

# Financial Market Integration, Exchange Rate Policy, and the Dynamics of Business and Employment in Korea\*

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## Abstract

We study the consequences of different degrees of international financial market integration and exchange rate policies in a calibrated, medium-scale model of the Korean economy. The model features endogenous producer entry into domestic and export markets and search-and-matching frictions in labor markets. This allows us to highlight the consequences of financial integration and the exchange rate regime for the dynamics of business creation and unemployment. We show that, under flexible exchange rates, 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. Pegging 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 we focus on.

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## 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.<sup>1</sup> 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.<sup>2</sup> 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.<sup>3</sup>

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 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).

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<sup>1</sup> Eichengreen (2004a, 2008) summarizes events and explanations and provides references to much literature.

<sup>2</sup> See Heathcote and Perri (2014) for a survey of literature on international financial market integration and risk sharing and Corsetti, Dedola, and Leduc (2012) for a survey on monetary policy in open economies.

<sup>3</sup> 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).

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.<sup>4</sup>

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.

## **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.<sup>5</sup>

### *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,

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<sup>4</sup> See Bilbiie, Ghironi, and Melitz (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.

<sup>5</sup> Cacciatore, Ghironi, and Turnovsky (2015) use the model presented here to study the consequences of structural reforms and trade integration for New Zealand.

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).<sup>6</sup>

The representative household in the Home economy maximizes the expected intertemporal utility function  $E_0 \sum_{t=0}^{\infty} \beta^t [u(C_t) - l_t v(h_t)]$ , 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. Period utility from consumption,  $u(\cdot)$ , and disutility of effort,  $v(\cdot)$ , satisfy the standard assumptions.

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

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

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

$$P_t = \left[ \int_0^1 P_t(n)^{1-\phi} dn \right]^{\frac{1}{1-\phi}}, \quad (2)$$

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

## 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

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<sup>6</sup> 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.

domestically.<sup>7</sup>

### 2.2.1 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-Mortensen-Pissarides (DMP) framework.<sup>8</sup> To hire new workers, firms need to post vacancies, incurring a cost of  $\kappa$  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  $q_t \nu_t$ , where  $\nu_t$  is the number of vacancies posted by the firm in period  $t$ .<sup>9</sup>

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

The representative intermediate firm produces output  $y_t^I = Z_t l_t h_t$ , where  $Z_t$  is exogenous aggregate productivity.<sup>10</sup> We normalize steady-state productivity,  $Z$ , to 1 and assume that  $Z_t$  follows an  $AR(1)$  process in logarithms,  $\log Z_t = \phi_Z \log Z_{t-1} + \varepsilon_t$ , where  $\varepsilon_t$  represents *i.i.d.* draws from a normal distribution with zero mean and standard deviation  $\sigma_\varepsilon$ .

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  $\mathcal{G}\pi_{w,t}^2 / 2$ , where  $\mathcal{G} \geq 0$  is in units of consumption, and  $\pi_{w,t} \equiv (w_t / w_{t-1}) - 1$  is the net wage inflation rate. If  $\mathcal{G} = 0$ , there is no cost of wage adjustment.

<sup>7</sup>This production structure greatly simplifies the introduction of labor market frictions and sticky prices in the model.

<sup>8</sup> See Diamond (1982a, 1982b) and Mortensen and Pissarides (1994).

<sup>9</sup>In equilibrium,  $\nu_t = V_t$ .

<sup>10</sup>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.

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

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{u_{C,t}}{u_{C,0}} \left( \varphi_t Z_t l_t h_t - \frac{w_t}{P_t} l_t h_t - \frac{\vartheta}{2} \pi_{w,t}^2 l_t - \kappa \nu_t \right),$$

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:

$$\frac{\kappa}{q_t} = E_t \left\{ \beta_{t,t+1} \left[ (1-\lambda) \frac{\kappa}{q_{t+1}} + \varphi_{t+1} Z_{t+1} h_{t+1} - \frac{w_{t+1}}{P_{t+1}} h_{t+1} - \frac{\vartheta}{2} \pi_{w,t+1}^2 \right] \right\}, \quad (3)$$

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.<sup>11</sup> 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

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<sup>11</sup>The same assumption is made by Arseneau and Chugh (2008), Gertler, Sala, and Trigari (2008), and Thomas (2008).



adjustment costs.

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 the Appendix 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  $\eta$  is the weight of firm surplus in the Nash bargaining problem. (The steady-state value of  $\eta_{w,t}$ ,  $\eta_w$ , differs from  $\eta$  if wages are sticky and there is non-zero steady-state wage inflation.)

The bargained wage satisfies:

$$\begin{aligned} \frac{w_t}{P_t} h_t = & \eta_{w,t} \left( \frac{v(h_t)}{u_{C,t}} + b \right) + (1 - \eta_{w,t}) \left( \varphi_t Z_t h_t - \frac{\theta}{2} \pi_{w,t}^2 \right) \\ & + E_t \left\{ \beta_{t,t+1} J_{t+1} \left[ (1 - \lambda)(1 - \eta_{w,t}) - (1 - \lambda - \iota_t)(1 - \eta_{w,t+1}) \frac{\eta_{w,t}}{\eta_{w,t+1}} \right] \right\}, \end{aligned} \quad (4)$$

where  $v(h_t)/u_{C,t} + b$  is the worker's outside option (the utility value of leisure plus an unemployment benefit  $b$ ), and  $\iota_t$  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  $(1 - \eta)\iota_t E_t(\beta_{t,t+1} J_{t+1})$ , 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  $\eta$  – 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  $\eta$ ), 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.<sup>12</sup> 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:  $v_{h,t} / u_{c,t} = \varphi_t Z_t$ , where  $v_{h,t}$  is the marginal disutility of effort.

### 2.2.2 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-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  $\omega$  and defined over a continuum  $\Omega$ :

$$Y_t(n) = \left( \int_{\omega \in \Omega} y_t(\omega, n)^{\frac{\theta-1}{\theta}} d\omega \right)^{\frac{\theta}{\theta-1}}, \quad (5)$$

where  $\theta > 1$  is the symmetric elasticity of substitution across product varieties.<sup>13</sup>

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

$$P_t^y = \left( \int_{\omega \in \Omega} p_t^y(\omega)^{1-\theta} d\omega \right)^{\frac{1}{1-\theta}}, \quad (6)$$

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

<sup>12</sup>See, among others, Thomas (2008) and Trigari (2009).

<sup>13</sup>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 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.<sup>14</sup> Plants employ different technologies indexed by relative productivity  $z$ . To save notation, we identify a variety with the corresponding plant productivity  $z$ , omitting  $\omega$ . 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:

$$\varphi_{z,t} \equiv \frac{p_t^y(z)}{P_t} = \frac{\varphi_t}{z}. \quad (7)$$

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:

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

When serving the Foreign market, each final producer faces per-unit iceberg trade costs,  $\tau_t > 1$ , and fixed export costs,  $f_{x,t}$ .<sup>15</sup> 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,

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<sup>14</sup>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.

<sup>15</sup>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, Loayza, Pasha, and Serven (2014) 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).

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.<sup>16</sup>

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:

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

We assume that  $G(\cdot)$  is a Pareto distribution with shape parameter,  $k_p > \theta - 1$ . 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:

$$N_{x,t} \equiv [1 - G(z_{x,t})] N_{d,t} = \left( \frac{z_{\min}}{\tilde{z}_{x,t}} \right)^{k_p} \alpha^{\frac{k_p}{\theta-1}} N_{d,t}. \quad (8)$$

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

$$Y_{d,t} = \left[ \int_{z_{\min}}^{\infty} y_{d,t}(z)^{\frac{\theta-1}{\theta}} dG(z) \right]^{\frac{\theta}{\theta-1}}, \quad Y_{x,t} = \left[ \int_{z_{x,t}}^{\infty} y_{x,t}(z)^{\frac{\theta-1}{\theta}} dG(z) \right]^{\frac{\theta}{\theta-1}}, \quad (9)$$

$$P_{d,t}^y = \left[ \int_{z_{\min}}^{\infty} p_t^y(z)^{1-\theta} dG(z) \right]^{\frac{1}{1-\theta}}, \quad P_{x,t}^y = \left[ \int_{z_{x,t}}^{\infty} p_t^y(z)^{1-\theta} dG(z) \right]^{\frac{1}{1-\theta}}. \quad (10)$$

Using equations (7) and (10), the real costs of producing the bundles  $Y_{d,t}$  and  $Y_{x,t}$  can then be expressed as:

$$\frac{P_{d,t}^y}{P_t} = N_{d,t}^{\frac{1}{1-\theta}} \frac{\varphi_t}{\tilde{z}_d}, \quad \frac{P_{x,t}^y}{P_t} = N_{x,t}^{\frac{1}{1-\theta}} \frac{\varphi_t}{\tilde{z}_{x,t}}. \quad (11)$$

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<sup>16</sup>Notice that  $z_{x,t}$  is the lowest level of plant productivity such that the profit from exporting is positive.

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

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

The producer chooses  $N_{d,t+1}$  and the productivity cutoff  $z_{x,t}$  to minimize this expression subject to (8), (11), and  $\tilde{z}_{x,t} = \alpha^{\frac{1}{\theta-1}} z_{x,t}$ .<sup>17</sup>

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

$$\frac{P_{x,t}^y}{P_t} Y_{x,t} \tau_t = \frac{(\theta-1)k_p}{[k_p - (\theta-1)]} f_{x,t} N_{x,t} \varphi_t. \quad (12)$$

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.

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

$$\varphi_t f_{e,t} = (1-\delta) E_t \left\{ \beta_{t,t+1} \left[ \varphi_{t+1} \left( f_{e,t+1} - \frac{N_{x,t+1}}{N_{d,t+1}} f_{x,t+1} \right) + \frac{1}{\theta-1} \left( \frac{P_{d,t+1}^y Y_{d,t+1}}{P_{t+1} N_{d,t+1}} + \frac{P_{x,t+1}^y Y_{x,t+1}}{P_{t+1} N_{x,t+1}} \frac{N_{x,t+1}}{N_{d,t+1}} \tau_{t+1} \right) \right] \right\}.$$

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:

<sup>17</sup>Equation (8) implies that, by choosing  $z_{x,t}$ , the producer also determines  $N_{x,t}$ .

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

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,  $P_{x,t}^d$ , letting the price in the foreign market be  $P_{x,t} = \tau_t P_{x,t}^d / S_t$ , 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,  $\Gamma_{d,t} \equiv \nu \pi_{d,t}^2 P_{d,t} Y_{d,t} / 2$ , and  $\Gamma_{x,t}^d \equiv \nu \pi_{x,t}^d P_{x,t}^d Y_{x,t} / 2$ , where  $\nu \geq 0$  determines the size of the adjustment costs (domestic and export prices are flexible if  $\nu = 0$ ),  $\pi_{d,t} \equiv (P_{d,t} / P_{d,t-1}) - 1$  and  $\pi_{x,t}^d \equiv (P_{x,t}^d / P_{x,t-1}^d) - 1$ .

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  $P_{x,t} = \tau_t P_{d,t} = \tau_t P_{d,t} / S_t$ . 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 the Appendix. We show there that the (real) price of Home output for domestic sales is given by:

$$\frac{P_{d,t}}{P_t} = \frac{\phi}{(\phi - 1)\Xi_{d,t}} \left( \frac{P_{d,t}^y}{P_t} \right), \quad (13)$$

where:

$$\Xi_{d,t} \equiv 1 - \frac{\nu}{2} \pi_{d,t}^2 + \frac{\nu}{(\phi-1)} \left\{ \pi_{d,t} (1 + \pi_{d,t}) - E_t \left[ \beta_{t,t+1} \pi_{d,t+1} \frac{(1 + \pi_{d,t+1})^2}{1 + \pi_{t+1}^C} \frac{Y_{d,t+1}}{Y_{d,t}} \right] \right\}, \quad (14)$$

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:

$$\frac{P_{x,t}}{P_t^*} = \frac{\phi}{(\phi-1) \Xi_{x,t}^d} \left( \frac{\tau_t P_{x,t}^y}{Q_t P_t} \right), \quad (15)$$

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:

$$\Xi_{x,t}^d \equiv 1 - \frac{\nu}{2} \pi_{x,t}^2 + \frac{\nu}{(\phi-1)} \left\{ (1 + \pi_{x,t}^d) \pi_{x,t}^d - E_t \left[ \beta_{t,t+1} \pi_{x,t+1}^d \frac{(1 + \pi_{x,t+1}^d)^2}{1 + \pi_{t+1}^C} \frac{Y_{x,t+1}}{Y_{x,t}} \right] \right\}. \quad (16)$$

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 (11), (13), and (15), we have:

$$\tilde{\rho}_{d,t} = \mu_{d,t} \frac{\phi_t}{\tilde{z}_d}, \quad \tilde{\rho}_{x,t} = \mu_{x,t} \frac{\tau_t \phi_t}{Q_t \tilde{z}_{x,t}}, \quad (17)$$

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

$$\tilde{y}_{d,t} \equiv \tilde{\rho}_{d,t}^{-\phi} N_{d,t}^{\frac{\theta-\phi}{1-\theta}} Y_t^C, \quad \tilde{y}_{x,t} \equiv \tilde{\rho}_{x,t}^{-\phi} N_{x,t}^{\frac{\theta-\phi}{1-\theta}} Y_t^{C*}. \quad (18)$$

### 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.<sup>18</sup> 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 quadratic cost of adjusting Foreign bond holding,  $\frac{\psi}{2} \left( A_{*,t+1} / P_t^* \right)^2$ .<sup>19</sup> 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:

$$\begin{aligned} A_{t+1} + S_t A_{*,t+1} + \frac{\psi}{2} S_t P_t^* \left( \frac{A_{*,t+1}}{P_t^*} \right)^2 + P_t C_t \\ = (1 + i_t) A_t + (1 + i_t^*) A_{*,t} S_t + w_t L_t + P_t b(1 - l_t) + T_t^G + T_t^A + T_t^I + T_t^F, \end{aligned}$$

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.<sup>20</sup>

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:

<sup>18</sup>Foreign nominal holdings of Foreign bonds are denoted by  $A_{*,t}^*$ .

<sup>19</sup>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.

<sup>20</sup> In equilibrium,

$$\begin{aligned} T_t^G = -P_t b(1 - l_t), \quad T_t^A = S_t P_t (\psi/2) \left( A_{*,t+1} / P_t^* \right)^2, \quad T_t^I = P_t (\varphi_t Z_t l_t - (w_t / P_t) l_t - (g/2) \pi_{w,t}^2 l_t - \lambda V_t), \\ T_t^F = \left( \frac{\mu_{d,t} - 1}{\mu_{d,t}} - \frac{\nu}{2} (\pi_{d,t})^2 \right) \tilde{p}_{d,t} N_{d,t} \tilde{y}_{d,t} + Q_t \left( \frac{\mu_{x,t} - 1}{\mu_{x,t}} - \frac{\nu}{2} (\pi_{x,t})^2 \right) \tilde{p}_{x,t} N_{x,t} \tilde{y}_{x,t} - \varphi_t (N_{x,t} f_{x,t} + N_{e,t} f_{e,t}). \end{aligned}$$



$$1 + \psi a_{t+1} = (1 + i_{t+1}) E_t \left( \frac{\beta_{t,t+1}}{1 + \pi_{C,t+1}} \right), \quad (19)$$

$$1 + \psi a_{*t+1} = (1 + i_{t+1}^*) E_t \left[ \beta_{t,t+1} \frac{Q_{t+1}}{Q_t (1 + \pi_{C,t+1}^*)} \right], \quad (20)$$

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

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 the Appendix.

#### 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:

$$Q_t a_{*,t+1} = Q_t \frac{1 + i_t^*}{1 + \pi_{C,t}^*} a_{*,t} + Q_t N_{x,t} \tilde{\rho}_{x,t} \tilde{y}_{x,t} - N_{x,t}^* \tilde{\rho}_{x,t}^* \tilde{y}_{x,t}^*. \quad (21)$$

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:

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

where  $TB_t$  is the trade balance:

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

#### 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.<sup>21</sup> 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  $\tilde{\pi}_t^C \equiv (\tilde{P}_t / \tilde{P}_{t-1}) - 1$ .

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:

$$1 + i_{t+1} = (1 + i_t)^{\ell_i} \left[ (1 + i) (\pi_{C_{R,t}})^{e_\pi} (\hat{Y}_{R,t}^g)^{\rho_{Yg}} \right]^{1 - \ell_i}, \quad (22)$$

where  $\hat{Y}_{R,t}^g \equiv Y_{R,t} / Y_{R,t}^{flex}$  denotes the output gap—deviations of real output,  $Y_{R,t}$ , from real output under flexible prices and wages,  $Y_{R,t}^{flex}$ —and  $\pi_{C_{R,t}}$  denotes data-consistent CPI inflation.<sup>22</sup>

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

<sup>21</sup>There is much empirical evidence that gains from variety are mostly unmeasured in CPI data, as documented most recently by Broda and Weinstein (2010).

<sup>22</sup> The sensitivity analysis of Section 7 summarizes the implications of replacing the policy rule (22)—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.

## 2.6 Foreign Aggregates

As summarized in Table 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.<sup>23</sup> 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:

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

where  $\tilde{z}_{x,t}^*$  is determined by imposing a zero export-profit condition that is the Foreign counterpart to equation (12):

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

In the above expression,  $\tau_t^*$  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 by Foreign to Home is:

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

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

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<sup>23</sup> We do not report the details of the foreign economy. They are discussed in depth by Cacciatore and Ghironi (2012).

$$\tilde{\rho}_{x,t}^* = Q_t \mu_{x,t}^* \tau_t^* \frac{\varphi_t^*}{\tilde{z}_{x,t}^*}.$$

In the above expression,  $\varphi_t^*$  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:

$$\mu_{x,t}^* \equiv \xi_t \frac{\phi}{(\phi - 1) \Xi_{x,t}^{*d}},$$

where:

$$\Xi_{x,t}^{*d} \equiv 1 - \frac{\nu}{2} \pi_{x,t}^{*d^2} + \nu (1 + \pi_{x,t}^{*d}) \pi_{x,t}^{*d} - \frac{\nu}{(\phi - 1)} E_t \left[ \beta_{t,t+1}^* (1 + \pi_{x,t+1}^{*d}) \pi_{x,t+1}^{*d} \frac{Y_{x,t+1}^*}{Y_{x,t}^*} \right],$$

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

### 3. Calibration and Model Properties

#### 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-à-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.<sup>24</sup> Table 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

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<sup>24</sup>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).

world, i.e., the calibration of those parameters is not symmetric across countries.)

### 3.1.1 Rest of the World

We set the discount factor  $\beta$  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  $\gamma_C$  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.<sup>25</sup> The elasticity of substitution across product varieties,  $\theta$  is set to 3.8 following Bernard, Eaton, Jensen, and Kortum (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,  $\phi$ , equal to  $\theta$ . 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  $\psi$  to 0.0025 as in Ghironi and Melitz (2005). The scale parameter for the cost of adjusting prices,  $\nu$ , is equal to 80, as in Bilbiie, Ghironi, and Melitz (2008). We choose  $\vartheta$ , the scale parameter of nominal wage adjustment costs, so that the model reproduces the volatility of unemployment relative to GDP observed in the data. This implies  $\vartheta = 260$ . To calibrate the entry costs, we follow Ebell and Haefke (2009) 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,  $\lambda$ , is 10 percent, as reported by Shimer (2005). To pin down exogenous plant exit,  $\delta$ ,

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<sup>25</sup>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 (1994). 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.

we target the portion of worker separation due to plant exit equal to 40 percent reported by Haltiwanger, Scarpetta, and Schweiger (2008).

Two labor market parameters are left for calibration: the scale parameter for the cost of vacancy posting,  $\kappa$ , and the matching efficiency parameter,  $\chi$ . 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, Galí, and Gertler (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.

### 3.1.2 *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 (22), 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,  $\tau_t^*$ ; and iceberg trade costs related to exports,  $\tau_t$ . 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  $\tau^{NT*}$  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, Chung, and Roberts (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  $\phi_z$  to 0.999, consistent with the evidence of a unit root in Korean productivity (Kim, Lim, and Park, 2009). We calibrate the volatility of productivity innovations to match the volatility of Korea's GDP. This requires setting  $\sigma_\epsilon = 0.02$ .

### 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 2 as the benchmark to explain the model's properties and compare them to data.

Figure 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.<sup>26</sup> 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,

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<sup>26</sup> Intuitively,  $\eta_{w,t}$  increases to ensure optimal sharing of the cost of adjusting wages between firms and workers.

$z_{x,t}$  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  $TOT_t \equiv Q_t \tilde{p}_{x,t} / \tilde{p}_{x,t}^*$ ) 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 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 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 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.<sup>27</sup> Model II augments the productivity shocks with an exogenous stochastic component in terms of trade dynamics (discussed in more detail in Section 7 below), a result of which is that the model matches trade-related volatilities more closely, even if it fails to replicate the countercyclicality

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<sup>27</sup> 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's (2012) original version of the model with symmetric country size.



of the trade balance observed in the data.<sup>28</sup>

## 4. The Macroeconomic Consequences of Financial Integration

### 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 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 (21) 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 (21) 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 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).

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<sup>28</sup> 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.)

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,  $P_{x,t}^y / P_t = N_{x,t}^{1-\theta} \varphi_t / \tilde{z}_{x,t}$ , 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 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.

#### 4.2 *Implications for Welfare and Efficiency*

Similarly 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 5 computes the welfare cost of business cycles associated to the three alternative international asset markets we consider. We compute the percentage  $\Delta_{BC}$  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:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(C_t^a, l_t^a, h_t^a) = \frac{1}{1-\beta} u\left[\left(1 + \frac{\Delta_{BC}}{100}\right) C, l, h\right].$$

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  $\Delta_{BC}$  implies that the welfare costs of business cycles computed are reduced.

Table 5 shows that financial integration leads to a substantial reduction in the welfare cost of our model-Korea's business cycle. In particular,  $\Delta_{BC}$  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.

## **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  $\xi_t$  to the Foreign export markup,  $\mu_{x,t}^*$ .<sup>29</sup> Normalizing the steady-state value of  $\xi_t$  to 1, we assume that  $\xi_t$  follows an  $AR(1)$  process in logarithms,  $\log \xi_t = \phi_\xi \log \xi_{t-1} + \varpi_t$ , where  $\varpi_t$  represents *i.i.d.* draws from a normal distribution with zero mean and standard deviation  $\sigma_\varpi$ . We calibrate the persistence of the shock  $\phi_\xi$  and the standard deviation of innovations  $\sigma_\varpi$  to match the observed autocorrelation and standard deviation of Korea's terms of trade. This requires setting  $\phi_\xi = -0.25$  and  $\sigma_\varpi = 0.45$ .<sup>30</sup> As shown in Table 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 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 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, 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

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<sup>29</sup> On the supply side,  $\xi_t$  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.

<sup>30</sup> 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  $\xi_t$  and the endogenous nature of the terms of trade in our model then jointly affect the equilibrium path of  $TOT_t$ .

resources are available for domestic consumption and investment, and both variables increase by less.

Table 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 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.

## **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.<sup>31</sup> And it is interesting to consider whether internationally complete markets can be a better representation of Korea's

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<sup>31</sup> 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.

integration with global financial markets than incomplete markets for the period between 1998 and 2007.

We perform this exercise in Figures 4 and 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 6-8, where model-generated business cycle moments under these scenarios are compared to the properties of the data in the relevant periods. Table 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 2 and 4 and Figures 3 and 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 2 and 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 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 cyclicity 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 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 3 than in Table 8.

Table 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.<sup>32</sup>

## 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 (22) under flexible exchange rates.

Second, we considered alternative values for the parameters whose calibration is relatively controversial in the literature. For household preferences, we considered a higher Frisch elasticity of labor supply ( $1/\underline{\gamma}_h = 4$ , 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 (22)—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

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<sup>32</sup> 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.



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.<sup>33</sup> Thus, we re-computed all figures and tables replacing the assumption of a flexible exchange rate and rule (22) with the policy rule:

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

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 the Appendix. Consistent with the fact that Milani and Park 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 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.<sup>34</sup>

## 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

<sup>33</sup> For instance, Chung, Jung, and Yang (2007), Eichengreen (2004b), Milani and Park (2015), Ortiz, Ottonello, Sturzenegger, and Talvi (2009), and Ortiz and Sturzenegger (2007).

<sup>34</sup> 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.

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

## 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:

$$J_t = \varphi_t Z_t h_t - \frac{w_t}{P_t} h_t - \frac{\mathcal{G}}{2} \pi_{w,t}^2 + E_t \beta_{t,t+1} (1-\lambda) J_{t+1}. \quad (\text{A.1})$$

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,

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

The value of being unemployed is:

$$U_{u,t} = \frac{v(h_t)}{u_{c,t}} + b + E_t \left\{ \beta_{t,t+1} \left[ \iota_t W_{t+1} + (1-\iota_t) U_{u,t+1} \right] \right\}, \quad (\text{A.3})$$

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:

$$H_t = \frac{w_t}{P_t} h_t - \left( \frac{v(h_t)}{u_{c,t}} + b \right) + (1-\lambda-\iota_t) E_t (\beta_{t,t+1} H_{t+1}). \quad (\text{A.4})$$

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

$$\eta H_t \frac{\partial J_t}{\partial w_t} + (1-\eta) J_t \frac{\partial H_t}{\partial w_t} = 0, \quad (\text{A.5})$$

where:

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

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

$$\eta_{w,t} H_t = (1-\eta_t) J_{w,t}, \quad (\text{A.6a})$$

where:

$$\eta_{w,t} \equiv \frac{\eta}{\eta - (1-\eta)(\partial H_t / \partial w_t)(\partial J_t / \partial w_t)^{-1}}. \quad (\text{A.6b})$$

Combining equations (A.5) and (A.6) yields equation (4) of the text.

## 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,  $P_{x,t}^d$ , letting the price in the foreign market be determined by  $P_{x,t} = \tau_t P_{x,t}^d / S_t$ . When choosing  $P_{d,t}$  and  $P_{x,t}^d$ , the firm maximizes

$$E_t \sum_{s=t}^{\infty} \beta_{t,t+s} \left[ \left( \frac{P_{d,s}}{P_s} - \frac{P_{d,s}^y}{P_s} \right) Y_{d,s} + \left( \frac{P_{x,s}^d}{P_s} - \frac{P_{x,s}^y}{P_s} \tau_s \right) Y_{x,s} - \frac{\Gamma_{d,s}}{P_s} - \frac{\Gamma_{x,s}^d}{P_s} \right], \quad (\text{A.7})$$

where  $\Gamma_{d,s} \equiv \nu \pi_{d,s}^2 P_{d,s} Y_{d,s} / 2$ ,  $\Gamma_{x,s}^d \equiv \nu \pi_{x,s}^{d^2} P_{x,s}^d Y_{x,s} / 2$ ,  $\pi_{d,s} \equiv (P_{d,s} / P_{d,s-1}) - 1$ ,  $\pi_{x,s}^d \equiv (P_{x,s}^d / P_{x,s-1}^d) - 1$ ,

and output bundle demands are determined by:

$$Y_{d,s} = \left( \frac{P_{d,s}}{P_s} \right)^{-\phi} Y_t^C, \quad Y_{x,s} = \left( \frac{\tau_s P_{x,s}^d}{Q_s P_s} \right)^{-\phi} Y_t^{C*}.$$

First-order optimality conditions for  $P_{d,t}$  and  $P_{x,t}^d$  and straightforward, though tedious, algebra yield equations (13)-(16) in the text. (To obtain (15)-(16), recall that  $P_{x,t} = \tau_t P_{x,t}^d / S_t$  and  $Q_t \equiv S_t P_t^* / P_t$ .)

### C. Other Equilibrium Details

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

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

Wage inflation and consumer price inflation are tied by:

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

The expression for the consumption price index implies:

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

Finally, labor market clearing requires:

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

### D. Managed Exchange Rates

See Figures A.1-A.5 and Tables A.1-A.5. Figures A.1-A.5 replicate Figures 1-5, replacing impulse responses under flexible exchange rates with responses under managed exchange rates. Tables A.1-A.3 replicate Tables 3-5 and Tables A.4-A.5 replicate Tables 8 and 9, replacing results obtained under flexible exchange rates with results under managed exchange rates.

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TABLE 1: MODEL SUMMARY

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

TABLE 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	$\varrho_{Yg} = 0.19$
Bond Adjustment Cost	$\psi = 0.0025$

TABLE 3: BUSINESS CYCLE STATISTICS, BENCHMARK SCENARIO

Variable	$\sigma_X$			$\sigma_X/\sigma_{Y_R}$			$corr(X_t, Y_{R,t})$		
	<i>Data</i>	<i>Model I</i>	<i>Model II</i>	<i>Data</i>	<i>Model I</i>	<i>Model II</i>	<i>Data</i>	<i>Model I</i>	<i>Model II</i>
$Y_R$	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 4: BUSINESS CYCLE MOMENTS UNDER DIFFERENT ASSET MARKETS

Variable	Financial Autarky						Incomplete Markets						Complete Markets					
	<i>Model I</i>			<i>Model II</i>			<i>Model I</i>			<i>Model II</i>			<i>Model I</i>			<i>Model II</i>		
$Y_R$	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 ( $\sigma_X$ , percentage points), the second column reports standard deviations relative to real, data-consistent GDP ( $\sigma_X/\sigma_{Y_R}$ ), 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 5: WELFARE COST OF BUSINESS CYCLES UNDER DIFFERENT ASSET MARKETS

	$\Delta$ Welfare		
	Financial Autarky	Incomplete Markets	Complete Markets
<i>Model I</i>	2.06	1.91	0.25
<i>Model II</i>	4.30	4.05	3.16

$\Delta$ Welfare  $\equiv$  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 6: FINANCIAL AUTARKY UNDER FIXED EXCHANGE RATES

Variable	$\sigma_X$			$\sigma_X/\sigma_{Y_R}$			$corr(X_t, Y_{R,t})$		
	<i>Data</i>	<i>Model I</i>	<i>Model II</i>	<i>Data</i>	<i>Model I</i>	<i>Model II</i>	<i>Data</i>	<i>Model I</i>	<i>Model II</i>
$Y_R$	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;

$\sigma_X \equiv$  standard deviation of variable  $X$  (percentage points);

$corr(X_t, Y_{R,t}) \equiv$  contemporaneous correlation of variable  $X_t$  with data-consistent, real GDP;

*Model I*  $\equiv$  productivity shocks only; *Model II*  $\equiv$  productivity and terms of trade shocks.

TABLE 7: INCOMPLETE MARKETS UNDER FIXED EXCHANGE RATES

Variable	$\sigma_X$			$\sigma_X/\sigma_{Y_R}$			$corr(X_t, Y_{R,t})$		
	<i>Data</i>	<i>Model I</i>	<i>Model II</i>	<i>Data</i>	<i>Model I</i>	<i>Model II</i>	<i>Data</i>	<i>Model I</i>	<i>Model II</i>
$Y_R$	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 8: COMPLETE MARKETS UNDER FLEXIBLE EXCHANGE RATES

Variable	$\sigma_X$			$\sigma_X/\sigma_{Y_R}$			$corr(X_t, Y_{R,t})$		
	<i>Data</i>	<i>Model I</i>	<i>Model II</i>	<i>Data</i>	<i>Model I</i>	<i>Model II</i>	<i>Data</i>	<i>Model I</i>	<i>Model II</i>
$Y_R$	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 9: WELFARE COST OF BUSINESS CYCLES UNDER DIFFERENT ASSET MARKETS AND MONETARY POLICIES

	$\Delta$ Welfare		
	Financial Autarky	Incomplete Markets	Complete Markets
	Fixed Exchange Rates	Fixed Exchange Rates	Flexible Exchange Rates
<i>Model I</i>	1.97	2.15	0.25
<i>Model II</i>	4.72	4.29	3.16

$\Delta$ Welfare  $\equiv$  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 A.1: BUSINESS CYCLE STATISTICS, MANAGED EXCHANGE RATES

Variable	$\sigma_X$			$\sigma_X/\sigma_{Y_R}$			$corr(X_t, Y_{R,t})$		
	<i>Data</i>	<i>Model I</i>	<i>Model II</i>	<i>Data</i>	<i>Model I</i>	<i>Model II</i>	<i>Data</i>	<i>Model I</i>	<i>Model II</i>
$Y_R$	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.

TABLE A.2: BUSINESS CYCLE MOMENTS UNDER DIFFERENT ASSET MARKETS, MANAGED EXCHANGE RATES

Variable	Financial Autarky						Incomplete Markets						Complete Markets					
	<i>Model I</i>			<i>Model II</i>			<i>Model I</i>			<i>Model II</i>			<i>Model I</i>			<i>Model II</i>		
$Y_R$	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 ( $\sigma_X$ , percentage points), the second column reports standard deviations relative to real, data-consistent GDP ( $\sigma_X/\sigma_{Y_R}$ ), 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 A.3: WELFARE COST OF BUSINESS CYCLES UNDER DIFFERENT ASSET MARKETS, MANAGED EXCHANGE RATES

	$\Delta$ Welfare		
	Financial Autarky	Incomplete Markets	Complete Markets
<i>Model I</i>	2.12	1.96	0.25
<i>Model II</i>	4.39	4.12	3.15

$\Delta$ Welfare  $\equiv$  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 A.4: COMPLETE MARKETS UNDER MANAGED EXCHANGE RATES

Variable	$\sigma_X$			$\sigma_X/\sigma_{Y_R}$			$corr(X_t, Y_{R,t})$		
	<i>Data</i>	<i>Model I</i>	<i>Model II</i>	<i>Data</i>	<i>Model I</i>	<i>Model II</i>	<i>Data</i>	<i>Model I</i>	<i>Model II</i>
$Y_R$	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;

$\sigma_X \equiv$  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 A.5: WELFARE COST OF BUSINESS CYCLES UNDER DIFFERENT ASSET MARKETS AND MONETARY POLICIES

	$\Delta$ Welfare		
	Financial Autarky	Incomplete Markets	Complete Markets
	Fixed Exchange Rates	Fixed Exchange Rates	Managed Exchange Rates
<i>Model I</i>	1.97	2.15	0.25
<i>Model II</i>	4.72	4.29	3.15

$\Delta$ Welfare  $\equiv$  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.

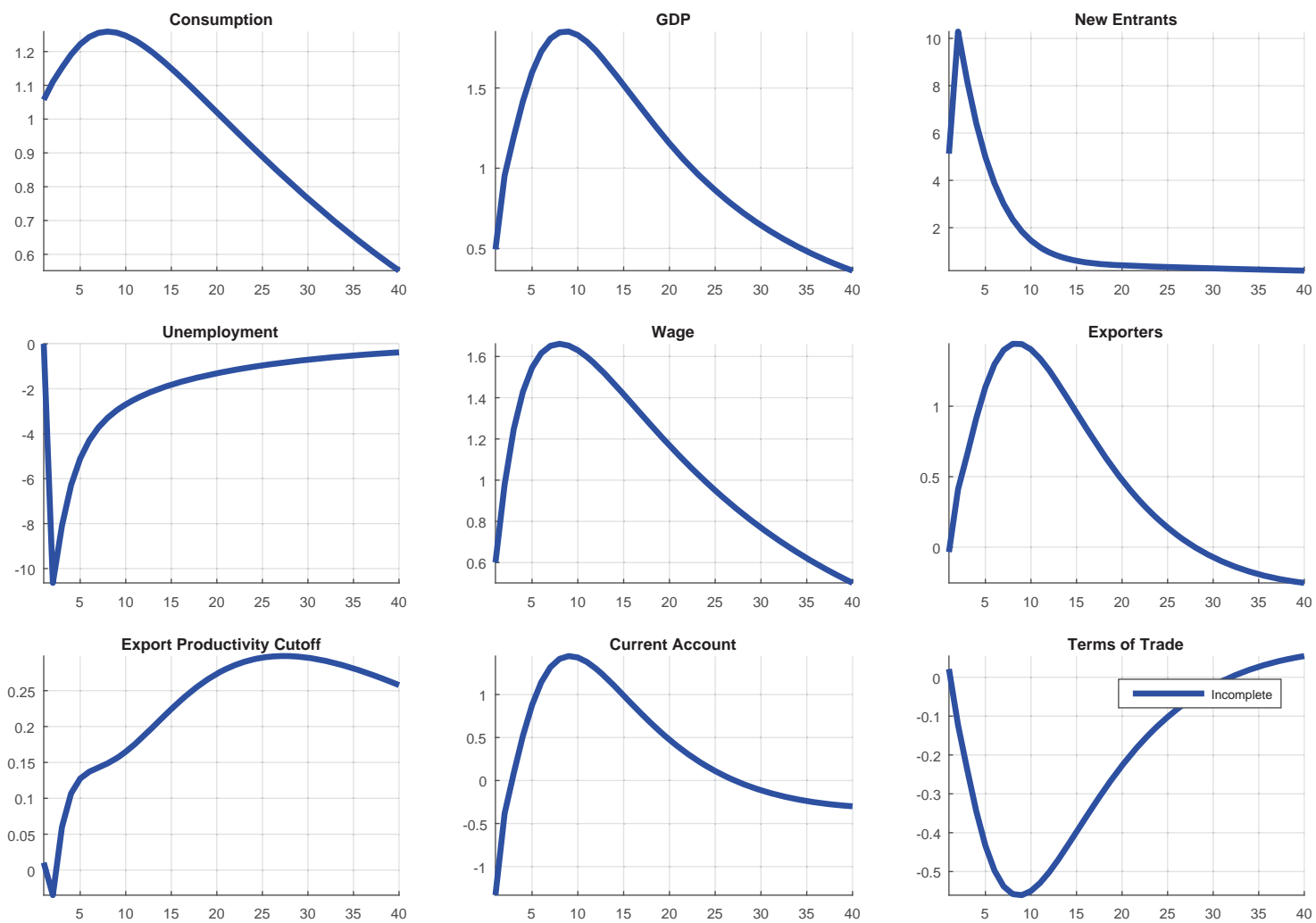


Figure 1. Home productivity shock, incomplete markets with flexible exchange rates. Responses show percentage deviations from steady state. Unemployment and current account are in deviations from steady state.

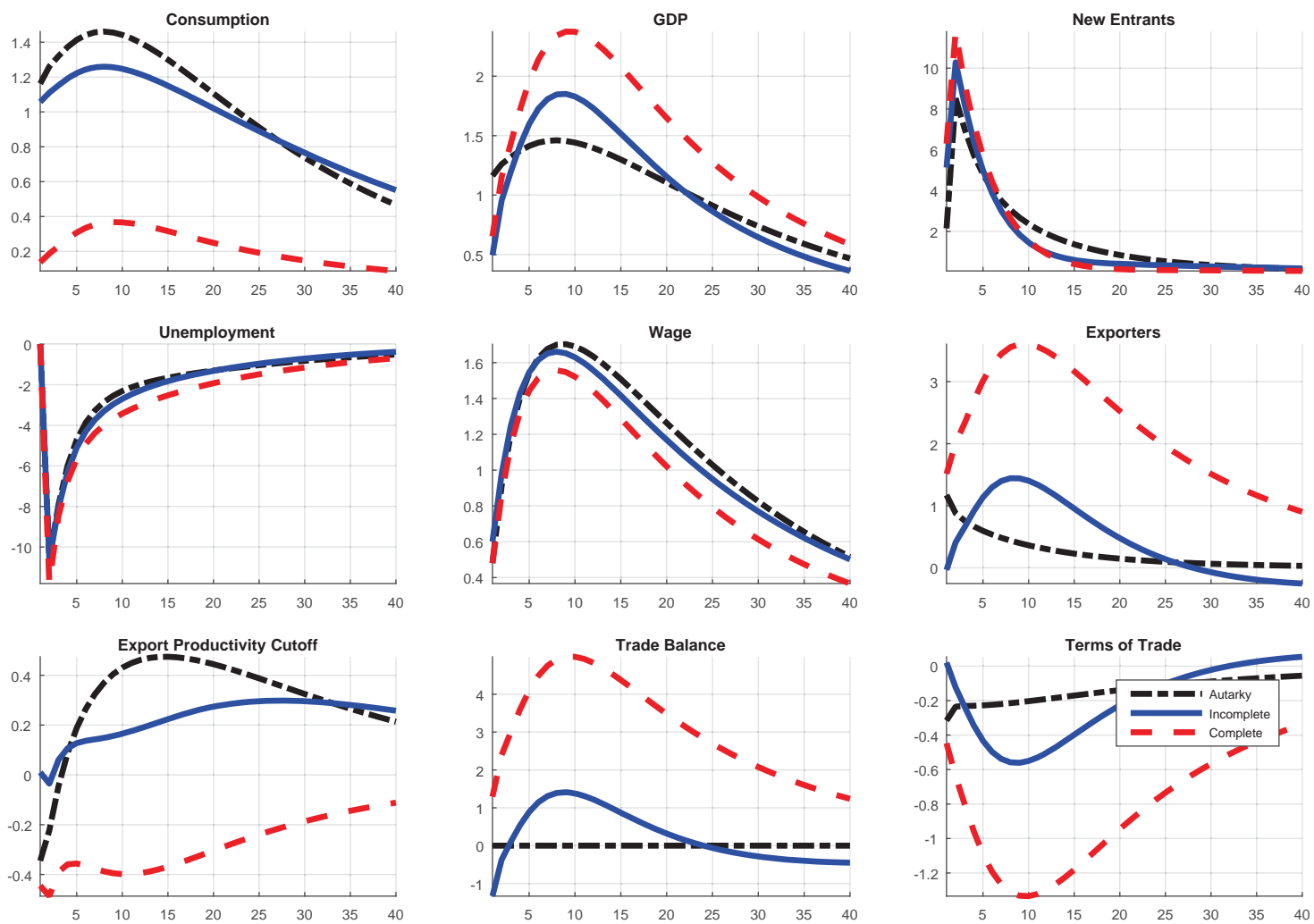


Figure 2. Home productivity shock, flexible exchange rates, incomplete markets (solid lines), financial autarky (dash-dotted lines), complete markets (dashed lines). Responses show percentage deviations from steady state. Unemployment and trade balance are in deviations from steady state.

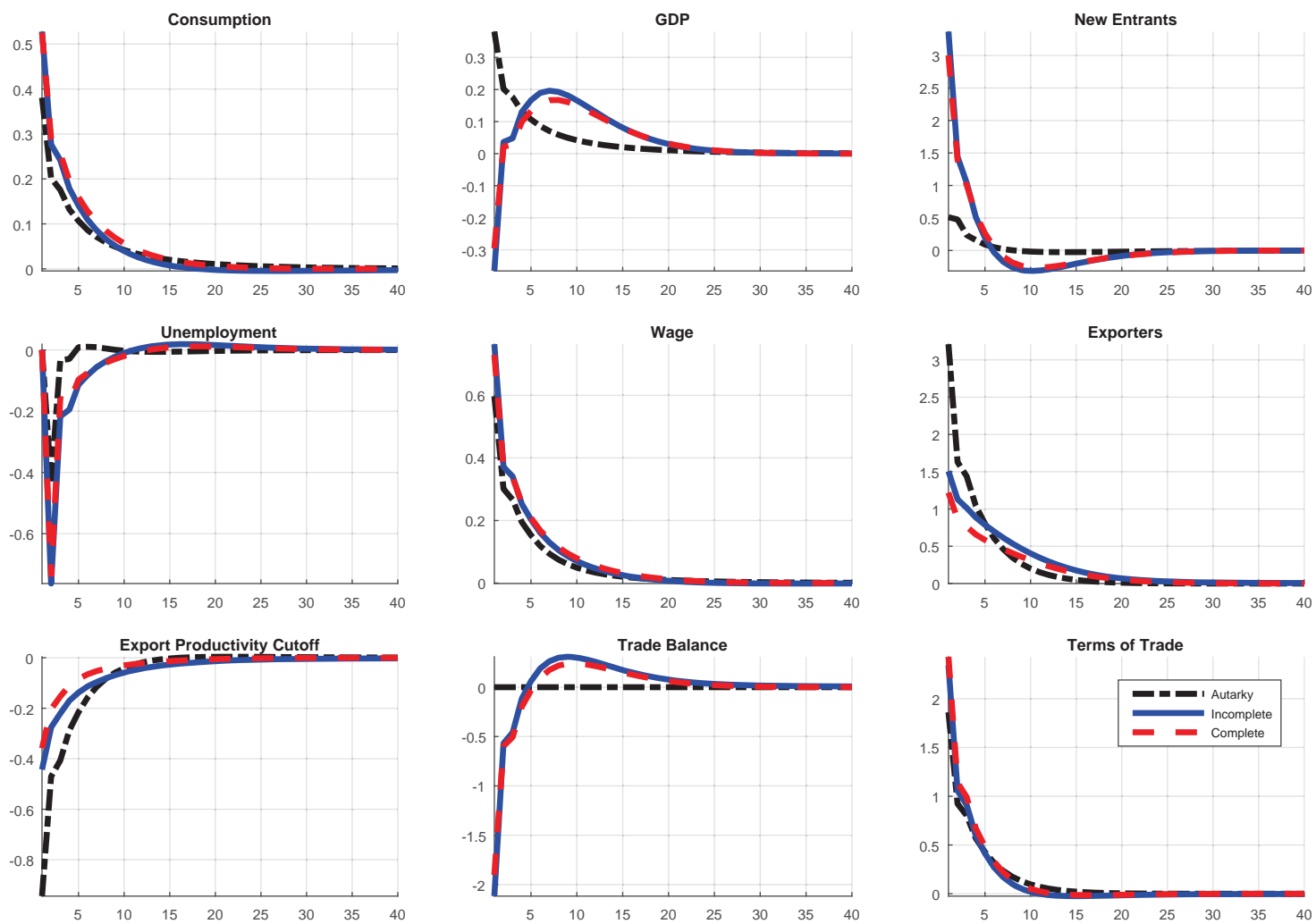


Figure 3. Terms of trade shock, flexible exchange rates, incomplete markets (solid lines), financial autarky (dash-dotted lines), complete markets (dashed lines). Responses show percentage deviations from steady state. Unemployment and trade balance are in deviations from steady state.

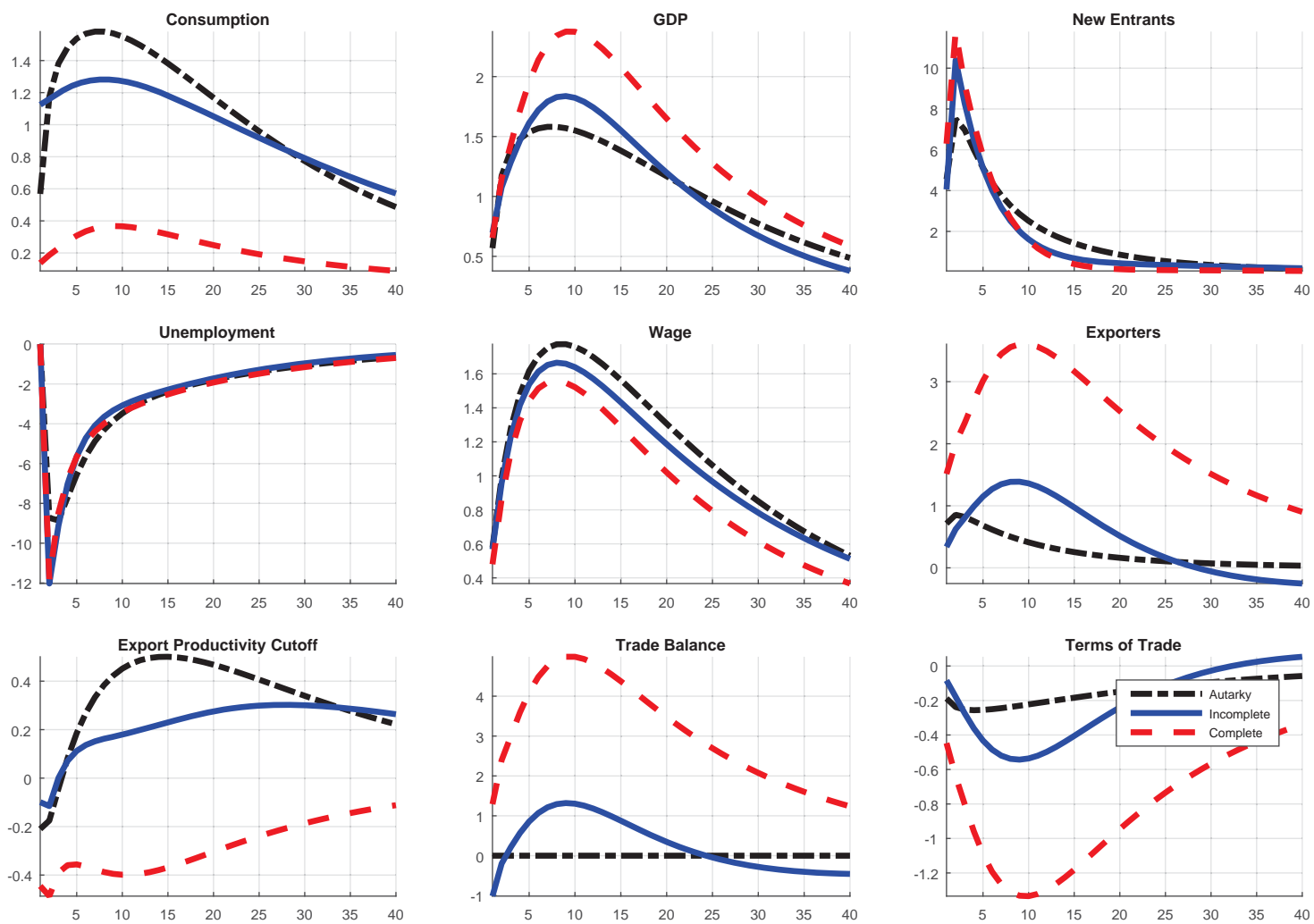


Figure 4. Productivity shock under different asset market and exchange rate policy assumptions: financial autarky and fixed exchange rate (dash-dotted lines), incomplete markets and fixed exchange rate (solid lines), complete markets and flexible exchange rates (dashed lines). Responses show percentage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

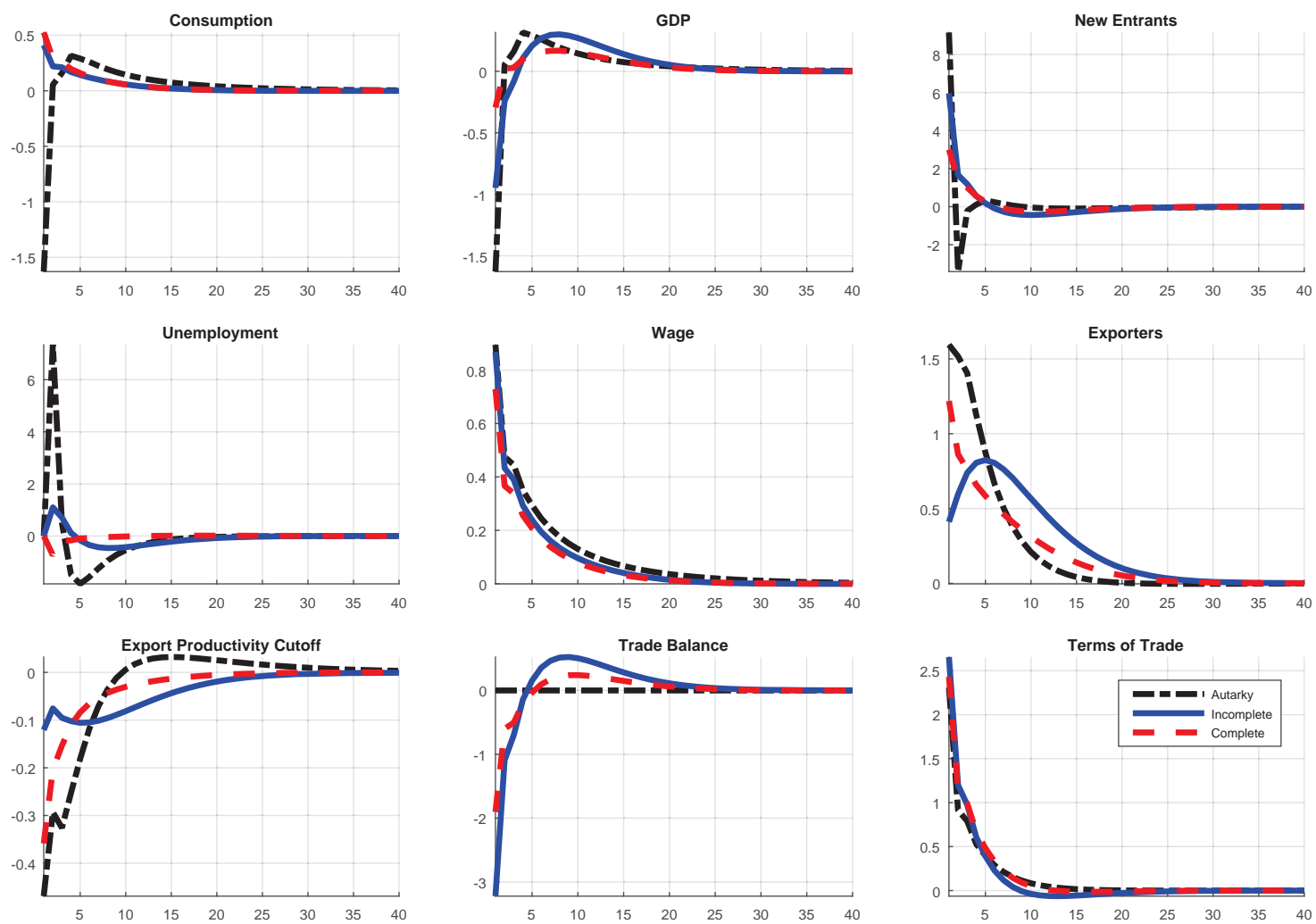


Figure 5. Terms of trade shock under different asset market and exchange rate policy assumptions: financial autarky and fixed exchange rate (dash-dotted lines), incomplete markets and fixed exchange rate (solid lines), complete markets and flexible exchange rates (dashed lines). Responses show percentage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

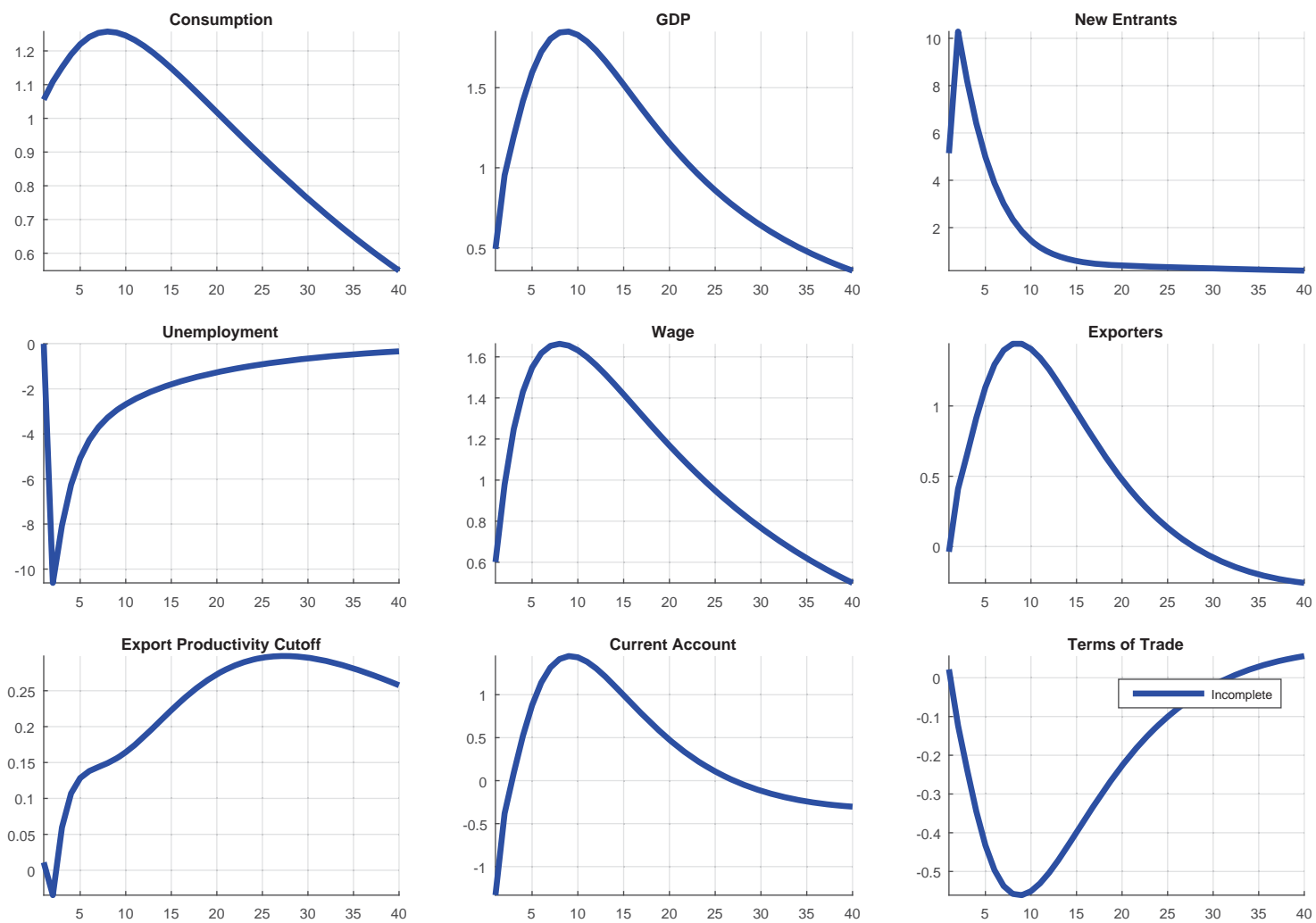


Figure A.1. Home productivity shock, incomplete markets with managed exchange rates. Responses show percentage deviations from steady state. Unemployment and current account are in deviations from steady state.



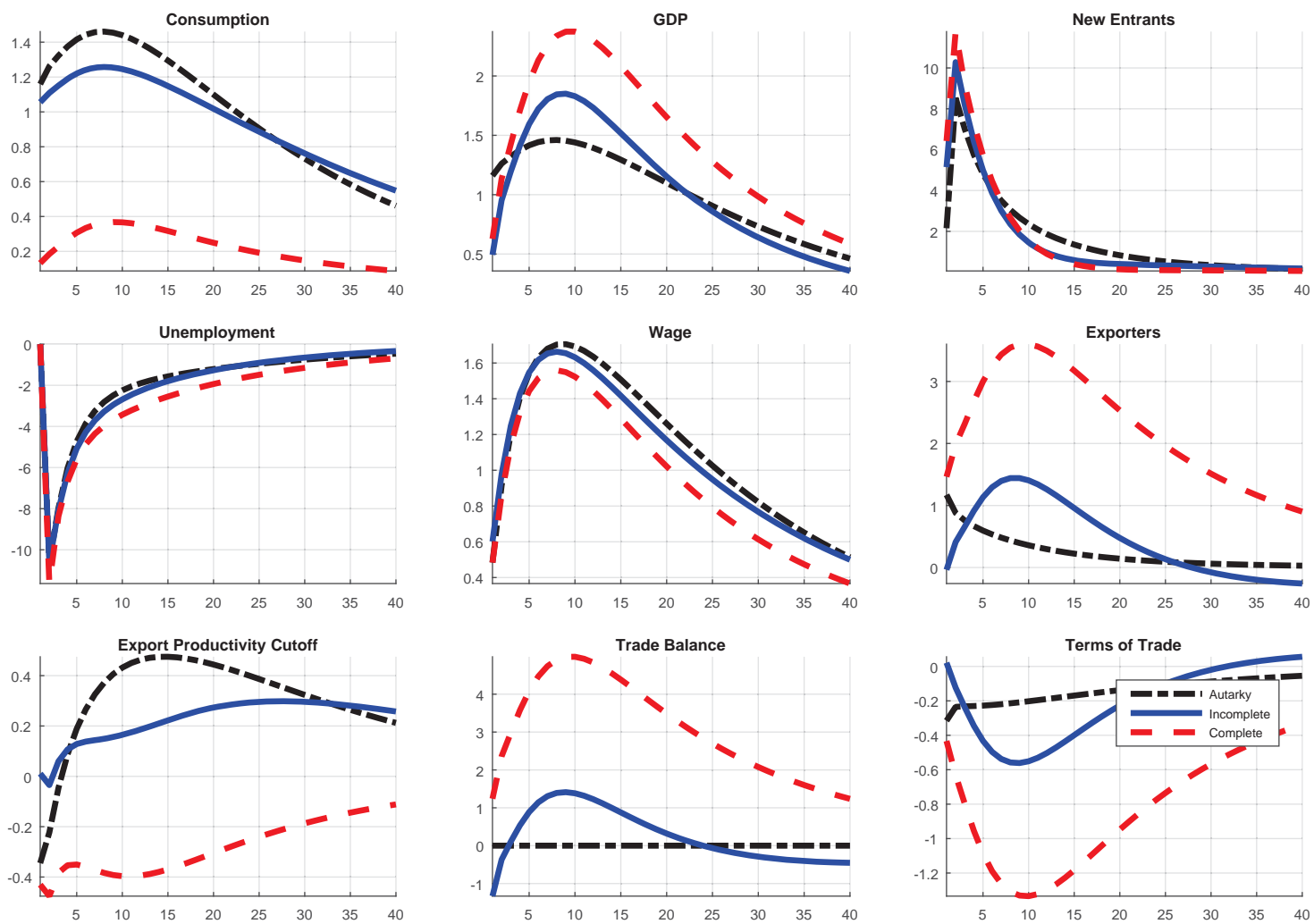


Figure A.2. Home productivity shock, managed exchange rates, incomplete markets (solid lines), financial autarky (dash-dotted lines), complete markets (dashed lines). Responses show percentage deviations from steady state. Unemployment and trade balance are in deviations from steady state.

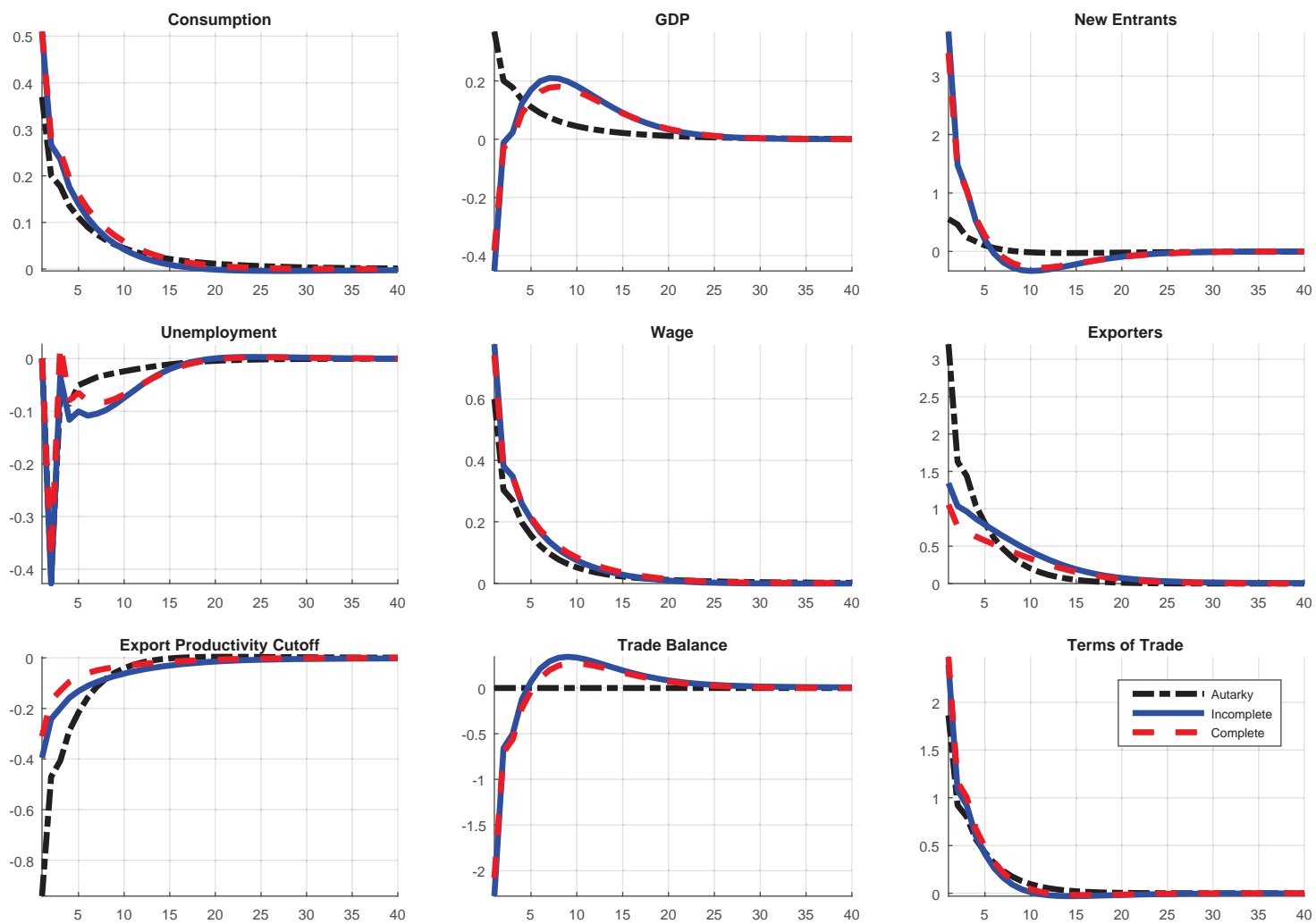


Figure A.3. Terms of trade shock, managed exchange rates, incomplete markets (solid lines), financial autarky (dash-dotted lines), complete markets (dashed lines). Responses show percentage deviations from steady state. Unemployment and trade balance are in deviations from steady state.

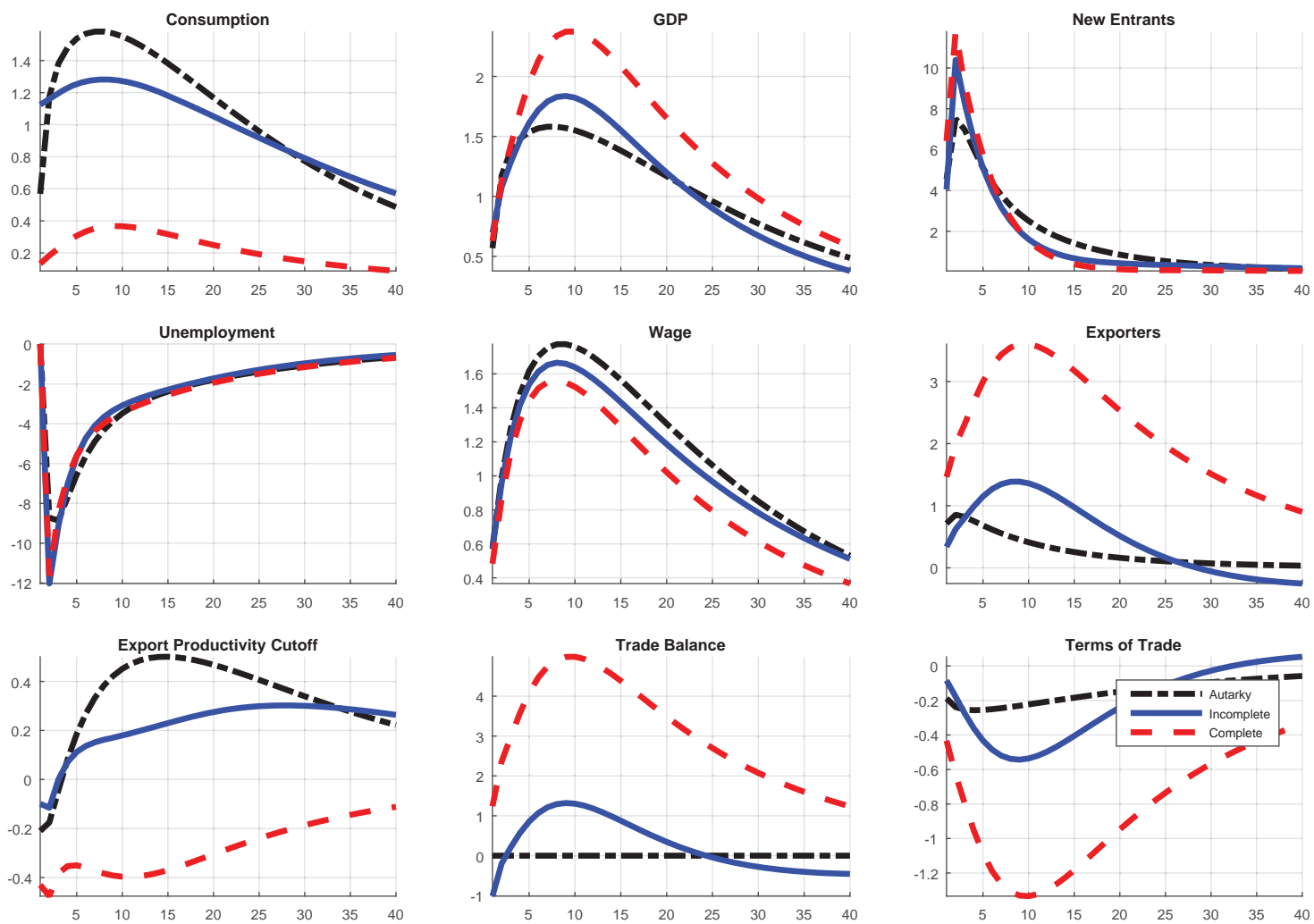


Figure A.4. Productivity shock under different asset market and exchange rate policy assumptions: financial autarky and fixed exchange rate (dash-dotted lines), incomplete markets and fixed exchange rate (solid lines), complete markets and managed exchange rates (dashed lines). Responses show percentage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

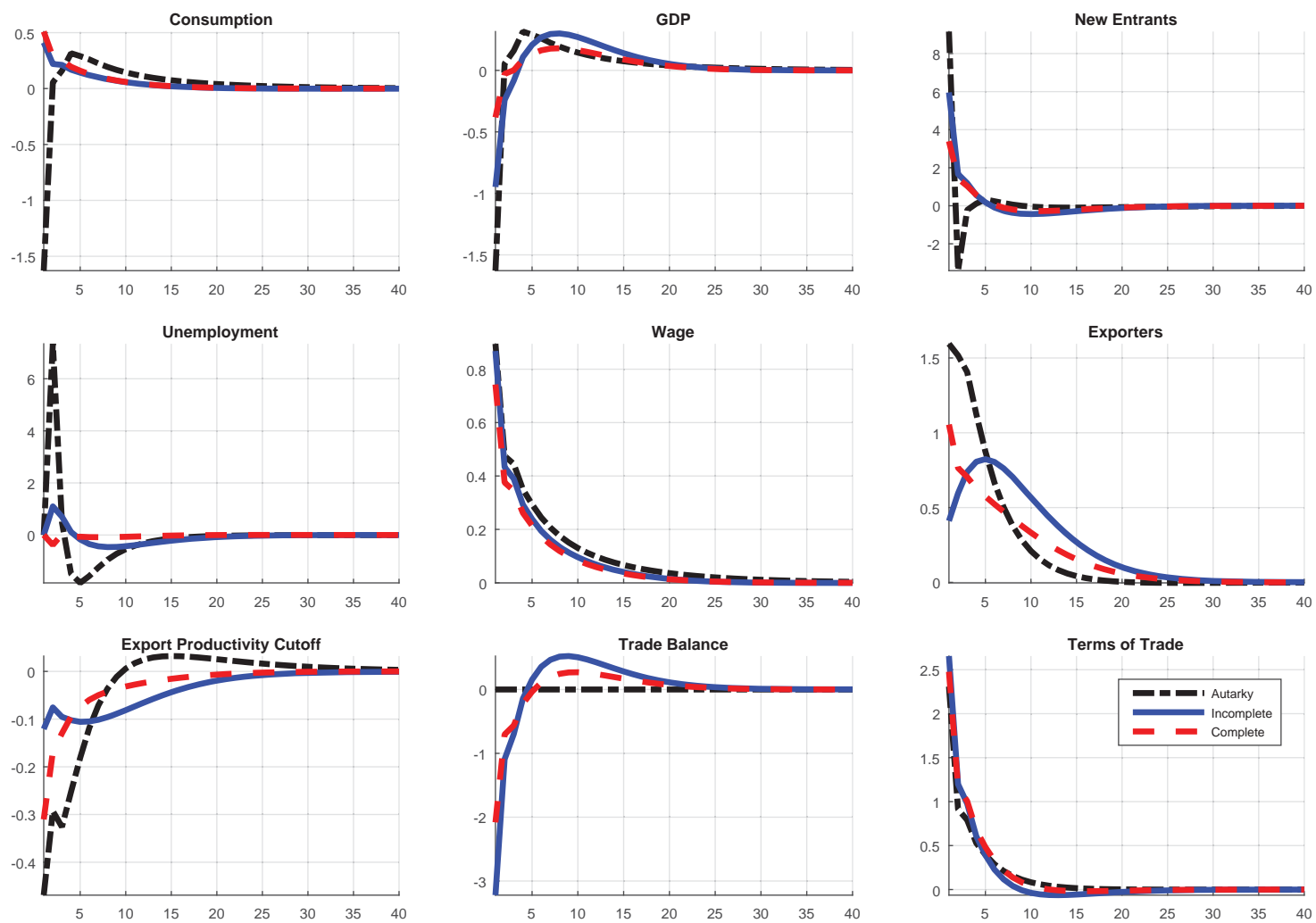


Figure A.5. Terms of trade shock under different asset market and exchange rate policy assumptions: financial autarky and fixed exchange rate (dash-dotted lines), incomplete markets and fixed exchange rate (solid lines), complete markets and managed exchange rates (dashed lines). Responses show percentage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