lambda)l_{t-1} + q_{t-1}V_{t-1}. \tag{C.1}$$

Wage inflation and consumer price inflation are tied by:

$$1 + \pi_{w,t} = (w_t/P_t)(w_{t-1}/P_{t-1})^{-1}(1 + \pi_{C,t}). \tag{C.2}$$

The expression for the consumption price index implies:

$$1 = \tilde{\rho}_{d,t}^{1-\theta} N_{d,t}^{\frac{1-\phi}{1-\theta}} + (\tilde{\rho}_{x,t}^{*})^{1-\theta}(N_{x,t}^{*})^{\frac{1-\phi}{1-\theta}}. \tag{C.3}$$

Finally, labor market clearing requires:

$$l_t h_t = N_{d,t}\frac{\tilde{y}_{d,t}}{Z_t \tilde{z}_d} + N_{x,t}\frac{\tilde{y}_{x,t}}{Z_t \tilde{z}_{x,t}}\tau_t + N_{e,t}\frac{f_{e,t}}{Z_t} + N_{x,t}\frac{f_{x,t}}{Z_t}. \tag{C.4}$$

Appendix D

MANAGED EXCHANGE RATES

See Figures D.1–D.5 and Tables D.1–D.5. Figures D.1–D.5 replicate Figures 1.1–1.5, replacing impulse responses under flexible exchange rates with responses under managed exchange rates. Tables D.1–D.3 replicate Tables 1.3–1.5 and Tables D.4–D.5 replicate Tables 1.8 and 1.9, replacing results obtained under flexible exchange rates with results under managed exchange rates.

Table D.1. Business cycle statistics, managed exchange rates

	σ_X			σ_X/σ_{Y_R}			$corr(X_t, Y_{R,t})$		
Variable	*Data*	*Model I*	*Model II*	*Data*	*Model I*	*Model II*	*Data*	*Model I*	*Model II*
Y_R	1.51	1.55	1.80	1	1	1	1	1	1
C_R	1.98	1.91	1.91	1.31	1.23	1.06	0.74	0.74	0.61
I_R	4.15	10.47	11.31	2.74	6.74	6.28	0.78	0.49	0.21
U	13.18	13.09	13.09	8.71	8.42	7.27	-0.57	-0.59	-0.51
X_R	4.43	2.18	3.32	2.93	1.40	1.84	0.37	0.73	0.11
IM_R	5.03	2.70	5.92	3.33	1.74	3.29	0.67	0.44	-0.26
TB_R/Y_R	1.13	0.54	0.69	0.75	0.35	0.38	-0.47	0.10	0.38
TOT	2.19	0.58	2.54	1.45	0.37	1.41	-0.50	-0.64	-0.60
$corr(Y_{R,t}, Y^*_{R,t})$	0.34	0.27	0.24						
$corr(C_{R,t}, C^*_{R,t})$	0.08	0.02	0.02						

Note: Data moments refer to the period 1998:Q1-2007:Q4;
$\sigma_X \equiv$ standard deviation of variable X (percentage points);
$corr(X_t, Y_{R,t}) \equiv$ contemporaneous correlation of variable X with data-consistent, real GDP;
Model I $\equiv$ productivity shocks only; *Model II* $\equiv$ productivity and terms of trade shocks.

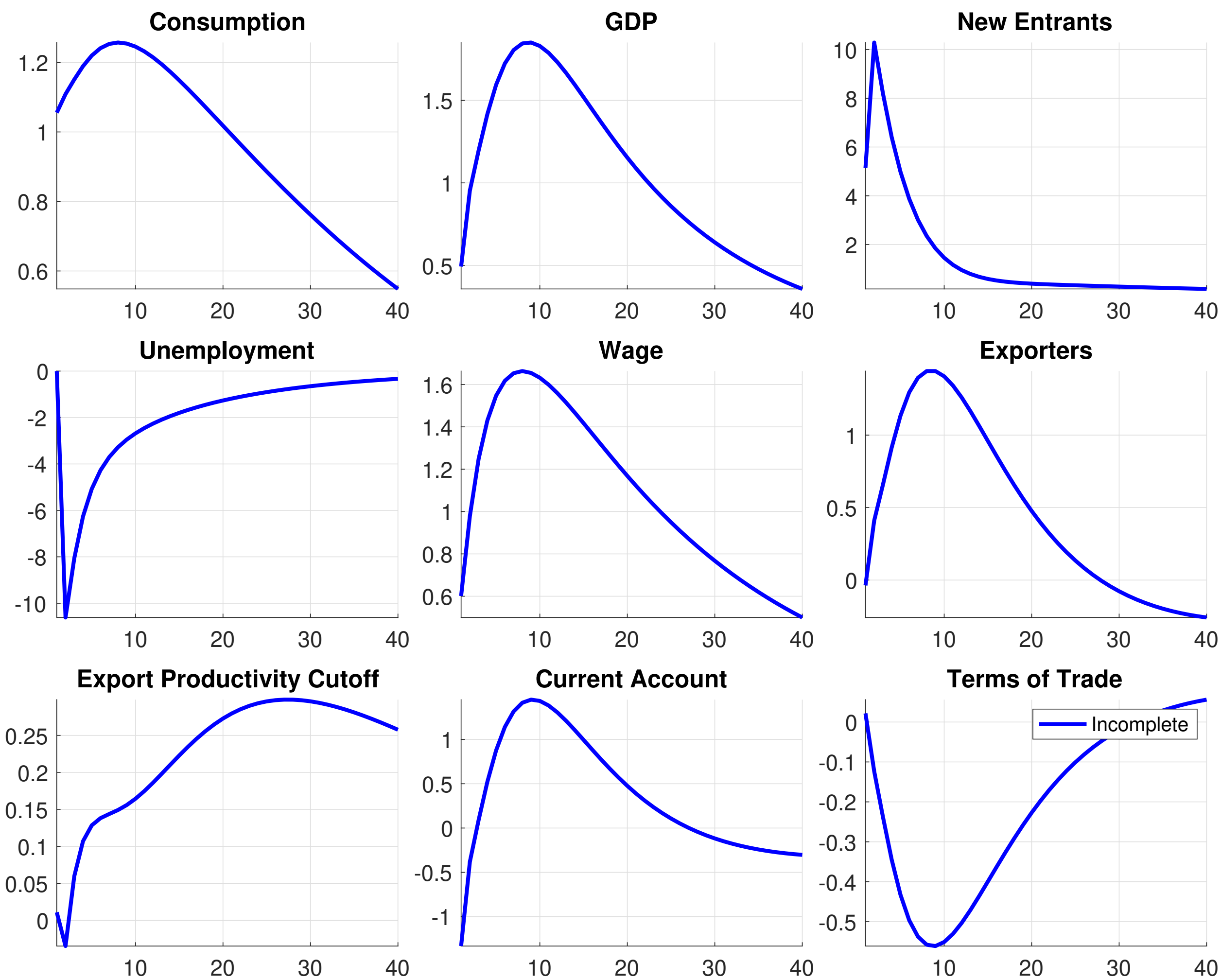


Figure D.1. Home productivity shock, incomplete markets with managed exchange rates. Responses show percentage deviations from steady state. Unemployment and current account are in deviations from steady state.

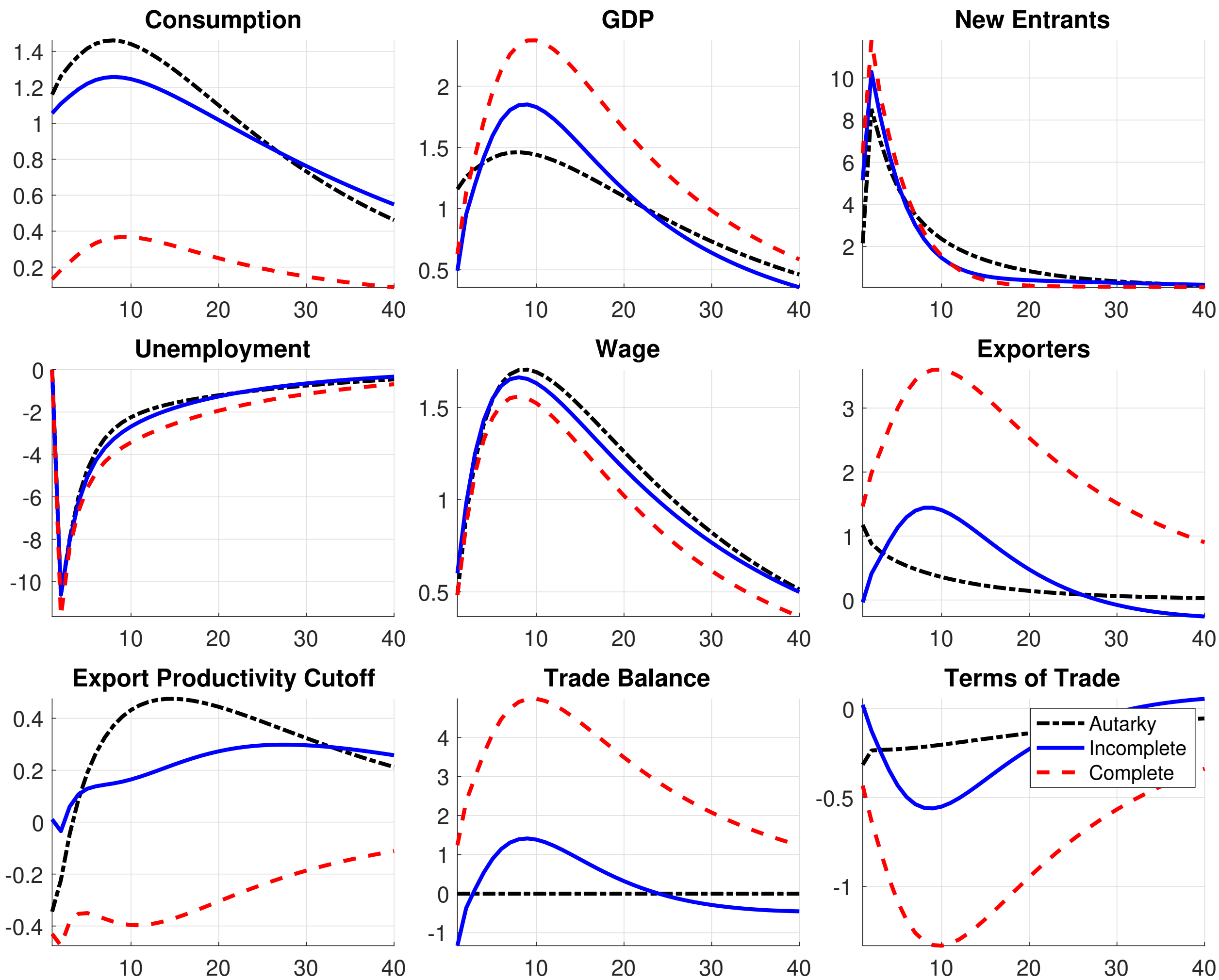


Figure D.2. Home productivity shock, managed exchange rates, incomplete markets (solid lines), financial autarky (dash-dotted lines), complete markets (dashed lines). Responses show percentage deviations from steady state. Unemployment and trade balance are in deviations from steady state.

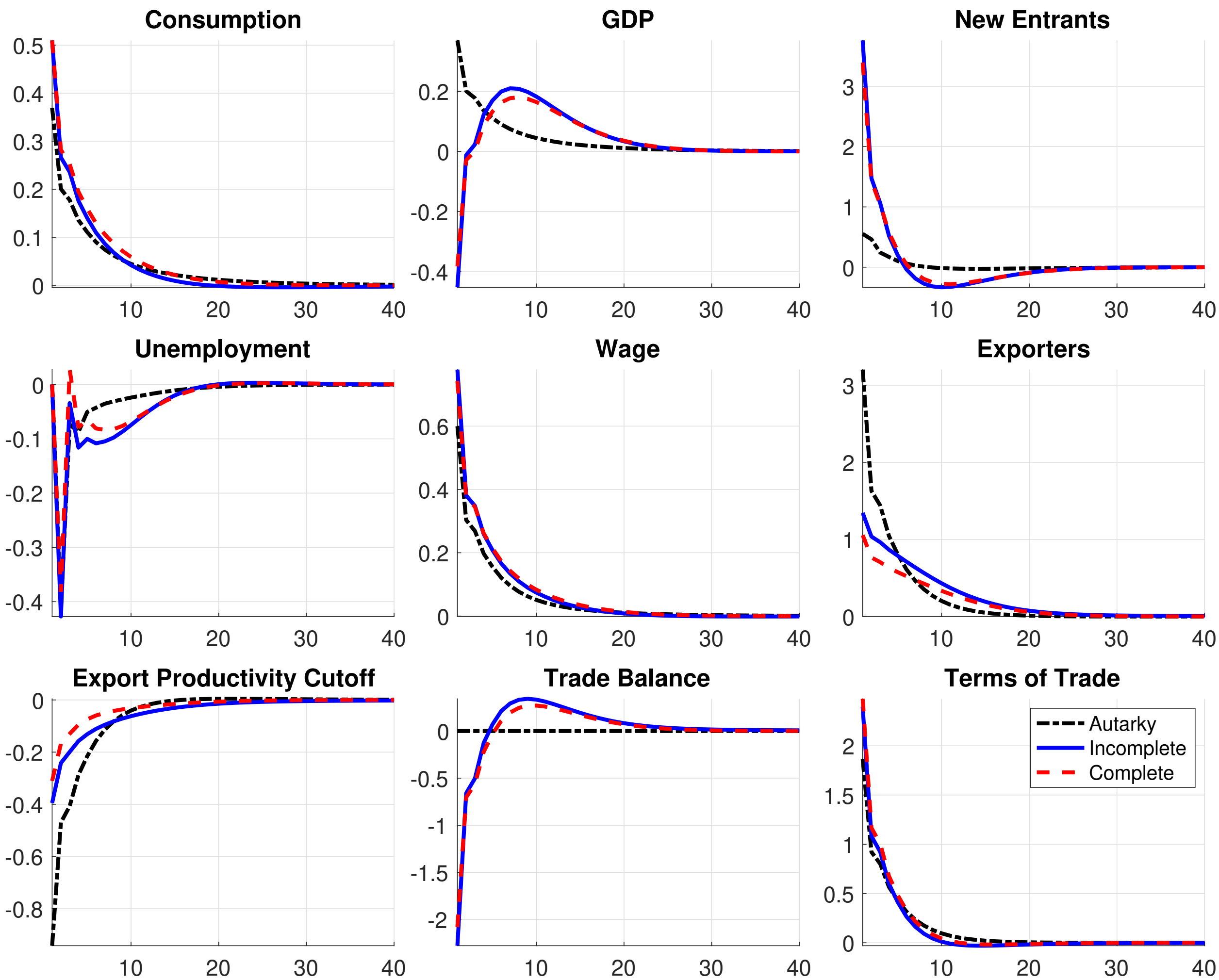


Figure D.3. Terms of trade shock, managed exchange rates, incomplete markets (solid lines), financial autarky (dash-dotted lines), complete markets (dashed lines). Responses show percentage deviations from steady state. Unemployment and trade balance are in deviations from steady state.

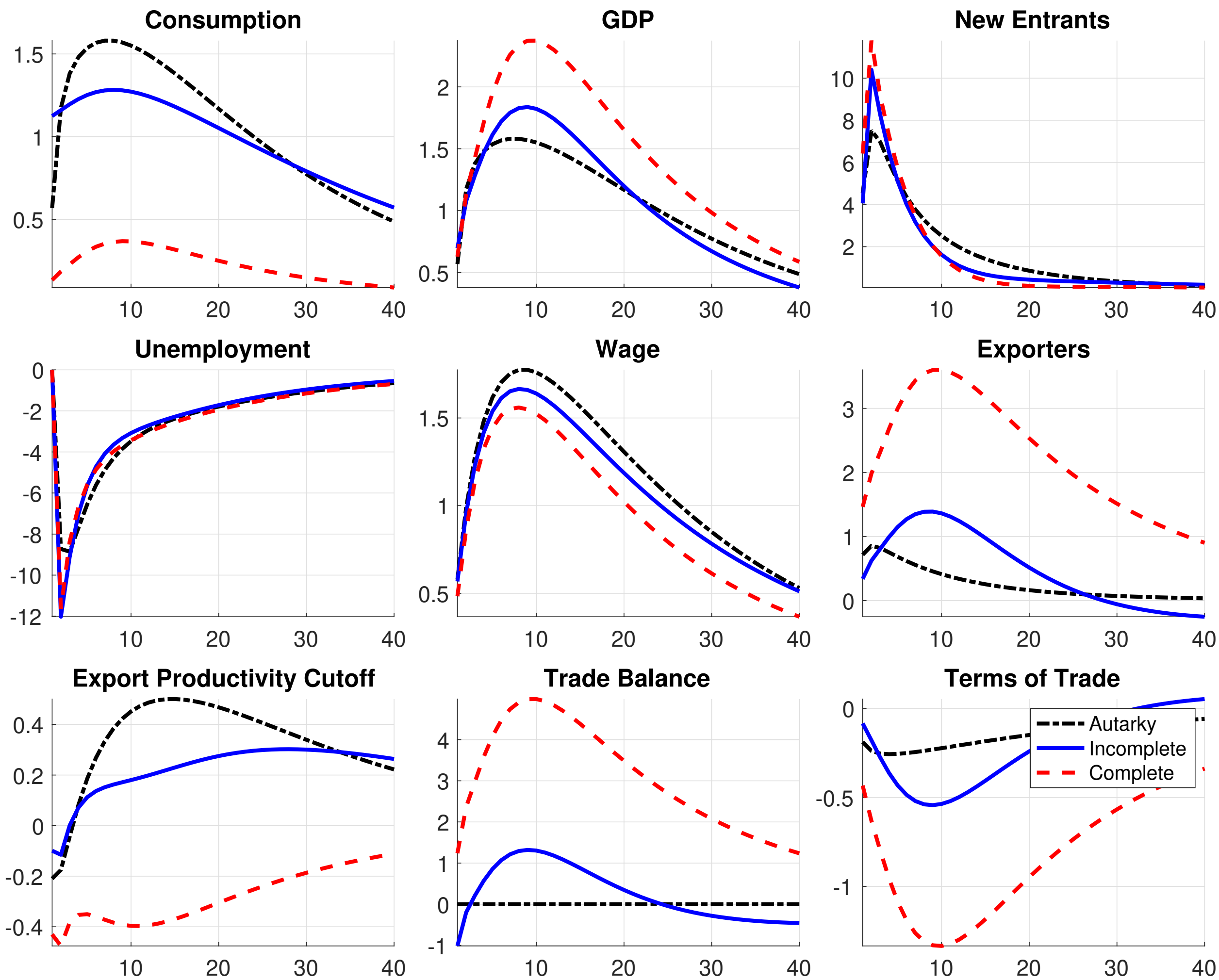


Figure D.4. Productivity shock under different asset market and exchange rate policy assumptions: financial autarky and fixed exchange rate (dash-dotted lines), incomplete markets and fixed exchange rate (solid lines), complete markets and managed exchange rates (dashed lines). Responses show percentage deviations from steady state. Unemployment and trade balance are in deviations from steady state.

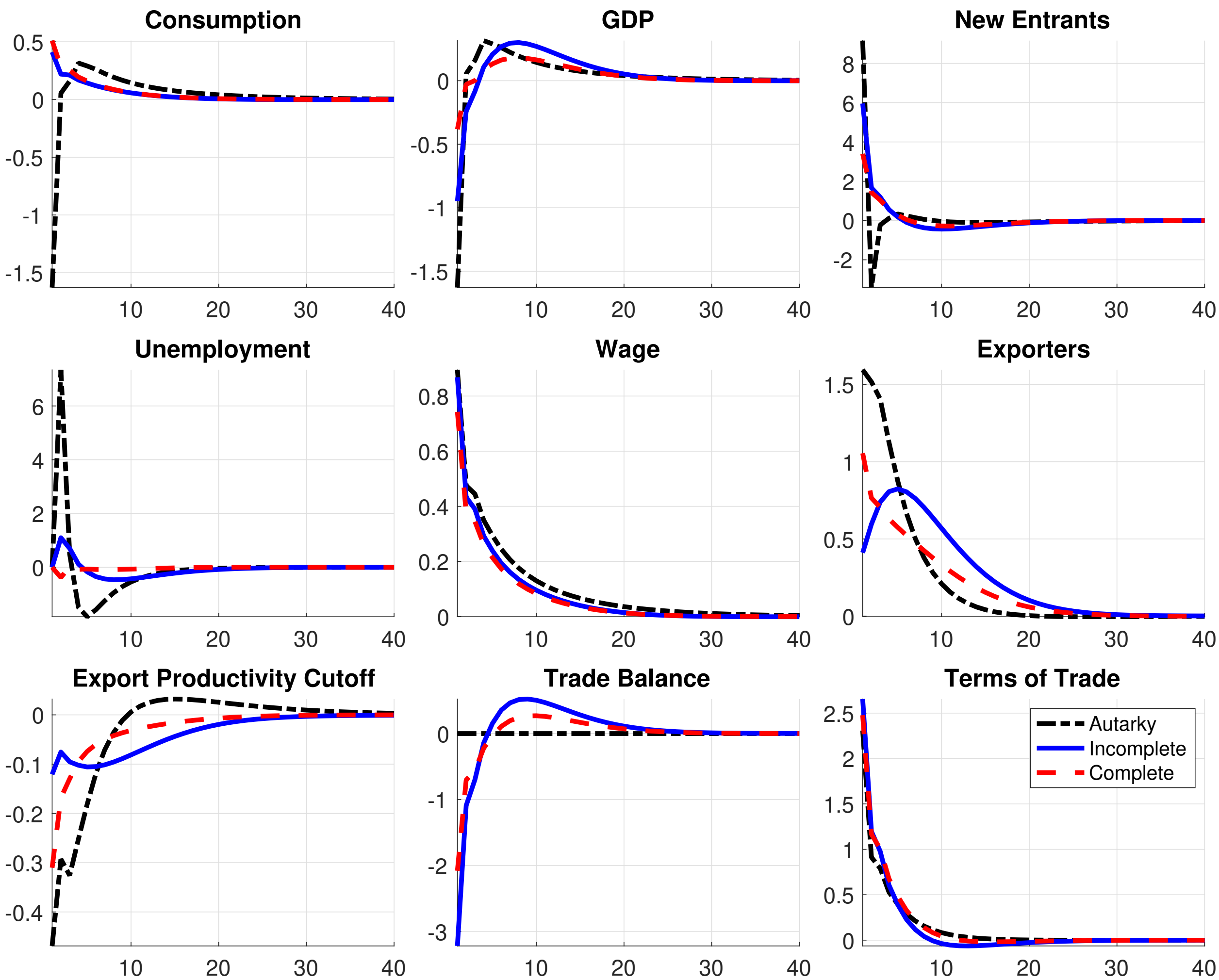


Figure D.5. Terms of trade shock under different asset market and exchange rate policy assumptions: financial autarky and fixed exchange rate (dash-dotted lines), incomplete markets and fixed exchange rate (solid lines), complete markets and managed exchange rates (dashed lines). Responses show percentage deviations from steady state. Unemployment and trade balance are in deviations from steady state.

Table D.2. Business cycle moments under different asset markets, managed exchange rates

	Financial Autarky						Incomplete Markets						Complete Markets					
Variable	*Model I*			*Model II*			*Model I*			*Model II*			*Model I*			*Model II*		
Y_R	2.01	1	1	2.01	1	1	1.55	1	1	1.80	1	1	2.07	1	1	2.22	1	1
C_R	2.01	1	1	2.01	1	1	1.91	1.23	0.74	1.91	1.06	0.61	0.70	0.34	-0.06	0.71	0.32	-0.13
I_R	8.75	4.35	0.68	8.80	4.37	0.67	10.47	6.74	0.49	11.31	6.28	0.21	13.77	6.64	0.40	14.31	6.43	0.26
U	14.19	7.06	-0.71	14.20	7.06	-0.71	13.09	8.42	-0.59	13.09	7.27	-0.51	13.45	6.48	-0.56	13.46	6.05	-0.52
N_E	8.82	4.38	0.68	8.84	4.40	0.68	10.67	6.86	0.51	11.37	6.32	0.24	14.08	6.79	0.41	14.53	6.53	0.29
X_R	1.74	0.86	0.97	4.50	2.23	0.40	2.18	1.40	0.73	3.32	1.84	0.11	4.41	2.13	0.99	4.87	2.19	0.71
IM_R	1.74	0.86	0.97	4.50	2.23	0.40	2.70	1.74	0.44	5.92	3.29	-0.26	2.57	1.24	-0.79	6.19	2.78	-0.63
TB_R/Y_R	0	0	0.73	0	0	0.73	0.54	0.35	0.10	0.69	0.38	0.38	0.88	0.42	0.95	0.95	0.43	0.96
TOT	0.48	0.24	-0.94	1.99	0.99	-0.20	0.58	0.37	-0.64	2.54	1.41	-0.60	1.47	0.71	-0.95	2.96	1.33	-0.75
$corr(Y_{R,t}, Y^*_{R,t})$	0.004			0.004			0.27			0.24			0.21			0.19		
$corr(C_{R,t}, C^*_{R,t})$	0.004			0.004			0.02			0.02			0.69			0.67		

Note: For every *Model*, the first column reports absolute standard deviations (σ_X, percentage points),
the second column reports standard deviations relative to real, data-consistent GDP (σ_X/σ_{Y_R}),
and the third column reports contemporaneous correlations with real, data-consistent GDP ($corr(X_t, Y_{R,t})$);
Model I $\equiv$ productivity shocks only; *Model II* $\equiv$ productivity and terms of trade shocks.

Table D.3. Welfare cost of business cycles under different asset markets, managed exchange rates

	ΔWelfare		
	Financial Autarky	Incomplete Markets	Complete Markets
Model I	2.12	1.96	0.25
Model II	4.39	4.12	3.15

ΔWelfare $\equiv$ change in welfare cost of business cycles (percentage of steady-state consumption); *Model I* $\equiv$ productivity shocks only; *Model II* $\equiv$ productivity and terms of trade shocks.

Table D.4. Complete markets under managed exchange rates

	σ_X			σ_X/σ_{Y_R}			$corr(X_t, Y_{R,t})$		
Variable	*Data*	*Model I*	*Model II*	*Data*	*Model I*	*Model II*	*Data*	*Model I*	*Model II*
Y_R	1.51	2.07	2.22	1	1	1	1	1	1
C_R	1.98	0.70	0.71	1.31	0.34	0.32	0.74	-0.06	-0.13
I_R	4.15	13.77	14.31	2.74	6.64	6.43	0.78	0.40	0.26
U	13.18	13.45	13.46	8.71	6.48	6.05	-0.57	-0.56	-0.52
X_R	4.43	4.41	4.87	2.93	2.13	2.19	0.37	0.99	0.71
IM_R	5.03	2.57	6.19	3.33	1.24	2.78	0.67	-0.79	-0.63
TB_R/Y_R	1.13	0.88	0.95	0.75	0.42	0.43	-0.47	0.95	0.96
TOT	2.19	1.47	2.96	1.45	0.71	1.33	-0.50	-0.95	-0.75
$corr(Y_{R,t}, Y^*_{R,t})$	0.34	0.21	0.19						
$corr(C_{R,t}, C^*_{R,t})$	0.08	0.69	0.67						

Note: Data moments refer to the period 1998:Q1-2007:Q4;
σ_X $\equiv$ standard deviation of variable X (percentage points);
$corr(X_t, Y_{R,t})$ $\equiv$ contemporaneous correlation of variable X with data-consistent, real GDP;
Model I $\equiv$ productivity shocks only; *Model II* $\equiv$ productivity and terms of trade shocks.

Table D.5. Welfare cost of business cycles under different asset markets and monetary policies

	ΔWelfare		
	Financial Autarky Fixed Exchange Rates	Incomplete Markets Fixed Exchange Rates	Complete Markets Managed Exchange Rates
Model I	1.97	2.15	0.25
Model II	4.72	4.29	3.15

ΔWelfare ≡ change in welfare cost of business cycles (percentage of steady-state consumption); *Model I* ≡ productivity shocks only; *Model II* ≡ productivity and terms of trade shocks.

Appendix E

ACCOUNTING PROFIT VERSUS ECONOMIC PROFIT

The entrants in the self-employed sector are unique in that they are initially unemployed workers. In other words, whether an unemployed worker decides to enter the market as a firm or not is also dependent on the worker's value of unemployment and self-employment. Thus the value of self-employment to an individual is not only dependent on the profits one earns today but also on the outside option of the worker:

$$e_{s,t} = d_{s,t} - \bar{\omega}_{s,t} + \mathbb{E}_t \left[\sum_{j=t+1}^{\infty} (1-\delta)^{j-t} \beta_{t,j} (d_j - \bar{\omega}_j) \right] \tag{E.1}$$

where

$$\bar{\omega}_{s,t} = u_b + (1-\delta_S)\, \mathbb{E}_t\, \beta_{t,t+1} \iota_{t+1} S^W_{t+1} \tag{E.2}$$

Since switching to self-employment implies the worker is essentially giving up the unemployment benefits and the possibility of being matched to a hired job next period, the outside option $\bar{\omega}_{s,t}$ can be interpreted as the opportunity cost of self-employment.

The value of a hiring firm is the profit it earns this period plus the present discounted value of the firm:

$$e_{h,t} = d_{h,t} + (1-\delta_H)\, \mathbb{E}_t\, \beta_{t,t+1} e_{h,t+1} \tag{E.3}$$

From this equation, using backward induction it is possible to show that $e_{h,t}$ equals the future discounted stream of profits:

$$e_{h,t} = \mathbb{E}_t \sum_{j=t}^{\infty} (\beta(1-\delta_H))^{j-t} \left(\frac{C_j}{C_t}\right)^{-\gamma} d_{j,t} \tag{E.4}$$

Furthermore, value of self-employed firm changes since the possibility of hiring firms exiting changes the outside option of self-employment ($\bar{\omega}_{s,t}$):

$$e_{s,t} = d_{s,t} - \bar{\omega}_{s,t} + (1-\delta_S)\, \mathbb{E}_t\, \beta_{t,t+1} e_{S,t+1} \tag{E.5}$$

where

$$\bar{\omega}_{s,t} = u_b + (1-\delta_S)(1-\delta_H)\, \mathbb{E}_t\, \beta_{t,t+1} \iota_{t+1} S^W_{t+1} \tag{E.6}$$

Appendix F

STEADY STATE ANALYSIS

In steady state, from the definition of aggregate employment and law of motion,

$$\begin{aligned} L &= N_H l_h + N_S \\ &= N_H \left[(1-\lambda) l_h + qv\right] + N_S \\ &= (1-\lambda)(L - N_S) + qvN_H + N_S \end{aligned} \tag{F.1}$$

Matches are equal to vacancy filling rate times aggregate vacancies:

$$\begin{aligned} M &= qV \\ &= q(vN_H + v_E N_{HE}) \\ &= l_h N_H \delta_H + (1-\delta_H) qvN_H \\ &= (\delta_H + \lambda(1-\delta_H))(L - N_S) \end{aligned} \tag{F.2}$$

Since new matches are also equal to total number of separations ($M = qV = \lambda^{tot} L$), total separation rate λ^{tot} can be written as:

$$\lambda^{tot} = \left[\delta_H + \lambda(1-\delta_H)\right]\left(1 - \frac{N_S}{L}\right) \tag{F.3}$$

where $\frac{N_S}{L}$ is the self-employment rate as a fraction of total employment.

Appendix G

EFFICIENT ALLOCATION

The social planner chooses $\{C_{H,j}, C_{S,j}, L_{H,j}, N_{S,j}, M_{S,j}, V_j\}_{j=t}^{\infty}$ to maximize the intertemporal utility function:

$$\mathbb{E}_t \sum_{j=t}^{\infty} \beta^{j-t} \left(\frac{C_j^{1-\gamma}}{1-\gamma} \right) \tag{G.1}$$

subject to the following constraints:

$$L_{H,t} = (1-\lambda)(1-\delta_H)L_{H,t-1} + \chi(1-(1-\lambda)L_{H,t} - N_{S,t})^{\xi} V_t^{1-\xi} \tag{G.2}$$

$$Y_t = C_t + \kappa V_t + (f_{rh} + f_{Th})\{N_{H,t} - (1-\delta_H)N_{H,t-1}\} + (f_{rs} + f_{Ts})\{N_{S,t} - (1-\delta_S)N_{S,t-1}\} \tag{G.3}$$

$$\rho(N_{H,t})Z_{H,t}L_{H,t} = C_{H,t} + M_{s,t}N_{S,t} \tag{G.4}$$

$$\rho(N_{S,t})Z_{S,t}M_{s,t}N_{S,t} = C_{S,t} \tag{G.5}$$

where expressions for C_t and Y_t are:

$$C_t = \left[(1-\alpha)^{1/\phi} C_{H,t}^{\frac{\phi-1}{\phi}} + \alpha^{1/\phi} C_{S,t}^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}} \tag{G.6}$$

$$Y_t = \left[(1-\alpha)^{1/\phi} (\rho(N_{H,t})Z_{H,t}L_{H,t})^{\frac{\phi-1}{\phi}} + \alpha^{1/\phi} (\rho(N_{S,t})N_{S,t}Z_{S,t}M_{s,t})^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}} \tag{G.7}$$

Note that the planner internalizes the variety effect on the relative price; hence $\rho(N_{H,t}) = N_{H,t}^{\frac{1}{\theta_H - 1}}$ and $\rho(N_{S,t}) = N_{S,t}^{\frac{1}{\theta_S - 1}}$. Law of motion on aggregate employment in the hiring sector (equation (G.2)) is derived by combining the firm-level equations. Recall the law of motion for hiring firm-level employment:

$$l_{h,t} = (1-\lambda)l_{h,t-1} + q_t v_t \tag{G.8}$$

Since $L_{H,t} = N_{H,t} l_{h,t}$, multiplying $N_{H,t}$ on each side and rewriting the equation gives us:

$$L_{H,t} = (1-\lambda)L_{h,t-1}\frac{N_{H,t}}{N_{H,t-1}} + q_t v_t N_{H,t} \tag{G.9}$$

Using the law of motion for hiring firms (eq. (2.15)), the expression above becomes:

$$\begin{aligned} L_{H,t} &= (1-\lambda)L_{H,t-1}\frac{(1-\delta_H)N_{H,t-1} + N_{HE,t}}{N_{H,t-1}} + q_t v_t N_{H,t} \\ &= (1-\lambda)(1-\delta_H)L_{H,t-1} + (1-\lambda)\left(\frac{l_{h,t} - q_t v_t}{1-\lambda}\right)N_{HE,t} + q_t v_t N_{H,t} \\ &= (1-\lambda)(1-\delta_H)L_{H,t-1} + q_t v_{E,t} N_{HE,t} + q_t v_t N_{H,t} \\ &= (1-\lambda)(1-\delta_H)L_{H,t-1} + q_t V_t \end{aligned}$$

Replacing q_t with the expression $M_t/V_t = \chi(1-(1-\lambda)L_{H,t} - N_{S,t})^{\xi} V_t^{-\xi}$ gives equation (G.2).

Let μ_t, λ_t, $\xi_{H,t}$, and $\xi_{S,t}$ denote the Lagrange multiplier on the law of motion for hiring sector employment, resource constraint, and output clearing equations in hiring and self-employed sector respectively. The first-order conditions with respect to $C_{H,t}$, $C_{S,t}$, $L_{H,t}$, V_t,

$N_{H,t}$, $N_{S,t}$, $M_{s,t}$ are the following:

$$\xi_{H,t} - \left(C_t^{-\gamma} - \lambda_t\right) \frac{\partial C_t}{\partial C_{H,t}} = 0 \tag{G.10}$$

$$\xi_{S,t} - \left(C_t^{-\gamma} - \lambda_t\right) \frac{\partial C_t}{\partial C_{S,t}} = 0 \tag{G.11}$$

$$\mu_t \left(\frac{\partial M_t}{\partial L_{H,t}} - 1\right) + \xi_{H,t}\rho(N_{H,t})Z_{H,t} + \lambda_t \frac{\partial Y_t}{\partial L_{H,t}} + \beta(1-\lambda)(1-\delta_H)\,\mathbb{E}_t\,\mu_{t+1} = 0 \tag{G.12}$$

$$\mu_t \frac{\partial M_t}{\partial V_t} - \kappa\lambda_t = 0 \tag{G.13}$$

$$\xi_{H,t}\left(\rho'(N_{H,t})Z_{H,t}L_{H,t} + \rho(N_{H,t})Z_{H,t}l_{h,t}\right) + \lambda_t\left(\frac{\partial Y_t}{\partial N_{H,t}} - (f_{rh} + f_{Th})\right) + \beta(1-\delta_H)\,\mathbb{E}_t(f_{rh} + f_{Th})\lambda_{t+1} = 0 \tag{G.14}$$

$$\begin{aligned} \mu_t \frac{\partial M_t}{\partial N_{S,t}} &- \xi_{H,t}M_{s,t} + \xi_{S,t}\left(\rho'(N_{S,t})Z_{S,t}M_{s,t}N_{S,t} + \rho(N_{S,t})Z_{S,t}M_{s,t}\right) \\ &+ \lambda_t\left(\frac{\partial Y_t}{\partial N_{S,t}} - (f_{rs} + f_{Ts})\right) + \beta(1-\delta_S)\,\mathbb{E}_t(f_{rs} + f_{Ts})\mu_{t+1} = 0 \end{aligned} \tag{G.15}$$

$$-\xi_{H,t}N_{S,t} + \xi_{S,t}\rho(N_{S,t})Z_{S,t}N_{S,t} + \lambda_t \frac{\partial Y_t}{\partial M_{s,t}} = 0 \tag{G.16}$$

Combining the first-order conditions for $C_{H,t}$ and $C_{S,t}$ gives the marginal rate of substitution between the two sector goods:

$$\frac{\xi_{H,t}}{\xi_{S,t}} = \left(\frac{\alpha C_{H,t}}{(1-\alpha)C_{S,t}}\right)^{-1/\phi} \tag{G.17}$$

Using the same two first conditions and condition (G.16), one can simplify the expression further by defining A_t as

$$A_t \equiv \left(\frac{C_{S,t}}{\alpha Y_t}\right)^{1/\phi}\left[\frac{1}{\rho(N_{S,t})Z_{S,t}}\left(\frac{C_{H,t}}{(1-\alpha)C_t}\right)^{-1/\phi} - \left(\frac{C_{S,t}}{\alpha C_t}\right)^{-1/\phi}\right] \tag{G.18}$$

Then the Lagrange multiplier λ_t can be written as:

$$\lambda_t = \frac{C_t^{-\gamma}}{1+A_t}\ ; \qquad \frac{\lambda_{t+1}}{\lambda_t} = \left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}\frac{1+A_t}{1+A_{t+1}} \tag{G.19}$$

Combining conditions (G.13) and (G.12) and utilizing the expressions of λ_t above, the job creation equation is derived as:

$$\frac{\kappa}{q_t} = (1-\xi)\rho(N_{H,t})Z_{H,t}\left[A_t\left(\frac{C_{H,t}}{(1-\alpha)C_t}\right)^{-1/\phi} + \left(\frac{\rho(N_{H,t})Z_{H,t}L_{H,t}}{(1-\alpha)Y_t}\right)^{-1/\phi}\right] - (1-\lambda)\xi\iota_t\frac{\kappa}{q_t} + (1-\lambda)(1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}\left(\frac{1+A_t}{1+A_{t+1}}\right)\frac{\kappa}{q_{t+1}} \tag{G.20}$$

Rewriting the first-order conditions (G.14) and (G.15) using the expressions above for the Lagrange multipliers gives the free entry condition for the hiring and self-employed firms respectively:

$$(f_{rh} + f_{Th}) = \frac{\theta_H}{\theta_H - 1}\rho(N_{H,t})Z_{H,t}l_{h,t}\left[A_t\left(\frac{C_{H,t}}{(1-\alpha)C_t}\right)^{-1/\phi} + \left(\frac{\rho(N_{H,t})Z_{H,t}L_{H,t}}{(1-\alpha)Y_t}\right)^{-1/\phi}\right] + (1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}\left(\frac{1+A_t}{1+A_{t+1}}\right)(f_{rh} + f_{Th}) \tag{G.21}$$

$$(f_{rs} + f_{Ts}) = \frac{\theta_S}{\theta_S - 1}\rho(N_{S,t})Z_{S,t}M_{s,t}\left[A_t\left(\frac{C_{S,t}}{\alpha C_t}\right)^{-1/\phi} + \left(\frac{\rho(N_{S,t})N_{S,t}Z_{S,t}M_{s,t}}{\alpha Y_t}\right)^{-1/\phi}\right] - A_t\left(\frac{C_{H,t}}{(1-\alpha)C_t}\right)^{-1/\phi}M_{s,t} - \frac{\xi}{1-\xi}\iota_t\frac{\kappa}{q_t} + (1-\delta_H)\,\mathbb{E}_t\,\beta_{t,t+1}\left(\frac{1+A_t}{1+A_{t+1}}\right)f_{rs} \tag{G.22}$$