Trade Finance Frictions and International Business Cycles*

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Abstract

I study how frictions in exporting firms' trade finance affect the business cycles of a small open economy within a general equilibrium framework. In the model, firms rely on external capital to cover large upfront fixed export costs but face credit constraints that limit borrowing based on the country's financial development. In quantitative general equilibrium exercises, I show that the effect of trade finance frictions on the aggregate economy is not as significant as on firm-level outcomes due to two mechanisms. First, the decrease in the extensive margin of exports from trade finance frictions is offset by an increase in the average productivity of exporters, limiting its aggregate impact. This extensive margin effect strengthens, while the selection effect weakens, when firm productivity is less dispersed. Second, wage adjustments in general equilibrium reduces the magnitude of these channels, diminishing the role of trade finance frictions at the aggregate level. This wage-adjustment effect is stronger with inelastic labor supply.

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1 Introduction

Trade finance refers to the practice that exporting firms rely on external capital to finance large upfront fixed export costs. Although the effects of trade finance and frictions in it on firm-level outcomes have been widely studied, their aggregate-level implication in general equilibrium, especially at a business cycle frequency, is relatively less explored.

In this paper, I study how frictions in trade finance affect the business cycles of a small open economy in general equilibrium. I do so in a small open economy model where a representative household solves an intertemporal problem and monopolistically competitive firms produce differentiated goods à la Melitz (2003). The distinctive feature of the model is that exporting firms should rely on trade finance to pay fixed export costs and they face frictions in doing so. These frictions come in the form of credit constraints, with the amount they can borrow being limited depending on a country's degree of financial development. Moreover, these fixed export costs consist of both domestic input and foreign input, which makes their value depend on the real exchange rate (RER).

By studying the effect of trade finance frictions on both exports and other economic outcomes in general equilibrium, the paper expands our understanding of trade finance frictions in several ways. First, the paper complements the important work of Chaney (2016) and Manova (2013) by providing useful analytical results in partial equilibrium. It then conducts quantitative analysis in general equilibrium to look at how trade finance frictions affect the business cycles of a small open economy.

The main findings are twofold. First, in partial equilibrium analytical analysis, I find that depreciation in the RER, defined as the foreign country price index divided by the home country price index ($\frac{P_t^*}{P_t}$), has two effects on the extensive margin of exports. On the one hand, it increases the price competitiveness of the home country exporters, a classic result in the literature. On the other hand, it increases the burden of export fixed costs, negatively affecting exports. The overall effect of RER depreciation on the extensive margin of exports is ambiguous and is determined by the relative strength of the two forces.

Second, in quantitative general equilibrium exercises, I identify three channels through which trade finance frictions affect the economy: the extensive margin, the intensive margin, and selection. Trade finance frictions prevent potential exporters from exporting and hence negatively affect the extensive margin of exports.This leads to a higher average productivity of exporters through the selection channel. The intensive margin channel, defined as the effect on a single firm's profit, is of second order in that it operates through the adjustment in aggregate variables such as the wage rate in general equilibrium. As a result, the effect of trade finance frictions is largely driven by the two competing channels: the extensive margin and selection effect. The two channels partially offset each other, which reduces the role of trade finance in the economy at the aggregate level. In the baseline, trade finance frictions generate no quantitatively significant difference in either steady state values or responses to an aggregate productivity shock of aggregate outcomes including consumption and GDP.

I also find that the relative strength of the two offsetting channels is closely related to the distribution of firm productivity. As firms' productivity becomes less dispersed, the extensive margin channel becomes stronger, while the selection channel becomes less important. In this case, an economy with less severe trade finance frictions enjoys higher consumption in steady state, and the responses (percentage deviations from steady state) of economic outcomes to shocks are also more sensitive. However, the difference depending on the degree of trade finance frictions is further reduced by the general equilibrium effect operating through the adjustment in the wage rate. Unlike in partial equilibrium where the wage rate is held fixed, the wage adjustment in general equilibrium downsizes the magnitude of all three channels. I show that this downsizing effect becomes stronger as the elasticity of labor supply decreases.

The idea of trade finance frictions is realistic. In practice, firms engaging in international trade rely on external capital to fund large upfront fixed costs. They also often have limited access to external capital since cross-border activities are essentially riskier than domestic sales for various reasons, including longer shipping times and exchange rate fluctuations. Empirical evidence corroborates the importance of such trade finance frictions. For example, Manova (2008) shows that, on average, exports rise about 40% as a country becomes more open to equity inflows from foreign investors. Antràs and Foley (2015) provide empirical evidence that if the importer is in a country with weaker contract enforcement, transactions more frequently take the form of cash-in-advance contracts. Desai et al. (2008) suggest that the ability of multinational affiliates to access capital owned by their parent firms affects the response of multinational activity to currency crises.

While there is a fair amount of research on trade finance frictions in partial equilibrium (e.g., Manova (2013) and Chaney (2016)), few have investigated its general equilibrium implications and even fewer study its implications on business cycles. An exception is recent work by Leibovici (2021), who studies the effect of financial development on the international trade of different sectors in general equilibrium. However, this work is distinct from this paper since Leibovici (2021) focuses on the reallocation of trade share across industries in steady state, while I study the effect on the extensive margin and the average productivity within an industry. In addition, I study the effect on the wage rate both in steady state and at a business cycle frequency by analyzing the impulse responses, which I do by incorporating trade finance frictions into a small open economy general equilibrium model and conducting quantitative analysis. I also compare some partial equilibrium results of the model with those of previous works.

The rest of the paper is organized as follows. Section 2 discusses the related literature and the paper's contributions to the literature. Section 3 describes the model environment of a small open economy with trade finance frictions and defines its monopolistically competitive equilibrium. Section 4 draws some partial equilibrium implications. Section 5 presents the results from the quantitative analysis, explains the economic intuition behind them, and discusses some robustness checks. Section 6 concludes.

2 Literature Review

This paper contributes to a few strands of literature. The first strand studies the role of trade finance frictions on firms' international activities. Empirical works such as Manova (2008), Antràs and Foley (2015), and Desai et al. (2008) show that trade finance frictions matter in trade and multinational activities. Manova et al. (2015) provide firm-level evidence that credit constraints restrict international trade and influence the pattern of multinational activity. On the theory side, Manova (2013) incorporates financial frictions into a partial equilibrium heterogeneous firm model to identify the mechanisms through which credit constraints affect trade. She also provides empirical evidence that financially developed economies export more in financially vulnerable sectors.

Furthermore, Chaney (2016) proposes a partial equilibrium model of international trade with trade finance constraints where firms possess heterogenous amounts of assets and theoretically shows that the effect of exchange rate fluctuations on exports is ambiguous. Foley and Manova (2015) provide a thorough survey of this literature. However, most of the previous studies I have just discussed focus on the partial equilibrium implications of trade finance frictions and lack general equilibrium considerations. This paper contributes to this literature by studying the role of trade finance frictions in a small open economy general equilibrium setting. I show that partial equilibrium predictions regarding firm-level export activity in my model are largely consistent with those in existing studies, but the role of trade finance frictions at the aggregate level is quantitatively very small in general equilibrium.

Second, this paper contributes to the literature on international real business cycles spawned by Backus et al. (1992). Other classic papers assuming complete markets include Backus et al. (1994), Cole and Obstfeld (1991), and Backus and Smith (1993). Aguiar and Gopinath (2007) and Schmitt-Grohé and Uribe (2003) study the small open economy incomplete-market real business cycle (RBC) models. Some recent papers focus on the role of financial frictions in business cycles. Mendoza (2010), Bianchi (2011), and Benigno et al. (2013) explain business cycles in small open economies using financial constraints and pecuniary externalities. There have also been some attempts to incorporate firm dynamics into business cycle models. Ghironi and Melitz (2005) incorporate Melitz (2003)-type firm dynamics into an RBC model. Fattal Jaef and Lopez (2014) add capital accumulation to the model of Ghironi and Melitz (2005) and find that incorporating firm dynamics does not improve the model performance in matching business cycle statistics. I contribute to this literature by building a small open economy business cycle model that incorporates trade finance frictions. This is distinct from papers like Mendoza (2010) and Bianchi (2011) in that I focus on the financial frictions in firms' export activity rather than those in a representative household's problem.

This paper also contributes to a fast-growing literature that combines international macro and international trade. Obstfeld and Rogoff (2000) try to answer the puzzles in international macro using trade costs. However, since then, the two fields have diverged for no good reason. The international macro field has focused on topics like capital flows and exchange rates but has paid relatively less attention to firm-level trade dynamics. On the contrary, the trade literature has focused on topics like gains from trade and patterns of trade without considering international macro aspects such as exchange rates and households' saving behavior.

Recently, there have been some attempts to bridge the gap between the two fields again. For example, Fitzgerald (2012) empirically shows that both asset market frictions and trade costs significantly impede countries' consumption risk sharing. Reyes-Heroles (2016) incorporates Ricardian comparative advantages à la Eaton and Kortum (2002) and Caliendo and Parro (2015) into a multicountry general equilibrium model. Blaum (2018) studies firms' export behavior during large exchange rate depreciation episodes using a partial equilibrium model. Dekle et al. (2015) incorporate firm dynamics into general equilibrium model to study the comovement of firm-level exports and RERs. Antràs and Caballero (2009) study trade flows, capital flows, and financial frictions together in the classical Heckscher-Ohlin-Mundell paradigm. More recently, Ebrahimian and Firooz (2020) develop a general equilibrium model of international trade to study the relationship between financial frictions and gains from trade. My contribution to this literature is twofold. First, I provide some partial equilibrium predictions regarding the effect of exchange rate fluctuations on firm-level export behavior. Second, I conduct various quantitative exercises to study the general equilibrium implications of a Melitz (2003) type of trade structure combined with trade finance constraints.

This paper can also speak to the accounting of the trade collapse in 2009 when world trade dropped by 10%. The literature attributes the collapse to several factors including the disintegration of international vertical supply chains, increased protectionism, and negative shocks to the efficiency of investment in durables. Especially since the trade collapse was preceded by a financial crisis, several papers, including Amiti and Weinstein (2011) and Chor and Manova (2012), attribute it to tightening trade credit. However, Bems et al. (2013) and Eaton et al. (2016) conclude that trade finance and protectionism did not play a critical role in the collapse. This paper largely supports their conclusion by showing that the aggregate effect of trade finance friction is not significant in general equilibrium.

Last, recent work by Leibovici (2021) studies the effect of financial frictions on trade in general equilibrium. Using a multi-industry general equilibrium model of international trade with input-output linkages and financial frictions, he finds that financial development leads to a substantial reallocation of international trade shares from labor- to capital-intensive industries in steady state, while its effect at the aggregate level is minor. Although both Leibovici (2021) and this paper study the general equilibrium implication of financial friction on trade, there is a clear distinction between the two. While Leibovici (2021) focuses on the reallocation of international trade across different sectors, I focus on the effect of financial frictions on the extensive margin and the average productivity of exporters within an industry. I also investigate how the dispersion of firm productivity affects such channels and how the wage adjustment in general equilibrium dampens the role of financial frictions. Moreover, I study the role of trade finance frictions in determining the responses of macro variables to aggregate productivity or exchange rate shocks at a business cycle frequency, which is absent in Leibovici (2021). These two papers are complementary in the sense that with different settings and distinctive mechanisms, they both find a consistent result that the effect of financial frictions at the aggregate level is not as significant as at the micro level.

3 Model

The model economy is a small open economy with a representative household and a continuum of heterogeneous firms. The economy consists of two sectors: tradable and non-tradable sectors. In the non-tradable sector, a homogeneous good exists, and for simplicity, I assume the economy is endowed with Y^N amount of it every period. In the tradable sector, a continuum of monopolistically competitive firms produces differentiated goods. Hereinafter, foreign variables are denoted with an asterisk superscript.

3.1 Household

3.1.1 Preferences

Household preferences follow a nested constant elasticity of substitution structure. The final consumption bundle C_t is a composite of the tradable goods bundle and the non-tradable good and is defined as

$$C_t \equiv \left[\omega {C_t^T}^{\frac{\eta-1}{\eta}} + (1-\omega){C_t^N}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}, \tag{1}$$

where C_t^T and C_t^N denote the tradable goods bundle and the non-tradable good respectively. η is the elasticity of substitution between the tradable goods bundle and non-tradable good, and ω captures the weight on the tradable goods. In turn, tradable bundle C_t^T consists of imported tradable bundle $C_{I,t}^T$ and domestically produced tradable bundle $C_{D,t}^T$, following

$$C_t^T \equiv \left[{C_{D,t}^T}^{\frac{\xi-1}{\xi}} + {C_{I,t}^T}^{\frac{\xi-1}{\xi}}\right]^{\frac{\xi}{\xi-1}}. \tag{2}$$

ξ is the elasticity of substitution between the imported tradable goods and domestically produced tradable goods. Finally, the domestically produced tradable bundle is composed of a continuum of differentiated goods as

$$C_{D,t}^T \equiv \left[\int_{i \in \Omega_t} q_{D,t}(i)^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}}, \tag{3}$$

where Ω_t is the set of domestic goods available in period t and σ is the elasticity of substitution between varieties. By the CES property, price indices of the final consumption bundle (P_t), tradable bundle (P_t^T), and domestically produced tradable goods ($P_{D,t}^T$) can be defined as follows:

$$P_t \equiv \left[\omega^\eta {P_t^T}^{1-\eta} + (1-\omega)^\eta {P_t^N}^{1-\eta} \right]^{\frac{1}{1-\eta}}, \tag{4}$$

$$P_t^T \equiv \left[{P_{D,t}^T}^{1-\xi} + {P_{I,t}^T}^{1-\xi} \right]^{\frac{1}{1-\xi}}, \tag{5}$$

$$P_{D,t}^T \equiv \left[\int_{i \in \Omega_t} p_{D,t}(i)^{1-\sigma} di \right]^{\frac{1}{1-\sigma}}. \tag{6}$$

P_t^N denotes the price of the homogenous non-tradable good, $p_{D,t}$ is the price of each domestically produced variety, and $P_{I,t}^T$ denotes the price of the imported tradable bundle. All prices are denominated in some common accounting unit. I assume $P_{I,t}^T = 1$ so that the imported tradable bundle is the numeraire. Demand for each domestic variety and imported tradable bundle is given as[1]

$$q_{D,t}(i) = \omega^\eta \left(\frac{p_{D,t}(i)}{P_t} \right)^{-\sigma} \left(\frac{P_t^T}{P_t} \right)^{\xi-\eta} \left(\frac{P_{D,t}^T}{P_t} \right)^{\sigma-\xi} C_t, \tag{7}$$

$$C_{I,t}^T = \omega^\eta \left(\frac{P_t^T}{P_t} \right)^{\xi-\eta} \left(\frac{P_{I,t}^T}{P_t} \right)^{-\xi} C_t.$$

[1] Since foreign variables are given exogenously, it is enough to focus on the imported tradable bundle $C_{I,t}^T$ rather than each variety in it.

Meanwhile, demand for the non-tradable good is given as

$$C_t^N = (1-\omega)^\eta \left(\frac{P_t^N}{P_t}\right)^{-\eta} C_t.$$

3.1.2 Intertemporal problem

A representative household endowed with labor L in each period faces the following intertemporal problem. A household can trade two kinds of assets. First, it can invest in an internationally traded risk-free bond that promises one unit of the tradable bundle next period. Second, it can trade shares of the home country's mutual funds that consist of domestic firms. The mutual fund pays the average profits of domestic firms as dividends. Then, it chooses consumption C_t, bond holdings B_{t+1}, and share of mutual funds $x_t \in [0,1]$ to maximize its lifetime utility according to

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{{C_t}^{1-\gamma}}{1-\gamma},$$

subject to the budget constraint

$$\begin{aligned} &P_t C_t + P_t^T B_{t+1} + \frac{\nu}{2} P_t^T B_{t+1}^2 + \tilde{v}_t (M_{D,t} + M_{E,t}) x_{t+1} \\ &= W_t L + P_t^N Y^N + (1 + r_t^*) P_t^T B_t + (\tilde{v}_t + \tilde{\pi}_t) M_{D,t} x_t + T_t. \end{aligned} \tag{8}$$

$\beta \in (0,1)$ is the discount factor, and γ is the coefficient of relative risk aversion. Note that all terms containing B_t are multiplied by the tradable goods price index P_t^T since the risk-free bond promises one unit of internationally traded tradable bundles. The interest rate r_t^* is exogenous from the perspective of the small open economy household. $\tilde{v}_t$ is the price of the mutual fund, and $\tilde{\pi}_t$ is the dividend. $M_{D,t}$ is the mass of domestic firms, which is also equal to the mass of the mutual fund in the economy at period t. $M_{E,t}$ is the mass of newly entering firms. The household spends its income on consumption, bond investment, and mutual fund investment. $\frac{\nu}{2} P_t^T B_{t+1}^2$ is the adjustment cost of bond holdings and helps pin down the steady state level of bond holdings in equilibrium.[2] The household draws income from the labor supply, the non-tradable good endowment, bond investments, and mutual fund investments. Last, T_t is a transfer of resources collected from the household's payment of the bond adjustment cost. T_t is equal to $\frac{\nu}{2} P_t^T B_{t+1}^2$ in equilibrium but it is not internalized by the household. Note that once C_t is retrieved from the intertemporal problem, choosing the consumption level of each variety and non-tradable good boils down to a purely static problem. Also, since the mutual fund shares are only traded domestically, $x_t = 1$ in equilibrium.

The household's fist order conditions give the following Euler equations for bond and mutual fund shares:

$$1 + \nu B_{t+1} = \beta \mathbb{E}_t \left[\frac{P_t}{P_{t+1}} \frac{P_{t+1}^T}{P_t^T} \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} (1 + r_{t+1}^*) \right], \tag{9}$$

$$\tilde{v}_t = \beta(1 - \psi) \mathbb{E}_t \left[\frac{P_t}{P_{t+1}} \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} (\tilde{v}_{t+1} + \tilde{\pi}_{t+1}) \right]. \tag{10}$$

3.2 Firms

3.2.1 Technology and pricing

A firm i's production technology in period t is given as

$$q_t(i) = A_t a_i l,$$

where A_t is period t aggregate productivity of the home country and a_i is firm i's time-invariant productivity drawn from a distribution $G(a)$ with support on $[a_{min}, \infty)$. l denotes the labor input. Since each firm produces a differentiated variety, I hereinafter drop the i subscript and express a variety in terms of productivity a following convention.

[2] See Schmitt-Grohé and Uribe (2003) for a detailed discussion about the adjustment cost and how to close a small open economy model.

Note that a firm's production is subject to both its own productivity and home country's aggregate productivity. Cost minimization implies that the cost of producing one unit of a variety is given as $\frac{W_t}{A_t a}$, where W_t is the wage rate. For simplicity, I assume there is no fixed cost for domestic production. However, export entails two additional types of costs. The first one is iceberg transportation cost: to deliver one unit of good to destinations, a firm should transport $\tau > 1$ units of it. The second one is fixed costs F_X that the firm pays every period, which is measured in effective units of labor. However, fraction $\mu \in [0, 1]$ of F_X should be paid in foreign labor ($\mu \frac{F_X}{A_t^*}$), while fraction $1 - \mu$ should be paid in domestic labor ($(1-\mu)\frac{F_X}{A_t}$). This formulation of fixed costs follows Chaney (2016)[3] and under this total costs of domestic sales ($TC_{a,D,t}$) and exports ($TC_{a,X,t}$) of a firm with productivity a are

$$
\begin{aligned}
TC_{a,D,t}(q_D) &= \frac{W_t}{A_t a} q_D, \\
TC_{a,X,t}(q_X) &= \frac{W_t}{A_t a} \tau q_X + (1-\mu)\frac{W_t}{A_t} F_X + \mu \frac{W_t^*}{A_t^*} F_X,
\end{aligned}
$$

where W_t^* is the foreign wage rate. Note that fixed costs also depends on countries' productivity, which follows Ghironi and Melitz (2005) and Fattal Jaef and Lopez (2014).

Under monopolistic competition, a firm sets its domestic and export prices according to

$$
\begin{aligned}
p_{D,t}(a) &= \frac{\sigma}{\sigma - 1} \frac{W_t}{A_t a}, \\
p_{X,t}(a) &= \frac{\sigma}{\sigma - 1} \frac{\tau W_t}{A_t a}.
\end{aligned}
$$

Subscripts D and X indicate domestic sales and exports respectively. Profits from a firm's

[3] Goldberg and Campa (2010) suggest that between 50% and 70% of the cost of entering foreign markets is denominated in foreign currency.

domestic sales and export with productivity a are then given as

$$\pi_{D,t}(a) = \frac{1}{\sigma} p_{D,t}(a) q_{D,t}(a)$$
$$\pi_{X,t}(a) = \frac{1}{\sigma} p_{X,t}(a) q_{X,t}(a) - (1-\mu)\frac{W_t}{A_t} F_X - \mu \frac{W_t^*}{A_t^*} F_X.$$

$q_{D,t}(a)$ is given as equation (7). Similarly, foreign demand for home country products $q_{X,t}(a)$ is given as

$$q_{X,t}(a) = \omega^{\eta} \left(\frac{p_{X,t}(a)}{P_t^*}\right)^{-\sigma} \left(\frac{P_t^{T*}}{P_t^*}\right)^{\xi-\eta} \left(\frac{P_{I,t}^{T*}}{P_t^*}\right)^{\sigma-\xi} C_t^*. \tag{11}$$

3.2.2 Trade finance frictions

Without any other frictions, all firms with $\pi_{X,t}(a) \geq 0$ export. Equivalently, all firms whose productivity is higher than a certain threshold export. This is a typical feature in Melitz (2003) type of international trade models. However, in practice, firms engaging in international trade often face some financial constraint as they should rely on external capital to fund large upfront fixed costs. Compared to domestically operating firms, exporters are likely to face especially more stringent capital constraint for several reasons. First, entering foreign markets requires additional upfront fixed costs that include conducting market research, localizing products, and acquiring local distribution networks. Second, cross-border shipping usually takes longer than domestic shipping, worsening exporters' working capital needs. Finally, international trade is often associated with higher risks due to exchange rate fluctuations. For a more detailed summary on trade finance frictions, see Foley and Manova (2015).

To model trade finance frictions in a tractable manner, I assume that exporting firms should pay fixed costs in advance and this should be entirely financed using external capital from international lenders. Also, this should be paid back with firms' export revenue.[4] In

[4] Chaney (2016), in a partial equilibrium model, assumes that upfront fixed costs are financed with a firm's domestic profits rather than export profits and shows that financially constrained firms exist under some condition. By alternatively assuming the latter, as in this paper, one can easily guarantee the existence of financially constrained firms without imposing additional assumptions that might not hold in general

addition, the model abstracts from the role of firms' net worth or accumulation of internal capital in either paying for the fixed costs or providing collateral. To borrow money, firms should pledge their export profits as collateral. However, they can divert part of their export revenue when they have to repay the borrowed money, leading to a pledgeability problem. To be specific, firms can divert fraction $1 - \kappa$ of their revenue, and therefore international lenders are willing to lend only up to κ fraction of a firm's revenue. Thus, $\kappa \in (0, 1]$ indicates the degree of financial development (or law enforcement) of a country. Such an interpretation of financial frictions is in line with Mendoza et al. (2009). It implies the following financial constraint:

$$\kappa r_{X,t}(a) \geq (1-\mu)\frac{W_t}{A_t}F_X + \mu\frac{W_t^*}{A_t^*}F_X,$$

where $r_{X,t}(a)$ denotes the export revenue of a firm with productivity a.[5] Equivalently, the constraint can be rewritten as

$$\pi_{X,t}(a) \geq \frac{1-\kappa}{\kappa}\left[(1-\mu)\frac{W_t}{A_t}F_X + \mu\frac{W_t^*}{A_t^*}F_X\right]. \tag{12}$$

This constraint means that only firms with high enough productivity and export profits can export. If $\kappa = 1$, firms cannot divert their revenue at all and the model collapses to classic Melitz (2003)-type models where financial frictions are absent. If $\kappa < 1$, some fairly productive firms cannot export due to financial constraint, although they could make positive profits from exporting. As κ gets closer to zero, the number of non-exporters that would export in a frictionless economy increases. Note that firms satisfying the following condition export in an economy without financial frictions:

$$\pi_{X,t}(a) \geq 0. \tag{13}$$

equilibrium.

[5] For simplicity, I assume that the interest rate on the borrowing from the international investors is negligible and it doesn't appear in the financial constraint. Since it is exogenous from the perspective of domestic firms, this assumption doesn't affect the main results in a qualitatively significant way.

(12) and (13) lead to two productivity cutoffs implicitly defined as

$$\pi_{X,t}(\bar{a}_{X,t}) = 0, \tag{14}$$

$$\pi_{X,t}(\bar{a}_{\kappa,t}) = \frac{1-\kappa}{\kappa}\left[(1-\mu)\frac{W_t}{A_t}F_X + \mu\frac{W_t^*}{A_t^*}F_X\right]. \tag{15}$$

It is straightforward that $\bar{a}_{X,t} \leq \bar{a}_{\kappa,t}$, and these cutoffs classify firms into three categories. First, firms with productivity $a \in [a_{min}, \bar{a}_{X,t})$ are not productive enough to export and operate only domestically. Second, firms with $a \in [\bar{a}_{X,t}, \bar{a}_{\kappa,t})$ are productive enough to make positive export profits, but they are financially constrained and therefore cannot export. Finally, firms with $a \in [\bar{a}_{\kappa,t}, \infty)$ export. Note that if $\kappa = 1$, $\bar{a}_{X,t} = \bar{a}_{\kappa,t}$ and there are no financially constrained firms.

3.2.3 Entry, exit, and ownership

Entry and exit are modeled à la Melitz (2003). In terms of modeling the ownership of firms, Ghironi and Melitz (2005) and Fattal Jaef and Lopez (2014) are the closest to this paper. In each period, there is an infinite mass of potential entrants. To enter the market, an entering firm should pay sunk entry cost F_E in units of effective labor ($\frac{F_E}{A_t}$). Once a firm enters, it draws its productivity from distribution $G(a)$ with support on $[a_{min}, \infty)$ and decides whether to produce only domestically or export as well. Note that even if a firm is willing to export, financial constraints might prevent it from doing so.

Moreover, since there is no fixed cost associated with domestic sales, all entrants operate at least domestically. Firms also face an exogenous exit risk with probability ψ at the end of every period. For tractability, I assume that there is a one-period time-to-build lag, so entrants at period t start operating at period $t+1$. Prospective entrants are forward-looking and form expectations on their future income flows. They enter as long as the expected present value of entry $\tilde{v}_t$ is not less than the sunk entry cost. Hence, entry occurs until the following free entry condition holds:

$$\tilde{v}_t = \frac{W_t}{A_t} F_E. \tag{16}$$

Here, $\tilde{v}_t$ is defined as

$$\tilde{v}_t = \mathbb{E}_t \sum_{s=0}^{\infty} [\beta(1-\psi)]^s \frac{P_t}{P_{t+s}} \frac{U_C(C_{t+s})}{U_C(C_t)} \tilde{\pi}_{t+s}. \tag{17}$$

It is the sum of the average firm's profit conditional on entry, $\tilde{\pi}_{t+s}$, discounted by exogenous exit risk and household's stochastic discount factor $\beta^s \frac{P_t}{P_{t+s}} \frac{U_C(C_{t+s})}{U_C(C_t)}$. Note that the expected present value of potential entrants is equal to the average value of existing firms. This is because all firms produce domestically since there is no fixed cost associated with domestic sales. The free entry condition pins down the mass of new entrants $M_{E,t}$ in each period. By the time-to-build lag assumption, the mass of domestic firms $M_{D,t}$ evolves following

$$M_{D,t+1} = (1-\psi)(M_{D,t} + M_{E,t}). \tag{18}$$

In addition, the mass of exporters $M_{X,t}$ is given as

$$M_{X,t} = (1 - G(\bar{a}_{\kappa,t}))M_{D,t}. \tag{19}$$

Firms are owned by a mutual fund that pays the average total profits $\tilde{\pi}_t$ as dividends. Households then trade shares of this mutual fund (x_t) at a price $\tilde{v}_t$. By iterating forward the mutual fund Euler equation from the household's problem and using the law of iterated expectation, one can obtain the potential market entrants' average expected value of entering the market in equation (17).[6]

[6]See Appendix A.1 for the derivation.

3.2.4 Productivity distribution and aggregation

Following Ghironi and Melitz (2005), I assume firm productivity a follows a Pareto distribution with lower bound a_{min} and shape parameter $\alpha > \sigma - 1$: $G(a) = 1 - \left(\frac{a_{min}}{a}\right)^{\alpha}$. α controls the dispersion of productivity draws, and as it increases, productivity draws become less dispersed and more concentrated toward the lower end a_{min}. In the extreme, the density at a_{min} converges to 1 as $\alpha \to \infty$. Meanwhile, it is convenient to define $\theta \equiv \left[\frac{\alpha}{\alpha-(\sigma-1)}\right]^{\frac{1}{\sigma-1}}$ for aggregation.

As it is typical in Melitz (2003)-type models, aggregation can be done easily by only focusing on the *average* firm without the onerous task of keeping track of each firm. For this purpose, define the average productivity of all domestic firms $\tilde{a}_D$ and that of exporters $\tilde{a}_{X,t}$ as

$$\tilde{a}_D \equiv \left[\int_{a_{min}}^{\infty} a^{\sigma-1} dG(a)\right]^{\frac{1}{\sigma-1}}, \tag{20}$$

$$\tilde{a}_{X,t} \equiv \left[\frac{1}{1-G(\bar{a}_{\kappa,t})} \int_{\bar{a}_{\kappa,t}}^{\infty} a^{\sigma-1} dG(a)\right]^{\frac{1}{\sigma-1}}. \tag{21}$$

Because there is no fixed cost for domestic sales, firms with any productivity produces domestically, so $\tilde{a}_D$ is time invariant. On the contrary, the average productivity of exporters varies over time as the export cutoff $\bar{a}_{\kappa,t}$ changes. Using the definition of θ, these can be simplified as $\tilde{a}_D = \theta a_{min}$ and $\tilde{a}_{X,t} = \theta \bar{a}_{\kappa,t}$. In turn, the average profits from domestic sales and exporters are defined as

$$\tilde{\pi}_{D,t} \equiv \pi_{D,t}(\tilde{a}_D),$$

$$\tilde{\pi}_{X,t} \equiv \pi_{X,t}(\tilde{a}_{X,t}).$$

Then, since $1 - G(\bar{a}_{\kappa,t})$ fraction of firms export, the average total profit of firms $\tilde{\pi}_t$ is given as

$$\tilde{\pi}_t = \tilde{\pi}_{D,t} + (1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t}. \tag{22}$$

This corresponds to the average total profit that the mutual fund pays as dividends. The average domestic price and export price can be defined similarly as $\tilde{p}_{D,t} \equiv p_{D,t}(\tilde{a}_D)$ and $\tilde{p}_{X,t} \equiv p_{X,t}(\tilde{a}_{X,t})$. Then, price indices for domestically produced tradable goods and exported goods can be simplified as

$$P_{D,t}^T = M_{D,t}^{\frac{1}{1-\sigma}} \tilde{p}_{D,t}, \tag{23}$$

$$P_{X,t}^T \equiv \left[\frac{1}{1-G(\bar{a}_{\kappa,t})} \int_{\bar{a}_{\kappa,t}}^{\infty} p_{X,t}(a)^{1-\sigma} M_{X,t} dG(a) \right]^{\frac{1}{1-\sigma}} = M_{X,t}^{\frac{1}{1-\sigma}} \tilde{p}_{X,t}. \tag{24}$$

3.3 Small open economy monopolistically competitive equilibrium

The price of the non-tradable good P_t^N is determined by the non-tradable good market clearing condition:

$$(1-\omega)^\eta \left(\frac{P_t^N}{P_t} \right)^{-\eta} C_t = Y^N. \tag{25}$$

The labor market clearing condition pins down the wage rate according to:

$$L = M_{D,t} \frac{q_{D,t}(\tilde{a}_D)}{A_t \tilde{a}_D} + M_{E,t} \frac{F_E}{A_t} + M_{X,t} \left(\frac{\tau q_{X,t}(\tilde{a}_{X,t})}{A_t \tilde{a}_{X,t}} + (1-\mu) \frac{F_X}{A_t} \right). \tag{26}$$

The first term of the right-hand side is the amount of labor used for producing domestically consumed goods. The second term corresponds to the entry cost of new entrants. The last two terms indicate the variable labor input and the domestic labor component of the fixed export costs used by exporters.

In addition, for quantitative exercises in later sections, I define as follows some aggregate variables: export X_t, import I_t, net export NX_t, capital account CA_t, and gross domestic product GDP_t:[7]

$$X_t \equiv \frac{1}{1-G(\bar{a}_{\kappa,t})} \int_{\bar{a}_{\kappa,t}}^{\infty} p_{X,t}(a) q_{X,t}(a) M_{X,t} dG(a),$$

[7] Note that in my model, NX_t is not exactly equal to CA_t since some amount of resources goes to foreign agents in the form of fixed export cost payments. Hence, $NX_t = CA_t + M_{X,t}\mu \frac{W_t^*}{A_t^*} F_X$. Alternatively, I can define $NX_t \equiv X_t - I_t - M_{X,t}\mu \frac{W_t^*}{A_t^*} F_X$ to have $NX_t = CA_t$.

$$I_t \equiv P^T_{I,t} C^T_{I,t},$$

$$NX_t \equiv X_t - I_t,$$

$$CA_t \equiv P^T_t B_{t+1} - (1 + r^*_t) P^T_t B_t,$$

$$GDP_t \equiv P_t C_t + NX_t.$$

A small open economy monopolistically competitive equilibrium is defined as follows.

Definition (*Monopolistically competitive equilibrium*)**.** *a*) prices P_t, P^T_t, P^N_t, $P^T_{D,t}$, $p_{D,t}$, and $p_{X,t}$; *b*) wage rate W_t; *c*) consumption C_t, C^T_t, C^N_t, $C^T_{D,t}$, $C^T_{I,t}$, $q_{D,t}$, and $q_{I,t}$; *d*) bond holdings B_t; *e*) mutual fund share x_t; *f*) productivity cutoffs $\bar{a}_{X,t}$ and $\bar{a}_{\kappa,t}$; *g*) average productivity $\tilde{a}_D$ and $\tilde{a}_{X,t}$; *h*) average profit $\tilde{\pi}_{D,t}$, $\tilde{\pi}_{X,t}$, and $\tilde{\pi}_t$; *i*) value of mutual fund $\tilde{v}_t$; and *j*) mass of firms $M_{D,t}$, $M_{X,t}$, and $M_{E,t}$ such that 1) a follows the definition of prices indices and the pricing rules of firms; 2) c, d, and e solve the household problem given a, b, h, i, and j; 3) c satisfies the definition of composite consumption; 4) f satisfies the definition of productivity cutoffs given a, b, and c; 5) g is defined by equation (20) and (21) given f; 6) h and i satisfy households' Euler equation for mutual funds given a and c; 7) a and j satisfy the free entry condition given b; 8) j evolves following equation (18) and (19); and 9) a and b clear markets given c and j.

4 Partial Equilibrium Implications

Before moving on to the quantitative analysis, it is useful to look analytically at some of the partial equilibrium implications.

4.1 Export cutoffs and the RER

In this subsection, I first look at how exchange rate depreciation affects the extensive margin of exports. Recall that the export cutoff $\bar{a}_{\kappa,t}$ is determined by the trade finance constraint cutoff condition, according to equation (15). For ease of notation, let's define the remaining part of export demand as $q_{X,t}^{rem} \equiv \omega^{\eta} \left(\frac{P_t^{T*}}{P_t^*}\right)^{\xi-\eta} \left(\frac{P_{I,t}^{T\ *}}{P_t^*}\right)^{\sigma-\xi} P_t^* C_t^*$ so that $q_{X,t} = p_{X,t}(a)^{-\sigma} P_t^{*\sigma-1} q_{X,t}^{rem}$ and $q_{X,t}^{rem}$ is exogenous. I further assume that $q_{X,t}^{rem}$ is constant.[8] Also, let $\mathcal{F}_t \equiv (1-\mu)\frac{W_t}{A_t}F_X + \mu\frac{W_t^*}{A_t^*}F_X$, and let $w_t \equiv \frac{W_t}{P_t}$ and $w_t^* \equiv \frac{W_t^*}{P_t^*}$ denote the wage rates denominated in units of the final consumption bundle in home and foreign countries. Then, the export cutoff $\bar{a}_{\kappa,t}$ is obtained as

$$\bar{a}_{\kappa,t} = \left(\frac{\sigma\mathcal{F}_t}{q_{X,t,}^{rem}}\frac{1}{\kappa}\right)^{\frac{1}{\sigma-1}} \frac{\sigma}{\sigma-1}\frac{\tau w_t}{A_t}\frac{P_t}{P_t^*}. \tag{27}$$

Define the RER as $e_t \equiv \frac{P_t^*}{P_t}$. An increase in RER corresponds to exchange rate depreciation. In the following, I first look at the effect of an increase in P_t and P_t^* separately and then the effect of an increase in e_t (RER depreciation).

First, given A_t, A_t^*, w_t, w_t^*, and P_t^*, the partial derivative of the export cutoff with respect to P_t is given as

$$\frac{\partial\bar{a}_{\kappa,t}}{\partial P_t} = \frac{\bar{a}_{\kappa,t}}{P_t}\left[1 + \frac{1}{\sigma-1}\frac{(1-\mu)\frac{P_t w_t}{A_t}}{(1-\mu)\frac{P_t w_t}{A_t} + \mu\frac{P_t^* w_t^*}{A_t^*}}\right] > 0. \tag{28}$$

The first term in the brackets corresponds to the the traditional price competitiveness effect through the marginal cost of production. The second term arises from the increased burden of fixed costs. Both channels negatively affect the profitability of exporters and increase the export cutoff. The size of the second term is increasing in the domestic input share of the fixed cost. Also, note that $\bar{a}_{\kappa,t} = \left(\frac{\sigma\mathcal{F}_t}{q_{X,t,}^{rem}}\frac{1}{\kappa}\right)^{\frac{1}{\sigma-1}} \frac{\sigma}{\sigma-1}\frac{\tau w_t}{A_t}\frac{P_t}{P_t^*}$. A fall in κ, which implies a less-developed financial market, amplifies the effect of changes in P_t on $\bar{a}_{\kappa,t}$.

Next, given A_t, A_t^*, w_t, w_t^*, and P_t, the partial derivative of the export cutoff with respect

[8] This formulation of $q_{X,t}^{rem}$ is similar to that in Demidova and Rodríguez-Clare (2009) and Demidova and Rodriguez-Clare (2013). However, I also assume that P_t^{T*}, $P_{I,t}^{T\ *}$, and C_t^* proportionally adjust so that $q_{X,t}^{rem}$ is constant regardless of P_t^*. On the contrary, $p_{X,t}(a)$ does not automatically change in proportion to P_t^* to offset its effect on $q_{X,t}$. This can be justified under the small open economy assumption that domestic firms cannot affect price indices in foreign countries. This assumption allows a tractable analytical analysis on the effect of changes in P_t^* on the domestic variables.

to P_t^* is given as

$$\frac{\partial \bar{a}_{\kappa,t}}{\partial P_t^*} = \frac{\bar{a}_{\kappa,t}}{P_t^*}\left[-1 + \frac{1}{\sigma-1}\frac{\mu\frac{P_t^* w_t^*}{A_t^*}}{(1-\mu)\frac{P_t w_t}{A_t} + \mu\frac{P_t^* w_t^*}{A_t^*}}\right]. \tag{29}$$

Similarly to the P_t case, the first term in the brackets is the traditional price competitiveness effect. In this case, its sign is negative since an increase in the foreign price means an increased price competitiveness of domestic products. However, the sign of the second term, which is the effect through the fixed cost, is positive because some fraction (μ) of the fixed cost should be paid in foreign labor and a higher P_t^* increases the burden of it. The size of this effect depends on the foreign share of the fixed cost μ, and as long as $\mu > 0$, it has a negative effect on the profitability of an exporter. As a result, unlike $\frac{\partial \bar{a}_{\kappa,t}}{\partial P_t}$, the sign of $\frac{\partial \bar{a}_{\kappa,t}}{\partial P_t^*}$ is ambiguous and depends on the relative strength of the two channels. Again, a lower κ amplifies the magnitude of the overall effect, but it does not affect the sign.

Now, consider a more general case where the RER (e_t) changes. Given A_t, A_t^*, w_t, and w_t^*, the derivative of the export cutoff with respect to the RER is given as

$$\frac{\partial \bar{a}_{\kappa,t}}{\partial e_t} = \frac{\bar{a}_{\kappa,t}}{e_t}\left[-2 + \frac{P_t}{\sigma-1}\frac{F_X}{\mathcal{F}_t}\left(-(1-\mu)\frac{w_t}{A_t} + \mu\frac{w_r^*}{A_t^*}e_t\right)\right]. \tag{30}$$

It can be rewritten as[9]

$$\begin{aligned}\frac{\partial \bar{a}_{X\kappa,t}}{\partial e_t} = \frac{\sigma}{\sigma-1}\frac{\tau w_t}{A_t}\left(\frac{\sigma\mathcal{F}_t}{q_{X,t}^{rem}}\right)^{\frac{1}{\sigma-1}}\left(\frac{1}{\kappa}\right)^{\frac{1}{\sigma-1}}\frac{1}{e_t^2}\Bigg[&\underbrace{-2}_{\text{price competitiveness effect}} \\ &+\underbrace{\frac{P_t}{\sigma-1}\frac{F_X}{\mathcal{F}_t}\left(-(1-\mu)\frac{w_t}{A_t} + \mu\frac{w_r^*}{A_t^*}e_t\right)}_{\text{fixed cost valuation effect}}\Bigg].\end{aligned} \tag{31}$$

The effect of RER depreciation can be decomposed into two components. The first term inside the brackets corresponds to the classic price competitiveness effect of currency depreciation. RER depreciation increases home country exporters' price competitiveness abroad and lets

[9]For the derivation, see Appendix A.1.

less productive firms start exporting, thereby decreasing the export cutoff. The second term is the fixed cost valuation effect, and it arises since the export fixed cost consists of both home country and foreign country labor. Note that if foreign labor does not enter the export fixed cost ($\mu = 0$), only the price competitiveness effect is present and RER depreciation surely leads to a decrease in the export cutoff. If the share of foreign labor cost is large enough, RER depreciation can lead to a heavier fixed cost burden, which has a tightening effect on the trade finance constraint. The sign of the overall effect depends on the relative strength of the two channels. Moreover, a lower degree of financial development κ amplifies the magnitude of the overall effect. The results are summarized in the following proposition.[10]

Proposition 4.1. Given A_t, A_t^*, w_t^*, and w_t^*,

1. if $\mu \leq \frac{\frac{w_t}{A_t}}{\frac{w_t}{A_t}+e_t\frac{w_t^*}{A_t^*}}$, $\frac{\partial \bar{a}_{\kappa,t}}{\partial e_t} < 0$;

2. if $\mu > \frac{\frac{w_t}{A_t}}{\frac{w_t}{A_t}+e_t\frac{w_t^*}{A_t^*}}$, an increase in e_t has a positive fixed cost valuation effect on $\bar{a}_{\kappa,t}$, and the sign of $\frac{\partial \bar{a}_{\kappa,t}}{\partial e_t}$ is ambiguous;

3. and a lower κ increases $|\frac{\partial \bar{a}_{\kappa,t}}{\partial e_t}|$ but does not affect the sign of $\frac{\partial \bar{a}_{\kappa,t}}{\partial e_t}$.

Intuitively, if the foreign input share of the fixed cost is small, the traditional price competitiveness effect of RER depreciation dominates and an exporter's profitability will increase. In contrast, if the foreign share is large enough, the overall effect of RER depreciation will depend on the relative strength of the price competitiveness channel and the fixed cost valuation channel. In addition, lower financial development amplifies these effects.

[10] In the model of Chaney (2016), there are two productivity cutoffs, and only either the price competitiveness effect or the fixed cost valuation effect appears in each cutoff. In my model, there is only one export cutoff, and the two effects both affect the same cutoff.

4.2 Export cutoff and production cost

Now consider how the export cutoff responds to the domestic wage given A_t, A_t^*, P_t, P_t^*, and w_t^*. The partial derivative of export cutoff with respect to the real wage is given as

$$\frac{\partial \bar{a}_{\kappa,t}}{\partial w_t} = \frac{\bar{a}_{\kappa,t}}{w_t}\left[1 + \frac{1}{\sigma - 1}\frac{(1-\mu)\frac{P_t w_t}{A_t}}{(1-\mu)\frac{P_t w_t}{A_t} + \mu\frac{P_t^* w_t^*}{A_t^*}}\right] > 0. \tag{32}$$

Note that an increase in w_t has a similar price competitiveness effect and fixed cost effect to those of P_t. Intuitively, this is because a change in the production cost w_t is directly translated into a change in the price P_t. For a similar reason, a change in the foreign wage w_t^* has a similar effect on the domestic export cutoff to that of P_t^*. Moreover, lower κ has a similar amplifying effect without affecting the sign. Also, the response of the cutoff to a change in W_t can be easily obtained as $\frac{\partial \bar{a}_{\kappa,t}}{\partial W_t} = \frac{\partial \bar{a}_{\kappa,t}}{\partial w_t} = \frac{\partial \bar{a}_{\kappa,t}}{\partial w_t}\frac{1}{P_t}$.

Meanwhile, given P_t, P_t^*, w_t, and w_t^*, an increase in the aggregate productivity A_t lowers the production cost, and the export cutoff falls according to

$$\frac{\partial \bar{a}_{\kappa,t}}{\partial A_t} = -\frac{\bar{a}_{\kappa,t}}{A_t}\left[1 + \frac{1}{\sigma - 1}\frac{(1-\mu)\frac{P_t w_t}{A_t}}{(1-\mu)\frac{P_t w_t}{A_t} + \mu\frac{P_t^* w_t^*}{A_t^*}}\right] < 0. \tag{33}$$

4.3 Export cutoff, extensive margin, and average export profit

The extensive margin of exports in the economy is given as $M_{D,t}(1 - G(\bar{a}_{\kappa,t}))$, where $M_{D,t}$ is the mass of firms and G is the productivity distribution's cumulative distribution function. Given $M_{D,t}$, an increase in the export cutoff leads to a fall in the extensive margin of exports as

$$\frac{\partial(1 - G(\bar{a}_{\kappa,t}))}{\partial \bar{a}_{\kappa,t}} = -\alpha\left(\frac{1}{\bar{a}_{\kappa,t}}\right)^{\alpha+1} < 0.$$

In addition, given A_t, A_t^*, P_t, P_t^*, w_t, and w_t^*, the average export profit of exporters $\tilde{\pi}_{X,t}$

responds to an increase in the export cutoff according to

$$\frac{\partial \tilde{\pi}_{X,t}}{\partial \bar{a}_{\kappa,t}} = \frac{\sigma-1}{\sigma} \left(\frac{p_X(\tilde{a}_{X,t})}{P_t^*} \right)^{1-\sigma} \frac{q_{X,t}^{rem}}{\bar{a}_{\kappa,t}} > 0. \tag{34}$$

4.4 General equilibrium implications

In this section, I analytically showed how the export cutoff responds to a change in P_t, P_t^*, e_t, w_t or A_t; how the responses depend on the degree of financial development κ; and how the extensive margin of exports and the average export profit respond to a change in the export cutoff in partial equilibrium where other variables are held fixed. However, in general equilibrium, P_t, e_t, and w_t are all equilibrium outcomes and interact with each other. For example, in partial equilibrium, an increase in A_t lowers the cutoff, while an increase in W_t increases the cutoff. If an increase in A_t leads to an increase in W_t, the response of the export cutoff would be determined by the relative strength of the two competing forces in general equilibrium. Hence, it is a quantitative question of how the exports, and ultimately other macro variables including consumption and saving, respond to exogenous shocks in A_t or P_t^* in general equilibrium, and how the responses interact with financial development.

5 Quantitative Analysis

In this section, I quantitatively solve the model to analyze impulse responses of the economy to an aggregate productivity shock. I compare the responses depending on the degree of financial development and then investigate the role of the wage adjustment in general equilibrium.

5.1 Calibration

One period in the model represents a quarter, and the parameter values for the baseline analysis are summarized in Table 1. Regarding preferences, I choose standard values for the discount factor (β) of 0.98 and the coefficient of risk aversion (γ) of 2. I choose the weight on tradable goods (ω) of 0.5 to match the steady state tradable goods share of 50%, following Lombardo and Ravenna (2012). I also take standard values for elasticities of substitution from the literature. I set the elasticity of substitution between tradable goods and non-tradable goods (η) to 0.83, which is a conservative value, following Bianchi (2011). The elasticity of substitution between domestically produced goods and imported goods (ξ) is set to 1.5 as in Fattal Jaef and Lopez (2014). Finally, I choose the elasticity of substitution between varieties (σ) of 6, which is consistent with the estimate of Broda and Weinstein (2006) and implies a 20% markup. The bond adjustment cost ν is set to 0.02 to target the bond holdings to GDP of 10% in steady state following Aguiar and Gopinath (2007).

For the productivity distribution, I normalize the minimum productivity (a_{min}) to 1 without loss of generality. I also choose the shape parameter (α) of 5.6, following Bernard et al. (2003) and Ghironi and Melitz (2005), which targets the standard deviation of log US plant sales of 1.67. Iceberg trade costs (τ) of 1.3 is taken from Ghironi and Melitz (2005) and is in line with Obstfeld and Rogoff (2000). The export fixed cost F_X is set to 0.005 to match the proportion of exporters of 21%, as reported by Bernard et al. (2003), jointly with other foreign variables. I choose the foreign labor share of the export fixed cost μ of 0.6, which is the median of the estimates (50%-70%) of Goldberg and Campa (2010). Entry cost F_E is normalized to 1 without loss of generality, and the exogenous death rate ψ of 0.025 targets 10% of job destruction per year in US data following Ghironi and Melitz (2005). I set the degree of financial development (κ) to 1 in the baseline as a benchmark, and I set κ to an extreme value of 0.1 to see how the degree of financial development affects an economy. Home country labor endowment (L) and non-tradable endowment Y^N are normalized to 1 and 10, respectively, in the baseline. Foreign variables are chosen to match the proportion of exporters of 21% jointly with the export fixed cost.

Regarding the stochastic process of the aggregate productivity A_t, I assume the following

Table 1: Baseline parameter values

Parameters	Values	Targets/Sources
Preferences	$\beta = 0.98$, $\gamma = 2$, $\omega = 0.5$	standard, 50% tradable share
Elasticity of substitution	$\eta = 0.83$, $\xi = 1.5$, $\sigma = 6$	standard, 20% mark-up
Bond adjustment costs	$\nu = 0.012$	10% bond to GDP
Productivity distribution	$a_{min} = 1$, $\alpha = 5.6$	1.67 std. dev. log sales of US firms
Exporting costs	$\tau = 1.3$, $F_X = 0.0032$, $\mu = 0.6$	standard, 21% proportion of exporters
Entry cost and exit probability	$F_E = 1$, $\psi = 0.025$	10% annual destruction rate
Financial constraint	$\kappa = 1$	baseline value
Home country endowments	$L = 1$, $Y^N = 10$	baseline values
Interest rates	$r^* = 0.04$	standard
Foreign variables	$P^* = 1$, $W^* = 10$, $A^* = 1$, $q_X^{rem} = 5$	21% proportion of exporters
Stochastic process	$\rho_A = 0.906$, $\sigma_A = 0.00852$	Backus et al. (1992)

AR(1) process:

$$A_{t+1} = A_t^{\rho_A} \exp^{\epsilon_{t+1}},$$

where ϵ_t is white noise with standard deviation σ_A. I take $\rho_A = 0.906$ and $\sigma_A = 0.00852$ from Backus et al. (1992).

5.2 Impulse response functions

To compute the impulse responses to an exogenous shock, I use linear approximation based on Klein (2000). Figure 1 shows the percentage deviations from steady state of endogenous variables to a 1% increase in home country aggregate productivity A_t under the baseline specification with $\kappa = 1$. The shock brings about non-monotonic dynamics over time. On impact, production cost falls due to an increase in productivity. This leads to a decrease in the price indices for domestically produced tradable goods (P_D^T) and exported goods (P_X^T) by as much as 0.1%.

Since the exported goods from home countries become more price competitive abroad, exports (X) increase by 0.5% at its peak. At the same time, as the profitability of entering the market and exporting increases, more firms enter the market and also begin to export.

The mass of new entrants (M_E) increases by almost 9% and as a result, the mass of domestic firms and exporters also increases. Meanwhile, the average profit from domestic sales ($\tilde{\pi}_D$) increases by 0.4% due to higher productivity. On the contrary, the response of the average export profit ($\tilde{\pi}_X$) is moderate. This is because the positive effect of a positive productivity shock is partially offset by a decrease in the average productivity of exporters due to a lower export cutoff ($\bar{a}_\kappa$). In turn, the average profit of domestic firms ($\tilde{\pi}$) that is composed of the average profit from domestic sales and exports increases by 0.2% from steady state.

On the household side, consumption increases since it gets higher income from the mutual fund, which pays the total profit of domestic firms as dividends. As demand for the non-tradable good increases while its supply is fixed, the price of non-tradable goods (P^N) increases by 0.5%, which also drives up the home country price index (P) by more than 0.2%. In addition, the wage rate W rises by 1% due to a higher demand for labor. Bond holdings (B) decrease since the increase in imports outweighs that in exports at first. As time passes, however, exports exceed imports and therefore bond holdings increase by roughly 1.2% above its steady state at the peak.

Moreover, the sign of the responses of average profits is reversed after roughly five quarters. This can be understood in two ways. First, the positive aggregate productivity shock decays faster than the rise in the wage rate W, leading to higher production costs that in turn drive down the average profit. Second, it can also be thought of in terms of household budget constraints. As time passes, households accumulate bonds above the steady state level and accrue interest income. At the same time, they also receive higher labor income. On the contrary, the increase in consumption expenditure is relatively moderate. For the budget constraint to hold, dividend income from the mutual fund, which is the average profit of domestic firms, should decrease.

Figure 1: Responses to an A shock of 1% ($\kappa = 1$)

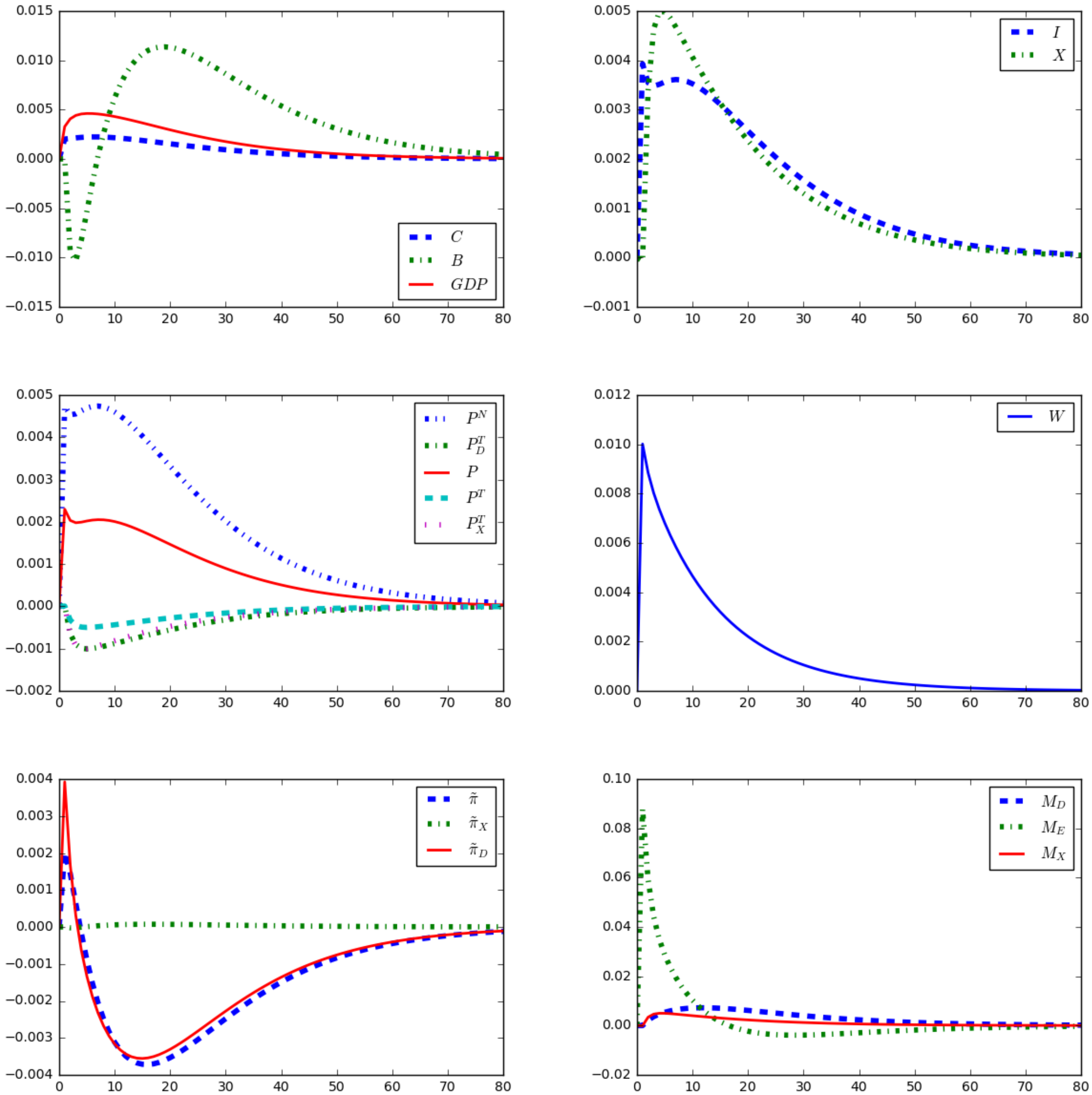


Figure 2 shows the impulse responses in a similar exercise but now with $\kappa = 0.1$. All other parameters are as in the baseline. Surprisingly, all the responses are almost identical to the baseline, not only qualitatively but also quantitatively. To further illustrate the role of financial development κ, Table 2 compares steady state values when $\kappa = 1$ and $\kappa = 0.1$. It is noteworthy that except for the average export profit $\tilde{\pi}_X$, the export cutoff $\bar{a}_\kappa$, and

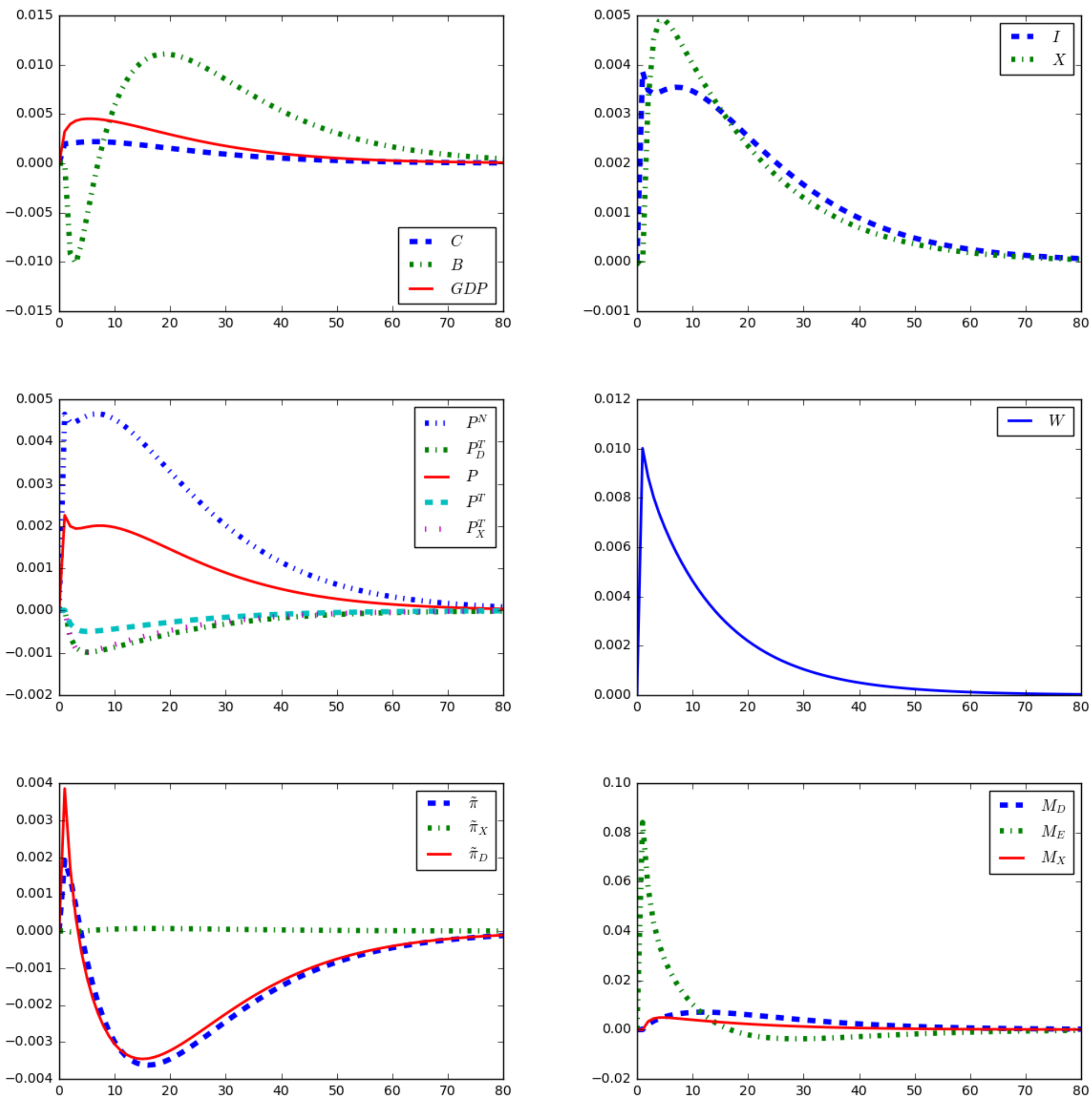
Table 2: Steady state values

Variables	Steady state values ($\kappa = 1$)	Steady state values ($\kappa = 0.1$)
Macro variables	$C = 8.62$, $C^T = 7.47$, $B = 1.6$, $I = 0.95$, $X = 0.95$, $GDP = 3.69$	$C = 8.60$, $C^T = 7.42$, $B = 1.6$, $I = 0.92$, $X = 0.91$, $GDP = 3.57$
Prices	$P = 0.42$, $P^N = 0.18$, $P^T = 0.25$, $W = 1.75$	$P = 0.42$, $P^N = 0.17$, $P^T = 0.25$, $W = 1.7$
Firm (average)	$\tilde{v} = 1.75$, $\tilde{\pi} = 0.08$	$\tilde{v} = 1.70$, $\tilde{\pi} = 0.08$
Firm (domestic)	$\tilde{\pi}_D = 0.04$, $M_D = 3.67$	$\tilde{\pi}_D = 0.04$, $M_D = 3.85$
Firm (exporter)	$\tilde{\pi}_X = 0.17$, $\tilde{a}_X = 2.05$, $1 - G(\bar{a}_\kappa) = 0.21$	$\tilde{\pi}_X = 1.98$, $\tilde{a}_X = 3.15$, $1 - G(\bar{a}_\kappa) = 0.02$

the proportion of exporters $1 - G(\bar{a}_\kappa)$, all the other variables do not show stark differences depending on the degree of financial development. However, the average export profit is more than ten times greater when $\kappa = 1$ than when $\kappa = 0.1$, and the proportion of exporters is more than ten times greater when $\kappa = 0.1$ than when $\kappa = 1$.

It is also helpful to look at the deviation from steady state in level deviations rather than percentage changes. Figures A.1 and A.2 present the deviation from steady state in level deviations in response to a one-unit increase in aggregate productivity A when $\kappa = 1$ and $\kappa = 0.1$, respectively. In this case, the unit of responses is meaningless, and the responses cannot be interpreted in the same way as in Figures 1 and 2. However, it can still provide some useful insight about the insensitivity of macro variables to financial development. Even in level deviations, the responses of all variables are nearly invariant to κ except for the average export profit $\tilde{\pi}_X$ and the mass of exporters M_X. The average export profit responds more when $\kappa = 0.1$, while the mass of exporters responds more when $\kappa = 1$. This, together with the comparison of steady state values, suggests that trade finance frictions affect the average profit of exports and the extensive margin of exports but it does not have a significant impact on the economy at the aggregate level. In the next subsection, I delve into how the effect of lower financial development is nullified in aggregate.

Figure 2: Responses to an A shock of 1% ($\kappa = 0.1$)



5.3 Intensive margin, extensive margin, and selection effect

In this subsection, I investigate how the total export profit $(1 - G(\bar{a}_\kappa))\tilde{\pi}_X$ responds to a productivity shock to understand the insensitivity of aggregate outcomes to financial development. For convenience, I denote the total export profit by $\tilde{\Pi}_X$. As a first step, I argue that it is enough to focus on the behavior of $\tilde{\Pi}_X$ in order to study the role of financial development. Note that κ first affects the export cutoff $\bar{a}_\kappa$ through the trade finance constraint condition. Then, the proportion of exporters $1 - G(\bar{a}_\kappa)$, the average productivity of exporters $\tilde{a}_X$, and the average export profit $\tilde{\pi}_X \equiv \pi_X(\tilde{a}_X)$ are determined. In turn, these affect the average profit of domestic firms through $\tilde{\pi} = \tilde{\pi}_D + (1 - G(\bar{a}_\kappa))\tilde{\pi}_X = \tilde{\pi}_D + \tilde{\Pi}_X$.

Note that this equation is the only equilibrium condition where the proportion of exporters and the average export profit appear. They also enter the equation in a multiplied form of $\tilde{\Pi}_X \equiv (1 - G(\bar{a}_\kappa))\tilde{\pi}_X$. Therefore, to understand the first-order effect of κ on the aggregate economy, it is crucial and sufficient to investigate $\tilde{\Pi}_X$ rather than $1 - G(\bar{a}_\kappa)$ and $\tilde{\pi}_X$ separately. The indirect effects of κ through interacting with other outcomes in general equilibrium are discussed in following subsections. Panel (d) of Figure 3 shows the response (level deviations from steady state divided by steady state GDP) of the total export profit $\tilde{\Pi}_X$ to a 1% increase in A with different values of κ. At first, $\tilde{\Pi}_X$ increases above its steady state by as much as 0.001% of steady state GDP,[11] and the responses of $\tilde{\Pi}_X$ with both values of κ evolve almost identically. Moreover, the steady state values of $\tilde{\Pi}_X$ are also very similar when $\kappa = 1$ (0.0387) and when $\kappa = 0.1$ (0.0389). These findings imply that the level of $\tilde{\Pi}_X$ evolves almost identically regardless of κ, which is why κ does not have a significant effect on the economy at the aggregate level.

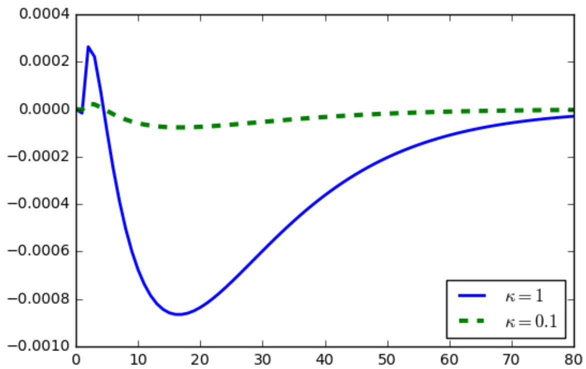
Now, I look more closely into how financial development affects the total export profit. For this, it is helpful to decompose the response of $\tilde{\Pi}_X$ to a productivity shock given the wage W into three components as follows:

[11] Since the steady state value of GDP is almost the same when $\kappa = 1$ and $\kappa = 0.1$, as shown in Table 2, the response in panel (d) can also be viewed as a level deviation of $\tilde{\Pi}_X$ from the steady state. Normalization by steady state GDP is just for economic interpretation.

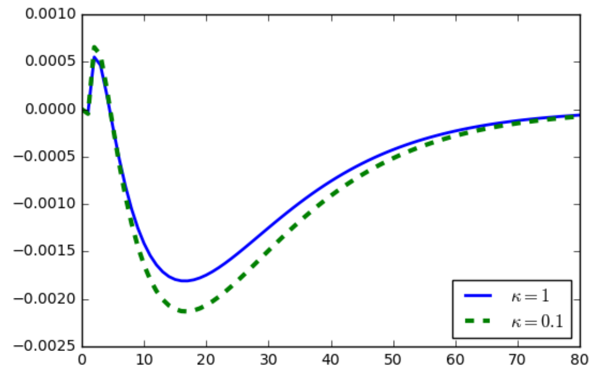
$$
\begin{aligned}
\frac{\partial \tilde{\Pi}_X}{\partial A} = \; & \underbrace{-g(\bar{a}_\kappa)\tilde{\pi}_X \frac{\partial \bar{a}_\kappa}{\partial A}}_{\text{Extensive margin, >0}} \\
& + \underbrace{(1 - G(\bar{a}_\kappa)) \left[\frac{\sigma - 1}{\sigma} \left(\frac{p_X(\tilde{a}_X)}{P^*} \right)^{1-\sigma} \frac{q_X^{rem}}{A} + (1 - \mu) \frac{W F_X}{A^2} \right]}_{\text{Intensive margin, >0}} \\
& + \underbrace{(1 - G(\bar{a}_\kappa)) \left[\frac{\sigma - 1}{\sigma} \left(\frac{p_X(\tilde{a}_X)}{P^*} \right)^{1-\sigma} \frac{q_X^{rem}}{\tilde{a}_X} \frac{\partial \tilde{a}_X}{\partial A} \right]}_{\text{Selection effect, <0}} . \qquad (35)
\end{aligned}
$$

The first term is the effect on the extensive margin through the change in the export cutoff. Given W, a positive A shock increases the extensive margin of exports. The second term is the response of the intensive margin of a firm with productivity $\tilde{a}_X$. Given W, the intensive margin of the firm increases due to higher productivity. The last term corresponds to the selection effect, which captures the change in the average productivity of exporters. As the export cutoff decreases in response to an increase in A, the average productivity of exporters also decreases.

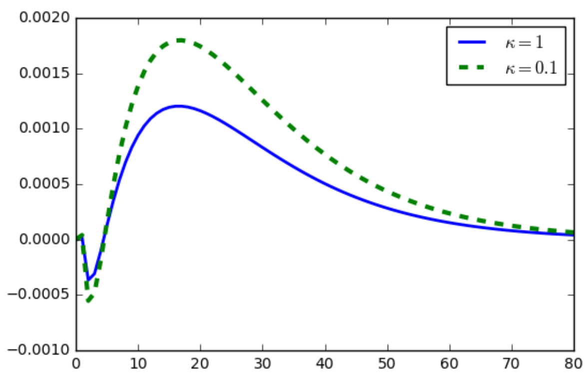
Figure 3: Responses of extensive margin, intensive margin, and selection ($\alpha = 5.6$)



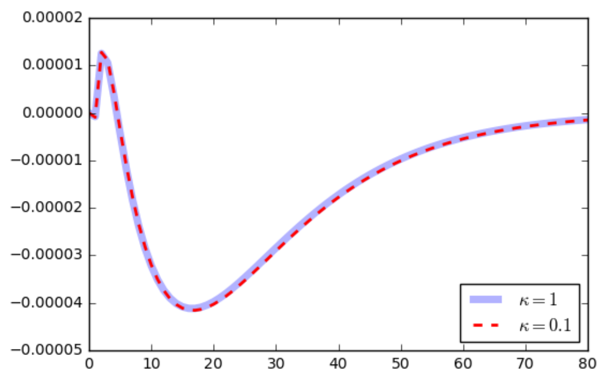
(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$



(c) Selection $(\tilde{a}_{X,t})$



(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{\kappa,t})$

Figure 3 presents the responses of the extensive margin $(1 - G(\bar{a}_\kappa))$, intensive margin $(\pi_X(\tilde{a}_X^{ss}))$, selection effect $(\tilde{a}_X)$, and total export profit $\tilde{\Pi}_X$ to a 1% increase in A. For economic interpretation, the responses of the intensive margin and the total export profit are calculated as the level deviation from steady state divided by steady state GDP. That of the selection effect is the level deviation divided by the average productivity of all firms $(\frac{\alpha}{\alpha-1})$. The response of the extensive margin is simply the level deviation from its steady state.

In panel (a), on impact, the proportion of exporters increases by roughly 0.02 %pt above its steady state when $\kappa = 1$, while the response when $\kappa = 0.1$ is much more subdued. Overall, the extensive margin of exports is much more responsive when $\kappa = 1$ than when

$\kappa = 0.1$. In panel (b), the intensive margin is calculated as the profit of a firm with steady state average export productivity when $\kappa = 0.1$, which I denote by $\tilde{a}_X^{ss}$.[12] When $\kappa = 1$, the intensive margin increases by as much as 0.05% of steady state GDP after roughly three quarters, and when $\kappa = 0.1$, the intensive margin responds slightly more sensitively. In panel (c), when $\kappa = 0.1$, the average productivity of exporters decreases by more than 0.05% of the average productivity of domestic firms. Throughout time horizons, the selection effect responds more sensitively when $\kappa = 0.1$ than when $\kappa = 1$. Last, in panel (d), the evolution of the total export profit does not show meaningful differences depending on κ as mentioned before.

To summarize, Figure 3 shows that the extensive margin responds to a productivity shock more sensitively when $\kappa = 1$, while the selection effect responds less sensitively when $\kappa = 1$. Since the steady state value of the extensive margin is greater when $\kappa = 1$ and that of the average productivity of export is greater when $\kappa = 0.1$, the different sensitivity in their responses implies that the extensive margin effect and the selection effect offset each other to make the response of $\tilde{\Pi}_X$ insensitive to κ. Together with the comparison of steady state, this suggests that both the steady state value of $\tilde{\Pi}_X$ and the evolution of its level is quantitatively invariant to changes in κ.

There are three things to bear in mind with these results. First, throughout the paper, I emphasize the extensive margin channel and then selection channel more than the intensive margin channel. I do this because the first two channels are ones where κ directly affects the economy through an adjustment in the export cutoff $\bar{a}_\kappa$. On the contrary, the intensive margin channel can be regarded as a second-order effect in the sense that it operates only through general equilibrium.

Second, the responses in Figure 3 are general equilibrium outcomes, unlike equation (35). In the decomposition of equation (35), I hold the wage constant for analytical convenience, but in general equilibrium, the wage also responds, which generates a second-order effect

[12] It is innocuous to use $\tilde{a}_X^{ss}$ since it is above the export cutoff $\bar{a}_{\kappa,t}$ over all time horizons after the shock.

on $\tilde{\Pi}_X$. This is why in Figure 3 the responses are not monotonic, and even the signs are reversed over time. The general equilibrium effect through the wage is discussed in Section 5.5. Last, but most important, I mainly focus on the responses of the three channels and the total export profit in *level* deviations rather than their percentage deviations from steady state. This is because the insensitivity of aggregate outcomes to κ arises from the fact that the level of $\tilde{\Pi}_X$ is quantitatively insensitive to κ while those of the extensive margin and the average productivity are very sensitive to κ as shown in this subsection and the comparison of steady state values in the previous subsection.

In contrast, percentage deviations from steady state are less helpful in understanding the role of financial development. For example, A.3 presents the responses of the three channels expressed in percentage deviations. In all panels, the responses are invariant to κ, but this is simply because steady state values are also dependent on κ. This is why in Figure 3 the responses are normalized by steady state GDP or average firm productivity rather than expressed as percentage deviations from steady state, and the normalization is purely for economic interpretation. But for other variables, I express the responses in percentage deviations from steady state following convention as in Figures 1 and 2. In the following subsection, I study why the level of the extensive margin, intensive margin, and selection effect responds differentially to financial development κ and relate it to the distribution of firm productivity.

5.4 Financial development and productivity dispersion

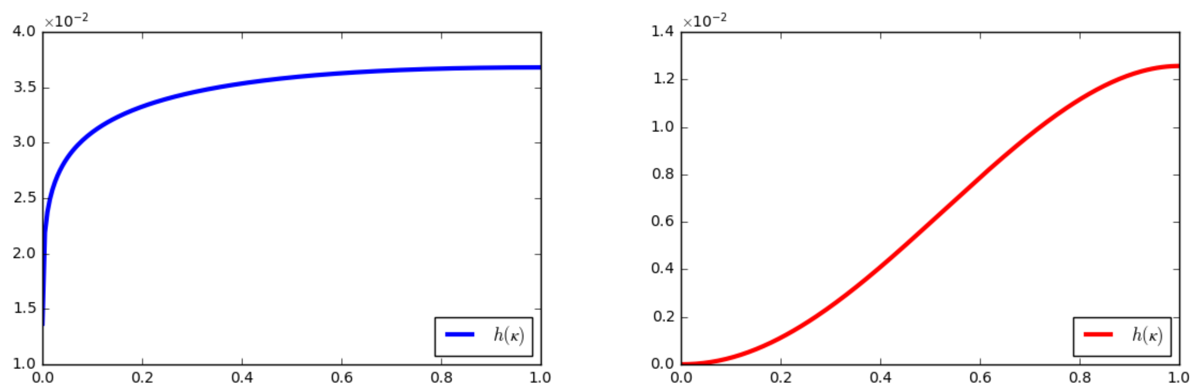
In this subsection I demonstrate, in two ways, that how κ affects the aggregate economy through $\tilde{\Pi}_X$ is closely related to the distribution of firm productivity. I first study how the level of $\tilde{\Pi}_X$ depends on κ given A and W, varying the dispersion of firm productivity. This exercise helps one to understand the effect of κ on the steady state values. I then study how κ affects the response of $\tilde{\Pi}_X$ to an A shock depending on the dispersion of firm productivity through the lens of the decomposition in equation (35). This helps one to understand the patterns in impulse responses shown in Figure 3.

First, I investigate why the level of $(1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t}$ is insensitive to κ in the baseline. For convenience, define $h(\kappa;\Theta) \equiv (1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t}$, where Θ is the set of A_t, W_t, and other model parameters. h simply redefines $(1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t}$ as a function of κ given other parameter values and endogenous variables. Similarly, define $h_{EM}(\kappa;\Theta) \equiv 1 - G(\bar{a}_{\kappa,t})$ and $h_{SE}(\kappa;\Theta) \equiv \tilde{\pi}_{X,t}$. The EM and SE subscripts indicate the extensive margin and selection effect.[13] For ease of notation, I omit Θ. Then, $h(\kappa)$ can be rearranged as

$$h(\kappa) = \left(\frac{\sigma}{\sigma-1}\frac{\tau W_t}{A_t}\right)^{-\alpha} \mathcal{F}_t \left(\frac{\sigma \mathcal{F}_t}{q_X^{rem} P_t^{*\sigma-1}}\right)^{-\frac{\alpha}{\sigma-1}} \left[\theta^{\sigma-1}\kappa^{\frac{\alpha-(\sigma-1)}{\sigma-1}} - \kappa^{\frac{\alpha}{\sigma-1}}\right], \tag{36}$$

where $\theta \equiv \left[\frac{\alpha}{\alpha-(\sigma-1)}\right]^{\frac{1}{\sigma-1}}$ and $\mathcal{F}_t \equiv [(1-\mu)\frac{W}{A} + \mu\frac{W^*}{A^*}]F_X$ as defined before. It is obvious that the shape of $h(\kappa)$ is mostly affected by the Pareto parameter α and the elasticity of substitution between varieties σ that constitute the exponents of κs. For comparison, Figure 4 compares $h(\kappa)$ with different values of α for a given σ.

Figure 4: $h(\kappa)$ with different α



(a) $\alpha = 5.6$

(b) $\alpha = 15.6$

Panel (a) corresponds to the baseline where $\alpha = 5.6$, and panel (b) is drawn with $\alpha = 15.6$. The latter implies the standard deviation of log sales of 0.09, which is much less than 1.67 in

[13]For this analysis, I assume A and W are constant. Therefore, the intensive margin for a certain firm does not vary by κ. As a result, the difference in the average export profit $\tilde{\pi}_X$ arises solely from the selection channel.

the baseline. When $\alpha = 5.6$, $h(\kappa)$ is concave in κ. In contrast, when α is high, $h(\kappa)$ features an S shape. As a result, the gap between the values of h when κ is low and when it is high is greater in panel (b), where α is high.[14] To understand why the shape of h depends on α in such a way, it is useful to think of the shape of h_{EM} and h_{SE} separately. Rearrange the functions to get

$$h_{EM}(\kappa) = \left(\frac{\sigma}{\sigma-1}\frac{\tau P_t w_t}{A_t}\right)^{-\alpha}\left(\frac{\sigma \mathcal{F}_t}{q_X^{rem} P_t^{*\sigma-1}}\right)^{-\frac{\alpha}{\sigma-1}} \kappa^{\frac{\alpha}{\sigma-1}} \tag{37}$$

and

$$h_{SE}(\kappa) = -\mathcal{F}_t + \mathcal{F}_t \frac{\alpha}{\alpha-(\sigma-1)}\frac{1}{\kappa}. \tag{38}$$

The extensive margin part h_{EM} is increasing in κ since a higher κ relaxes the trade finance constraint and lets more firms export. In contrast, the average profit part h_{SE} is decreasing in κ since a higher κ and the resulting lower export productivity cutoff lowers the average productivity of exporters. Moreover, the slopes of the curves are affected by the Pareto shape parameter α. As α increases, h_{EM} becomes more convex. On the contrary, a higher α makes h_{SE} flatter. Therefore h, which is the multiplication of h_{SE} and h_{EM}, becomes less concave as α increases.

The economic intuition behind the relationship between α and the shape of h_{EM} and h_{SE} is as follows. Consider some value of financial development κ_0 close to zero and the corresponding export cutoff $\bar{a}_{\kappa,0}$ as a starting point. Suppose that κ_0 slightly increases to κ_1. This leads to a decrease in the export cutoff to $\bar{a}_{\kappa,1}$. Then, firms with productivity $a \in (\bar{a}_{\kappa,1}, \bar{a}_{\kappa,0})$ would start to export. Denote the mass of new exporters by $M_{X,1}^{new}$, and repeat this to get a sequence $\{M_{X,n}^{new}\}_{n=1}^{\infty}$. Now, recall that as α increases, the dispersion of productivity ($\frac{\alpha}{(\alpha-1)^2(\alpha-2)}$) decreases and firms are more concentrated near the lower end a_{min}.

[14] Panel (a) is drawn with the steady state values of P and w under the baseline calibration, and panel (b) is drawn with those under alternative calibration where $\nu = 0.02$, $F_X = 0.0175$, and $\alpha = 15.6$. The adjustment of the parameters in the latter is done to match the baseline targets with the new value of α=15.6. Note that the explanation here is partial to the extent that the plots are drawn with fixed values of A and W, while in general equilibrium κ also affects them. This then affects the scale of h function; however, the shape of it is mostly governed by α in κ's exponents.

Then, if α is very high, the increase in $M_{X,n}^{new}$'s is very small at first, near $\kappa = 0$. As κ and n increase, the export productivity cutoff gets closer to a_{min}, where firms are concentrated. As a result, the mass of new exporters grows faster, making h_{EM} function more convex.

Next, I look into the intuition for the shape of h_{SE}. It is the average productivity of exporting firms. Consider some productivity cutoff $\bar{a}_\kappa^*$. As α increases, firms are more concentrated near $\bar{a}_\kappa^*$ in the region $[\bar{a}_X^*, \infty)$, leading to lower average productivity and in turn lower average export profit. Therefore, h_{SE} gets flatter as α increases.

This explains why the steady state $\tilde{\Pi}_X$ is very similar when $\kappa = 1$ and $\kappa = 0.1$, while that of the proportion of exporters and the average productivity of exporters is very different as in Table 2. Table 3 reports steady state values depending on κ when $\alpha = 15.6$. The difference in the steady state proportion of exporters is almost 21%pt, which is greater than when $\alpha = 5.6$ in Table 2. The difference in the average productivity of exporters when $\alpha = 15.6$ is 0.26, which is as much as 24% of the average firm productivity (1.068). This is much less than 1.1 in Table 2, which is as much as 90% of the average firm productivity when $\alpha = 5.6$ (1.217). This result is consistent with the analytical analysis above. As a result, the steady state values for the other variables show more difference depending on κ relative to Table 2.[15] When α is high, an economy with better financial development and hence less trade finance frictions enjoys higher consumption, export, GDP, and wage rate relative to an economy with severe trade finance frictions. This is consistent with the traditional wisdom that financial frictions cause inefficiency and make the economy worse off.

Now, I study how the responses of the extensive margin, intensive margin, selection effect, and the total export profit to a shock depends on financial development through the lens of the decomposition in equation (35). Recall that the response of the extensive margin to a positive A shock is given as $-g(\bar{a}_\kappa)\tilde{\pi}_X \frac{\partial \bar{a}_\kappa}{\partial A}$. Its magnitude depends on the density at the

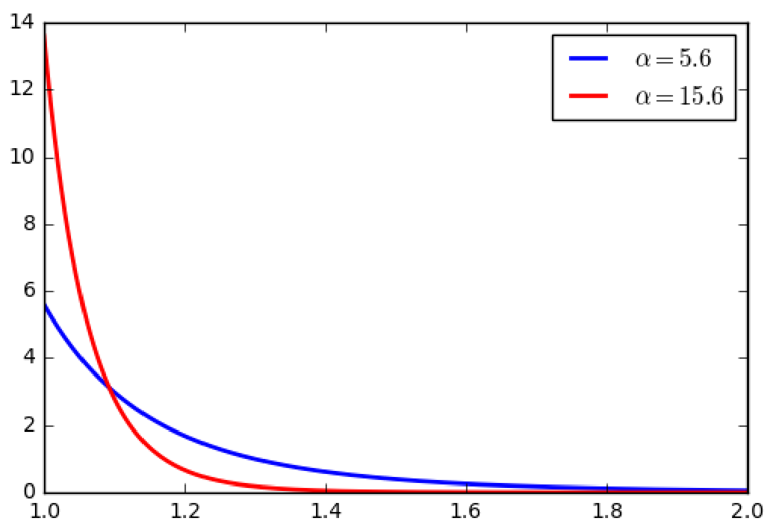
[15] Rigorously speaking, the results in Table 3 are general equilibrium outcomes, while the analytical analysis on $h(\kappa)$ assumes constant W. Despite this, the results corroborate that when α is high, κ may affect $\tilde{\Pi}_X$ significantly and in turn other macroeconomic outcomes.

Table 3: Steady state values

Variables	Steady state values ($\kappa = 1$)	Steady state values ($\kappa = 0.1$)
Macro variables	$C = 6.63$, $C^T = 4.54$, $B = 0.96$, $I = 0.55$, $X = 0.60$, $GDP = 2.12$	$C = 6.42$, $C^T = 4.28$, $B = 0.96$, $I = 0.40$, $X = 0.40$, $GDP = 1.61$
Prices	$P = 0.31$, $P^N = 0.09$, $P^T = 0.24$, $W = 1.04$	$P = 0.25$, $P^N = 0.07$, $P^T = 0.20$, $W = 0.81$
Firm (average)	$\tilde{v} = 1.04$, $\tilde{\pi} = 0.04$	$\tilde{v} = 0.81$, $\tilde{\pi} = 0.03$
Firm (domestic)	$\tilde{\pi}_D = 0.04$, $M_D = 2.58$	$\tilde{\pi}_D = 0.02$, $M_D = 3.76$
Firm (exporter)	$\tilde{\pi}_X = 0.05$, $\tilde{a}_X = 1.18$, $1 - G(\bar{a}_\kappa) = 0.21$	$\tilde{\pi}_X = 1.52$, $\tilde{a}_X = 1.44$, $1 - G(\bar{a}_\kappa) = 0.00$

productivity cutoff $g(\bar{a}_\kappa)$. Figure 5 plots the density of productivity $g(a)$ for two different values of α.

Figure 5: Productivity distribution $g(a)$



Suppose there are two different values of κ and their corresponding export cutoffs, and note that a lower κ leads to a higher cutoff. For two given cutoffs, the difference in the density of the cutoffs is larger when firms are more concentrated on the left. Therefore, the gap between the response of the extensive margin when $\kappa = 1$ and when $\kappa = 0.1$ is larger when α is high. Second, how the selection effect responds can be understood by looking at how the average exporter productivity changes in response to a change in the export cutoff.

The average exporter productivity is defined as $\tilde{a}_X \equiv \frac{1}{1-G(\bar{a}_\kappa)} \int_{\bar{a}_\kappa}^{\infty} adG(a)$. Then,

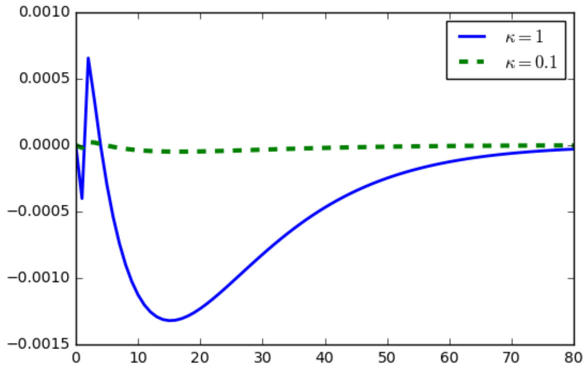
$$\begin{aligned} \frac{\partial \tilde{a}_X}{\partial \bar{a}_\kappa} &= \frac{g(\bar{a}_\kappa)}{1-G(\bar{a}_\kappa)} \left[\frac{1}{1-G(\bar{a}_\kappa)} \int_{\bar{a}_\kappa}^{\infty} adG(a) - \bar{a}_\kappa \right] \\ &= \frac{g(\bar{a}_\kappa)}{1-G(\bar{a}_\kappa)} \left[\mathbb{E}[a|a \geq \bar{a}_\kappa] - \bar{a}_\kappa \right]. \end{aligned} \tag{39}$$

If α is high, more firms are concentrated near the cutoff $\bar{a}_\kappa$. Therefore, the expectation of a conditional on $a \geq \bar{a}_\kappa$ is close to $\bar{a}_\kappa$, and the response of the average productivity becomes less sensitive to κ.

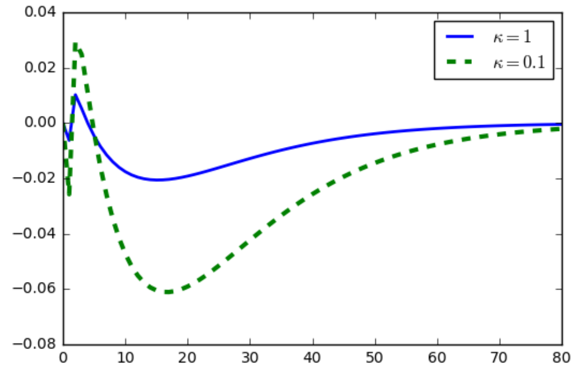
Figure 6 presents the responses of the extensive margin, intensive margin, selection effect, and total export profit when $\alpha = 15.6$. The responses are, again, in level deviations from steady state normalized as in Figure 3 rather than percentage deviations.[16] As predicted, the difference in the sensitivity of the extensive margin between $\kappa = 1$ and $\kappa = 0.1$ is larger than the baseline in Figure 3, while that of the selection effect almost disappears. As a result, the total export profit responds differentially depending on κ relative to the baseline. The lesson from the exercise is that if firms are less dispersed, the level of the total export profit $\tilde{\Pi}_X$ may vary significantly depending on the degree of financial development. When α is high, financial development affects not only the level deviations but also the percentage deviations of the three channels and the total export profit from their steady state.

[16] For the intensive margin and total export profit, it is tricky here because the steady state value of GDP is not similar when $\kappa = 1$ and $\kappa = 0.1$ as in the baseline. In Figure 6, I normalize them by steady state GDP when $\alpha = 5.6$. However, even if they are normalized by each case's steady state GDP, the key patterns remain qualitatively unchanged.

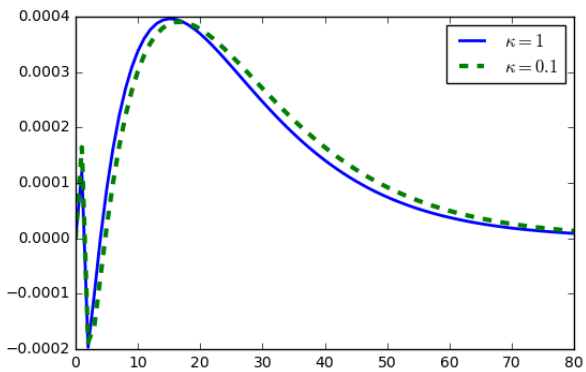
Figure 6: Responses of extensive margin, intensive margin, and selection ($\alpha = 15.6$)



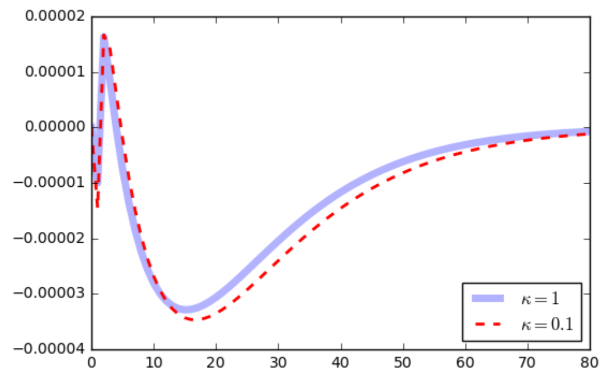
(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$



(c) Selection $(\tilde{a}_{X,t})$

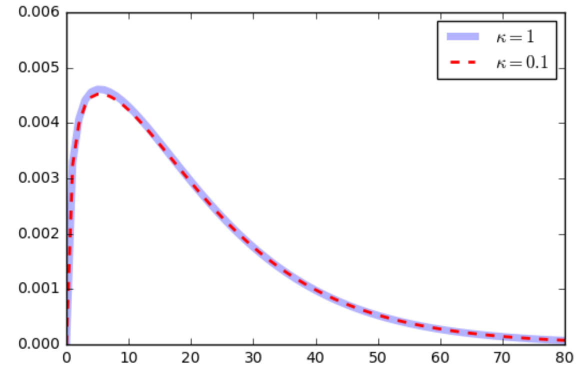


(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t})$

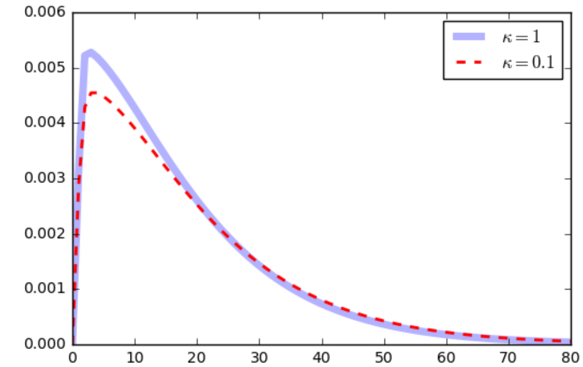
Figure A.4 presents the percentage deviations of those from steady state. It is distinct from Figure A.3 where $\alpha = 5.6$ in that the percentage deviations significantly depend on κ. Note that the selection effect is more sensitive when $\kappa = 1$ unlike in Figure 4. This is simply because the steady state value of $\tilde{a}_X$ is much lower when $\kappa = 1$. The total export profit responds more sensitively when $\kappa = 1$ since the sensitivity of the extensive margin dominates that of the selection effect. In other words, the effect of κ on the selection becomes small while that on the extensive margin becomes more significant due to less dispersion of firm productivity. Hence, the effect of κ on the total export profit is mainly driven by the extensive margin, and this higher sensitivity of $\tilde{\Pi}_X$ is translated into other macro outcomes as well.

Figure 7 compares the differential responses of some key variables depending on κ and α. The left panels are the baseline case where $\alpha = 5.6$ and the right panels are when $\alpha = 15.6$. Unlike the baseline exercise in the previous subsection, financial development affects the responses of aggregate outcomes as well, and they are more sensitive when $\kappa = 1$. However, note that the degree of financial development does not change the aggregate responses qualitatively, and even the quantitative difference is not very large. This finding is striking considering that I take fairly extreme values ($\kappa = 0.1$ and $\alpha = 13.6$) for the purpose of comparison.

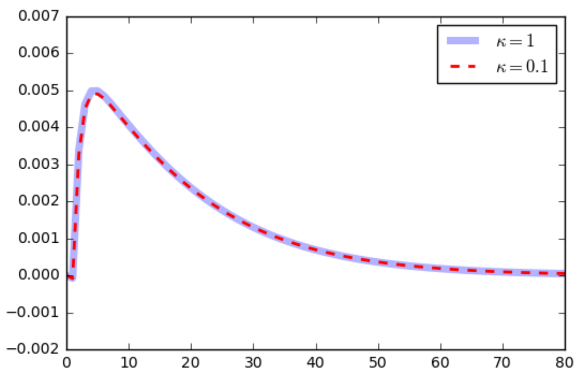
Figure 7: Impulse responses with different α and κ



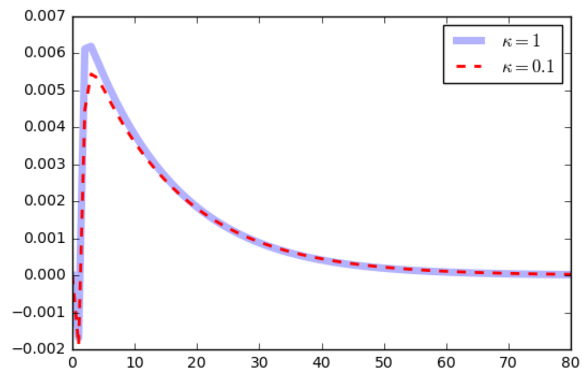
(a) GDP ($\alpha = 5.6$)



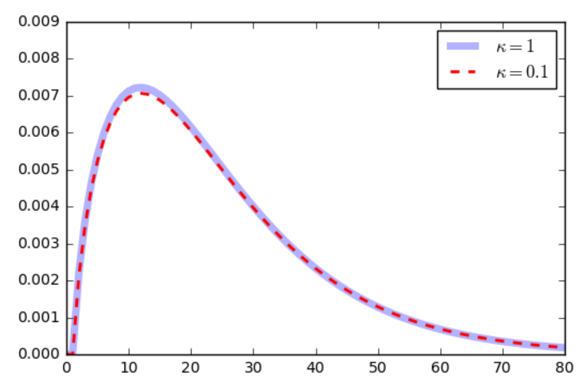
(b) GDP ($\alpha = 15.6$)



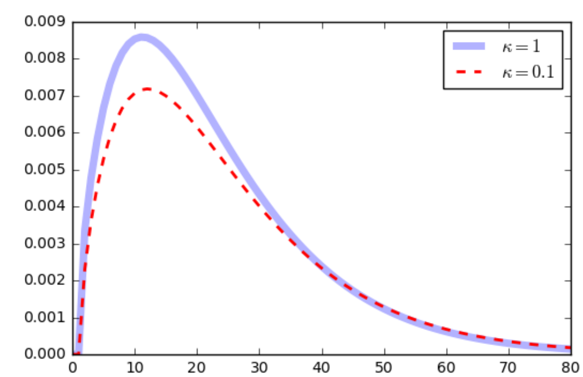
(c) X ($\alpha = 5.6$)



(d) X ($\alpha = 15.6$)

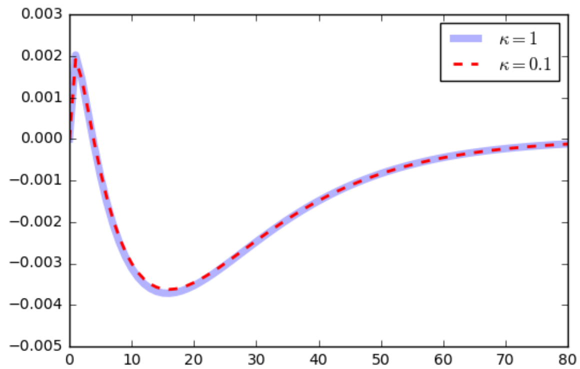


(e) M_D ($\alpha = 5.6$)

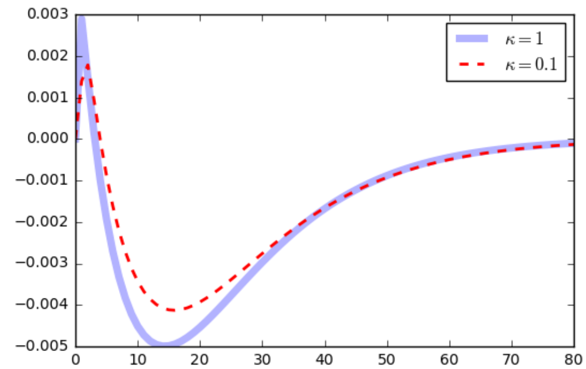


(f) M_D ($\alpha = 15.6$)

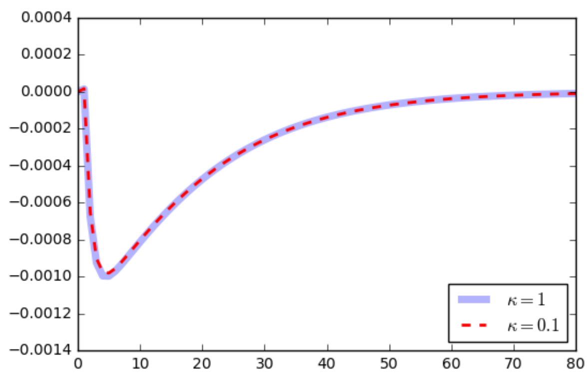
Figure 7 (continued): Impulse responses with different α and κ



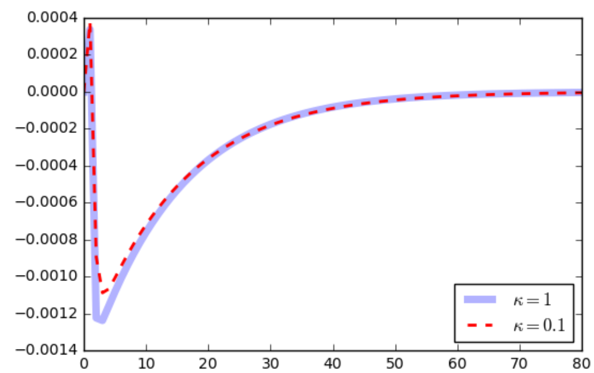
(g) $\tilde{\pi}$ $(\alpha = 5.6)$



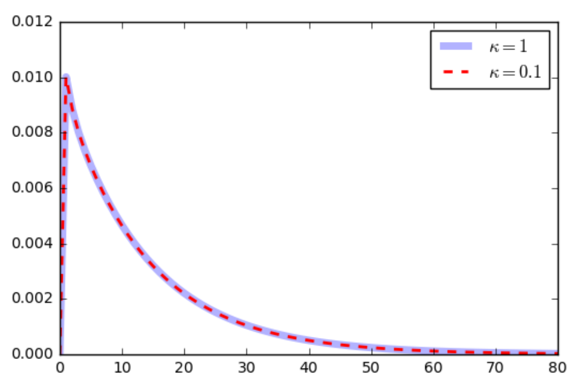
(h) $\tilde{\pi}$ $(\alpha = 15.6)$



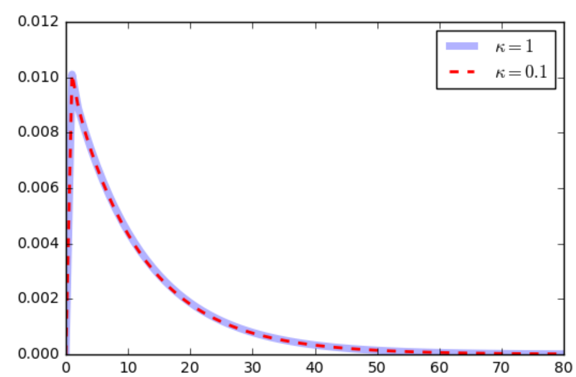
(i) P_X $(\alpha = 5.6)$



(j) P_X $(\alpha = 15.6)$



(k) W $(\alpha = 5.6)$



(l) W $(\alpha = 15.6)$

The main findings in this section can be summarized as follows. Less financial development suppresses the extensive margin of exports. However, the resulting increase in the average productivity of exporters offsets this effect in aggregate, rendering other aggregate variables insensitive to the degree of financial development. When the dispersion of firm productivity is small and firms are concentrated around low productivity, financial development may affect the aggregate economy. Nevertheless, this effect is quantitatively small with a reasonable value of dispersion. In the following subsection, I study why the difference is quantitatively tiny.

5.5 Understanding the general equilibrium effect

To further understand the role of the general equilibrium effect, I conduct an additional exercise where the wage rate W is held constant. Figures 8 and 9 present the impulse responses (percentage deviations from steady state) to a 1% positive productivity shock when W is set to be constant at the steady state level of the baseline specification. For this, the labor market clearing condition is dropped in the definition of a monopolistically competitive equilibrium. Figure 8 shows what happens when $\kappa = 1$, and Figure 9 shows the results when $\kappa = 0.1$.

Figure 8: Responses to an A shock of 1% with constant W ($\kappa = 1$)

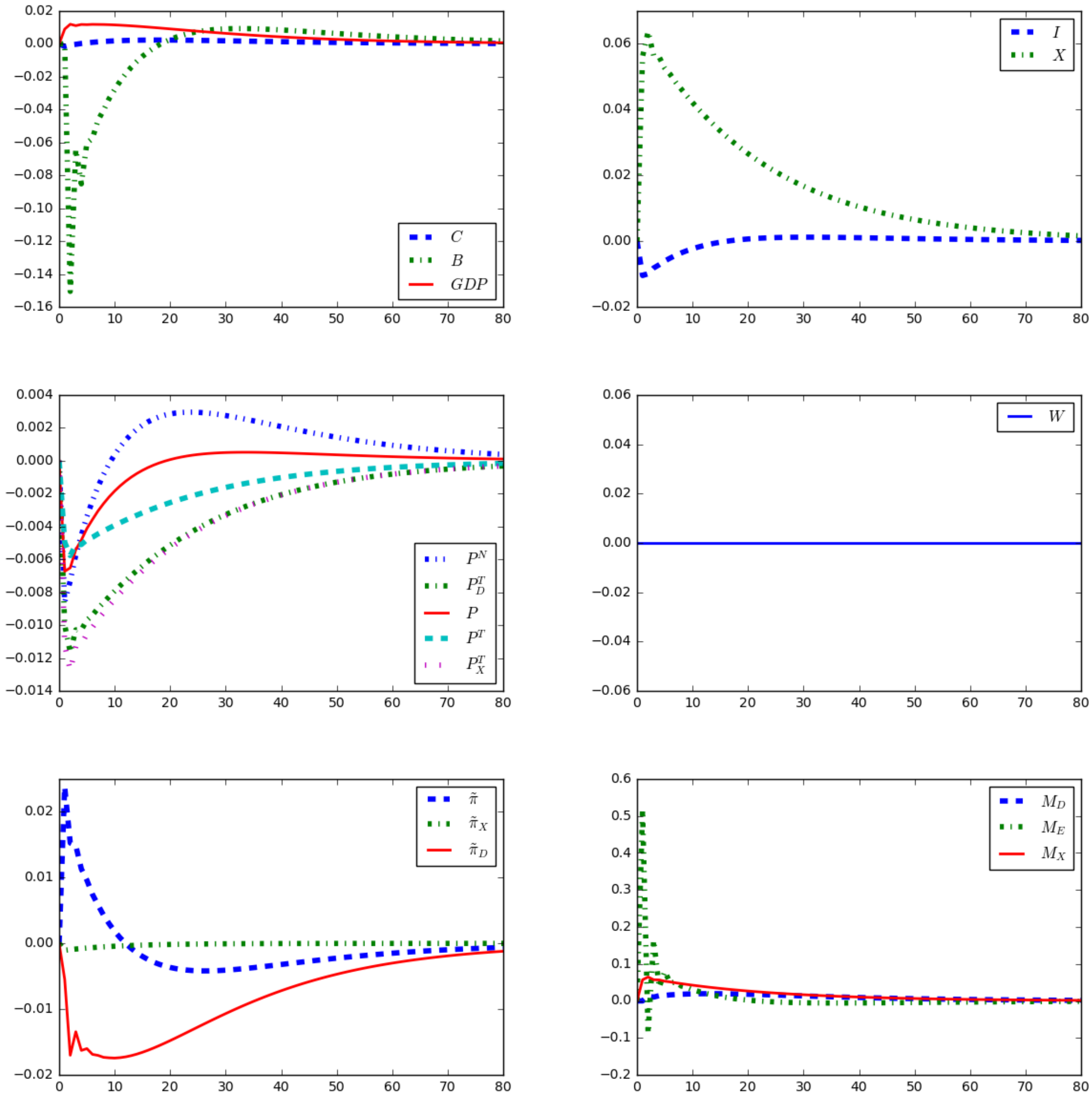
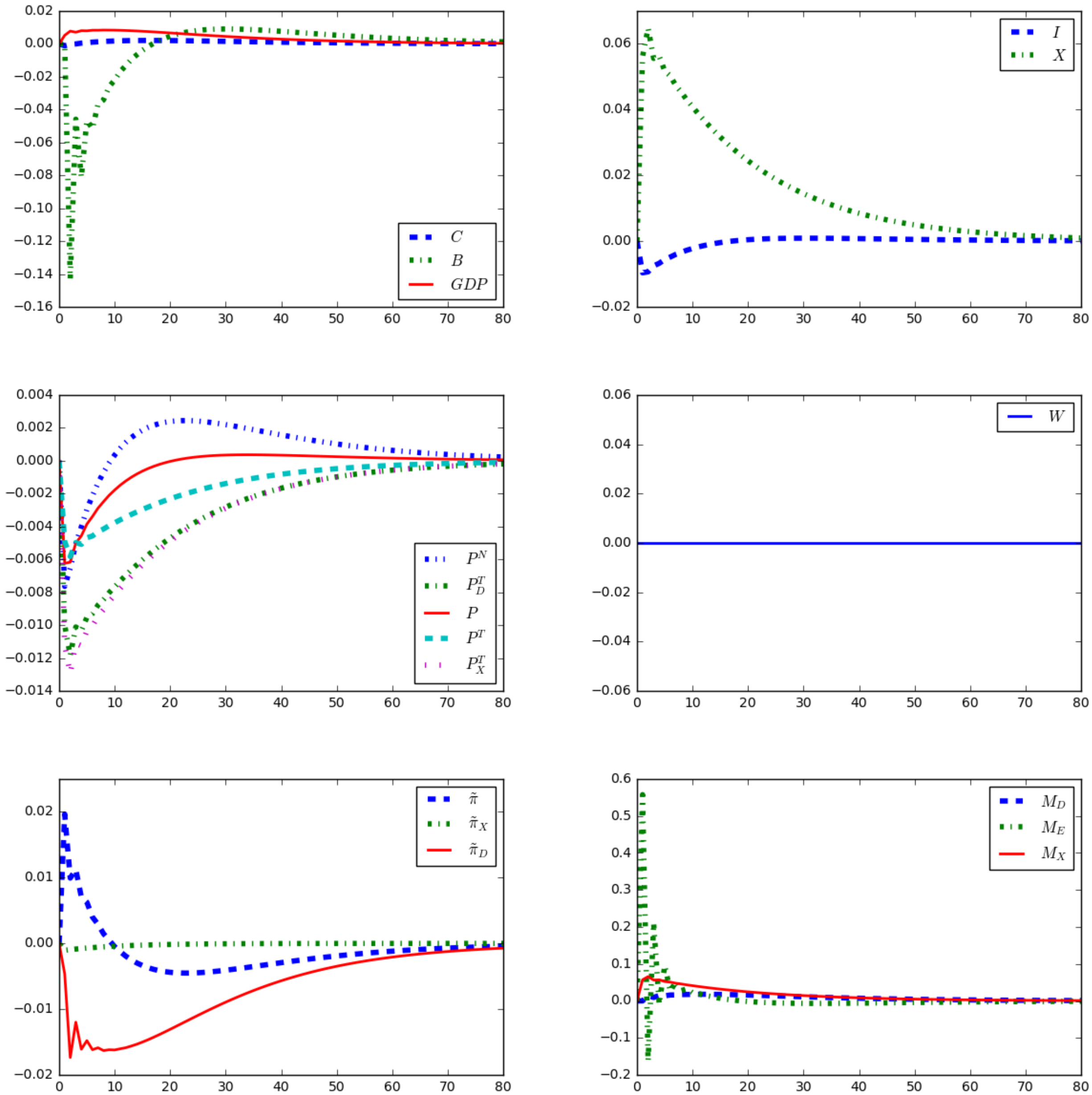


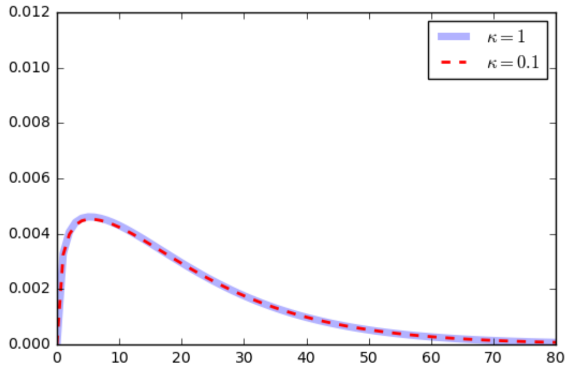
Figure 9: Responses to an A shock of 1% with constant W ($\kappa = 0.1$)



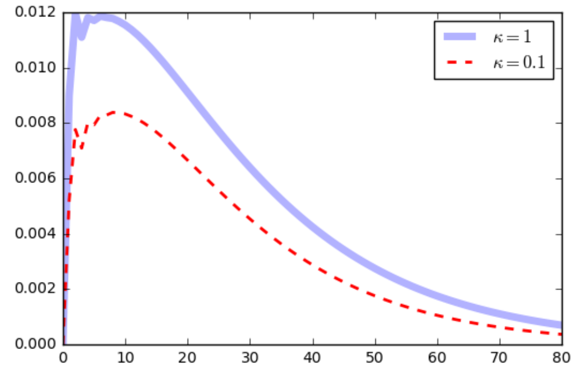
In both figures, the price indices and macro variables move differently compared to the baseline case. By construction, the wage W remains constant, and as a result the profitability of entering the market increases and the mass of new entrants surges. Since the domestic household should fund the new entrants through investment on the mutual fund but the labor income is fixed, it should reduce consumption and imports. As a result, price indices also decrease.

Another noticeable observation is that aggregate variables respond quantitatively differentially depending on the financial development κ, which is clearer in Figure 10. The figure shows the responses (percentage deviations from steady state) of some key variables depending on κ in general equilibrium and in partial equilibrium. The left panels show the baseline responses where the wage is allowed to freely adjust in general equilibrium. The right panels show partial equilibrium results where W is fixed. In partial equilibrium, variables respond more sensitively when $\kappa = 1$. This implies that the insensitivity of aggregate variables to the financial development in the baseline is related to the wage adjustment in general equilibrium.

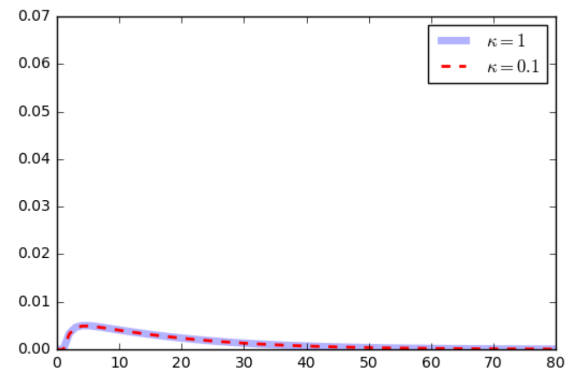
Figure 10: Impulse responses in general equilibrium (GE) and partial equilibrium (PE)



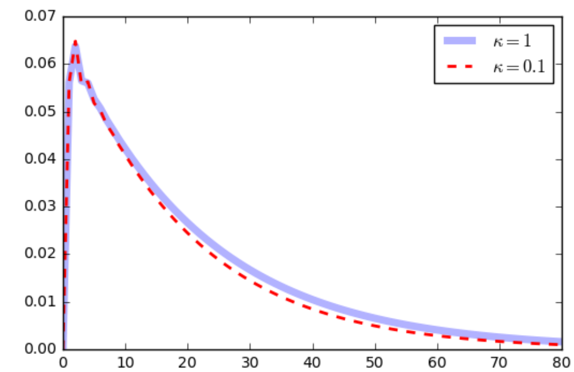
(a) GDP (GE)



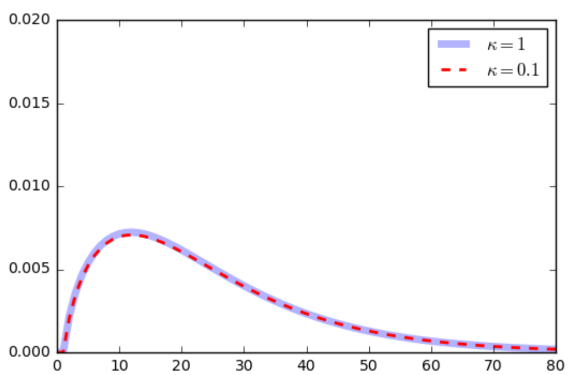
(b) GDP (PE)



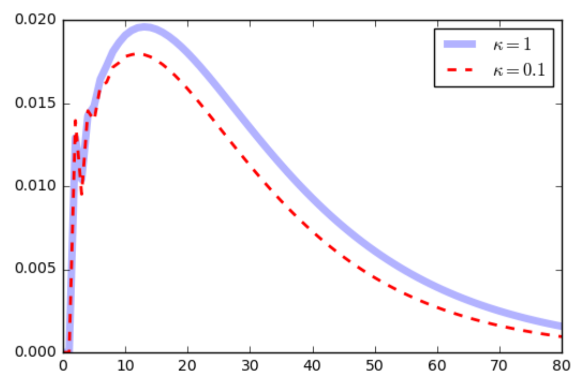
(c) X (GE)



(d) X (PE)

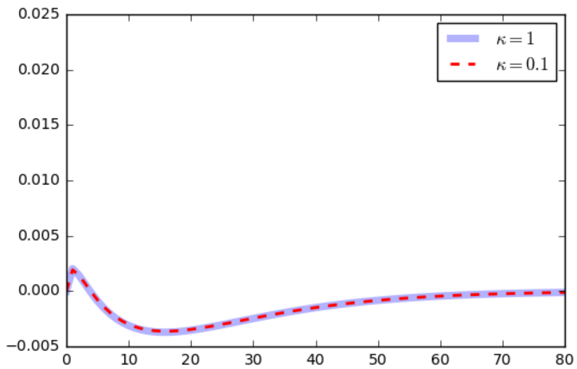


(e) M_D (GE)

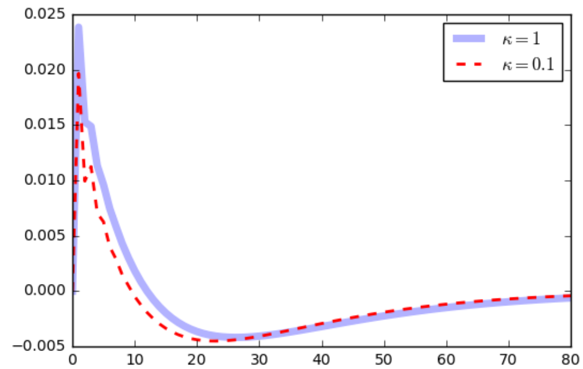


(f) M_D (PE)

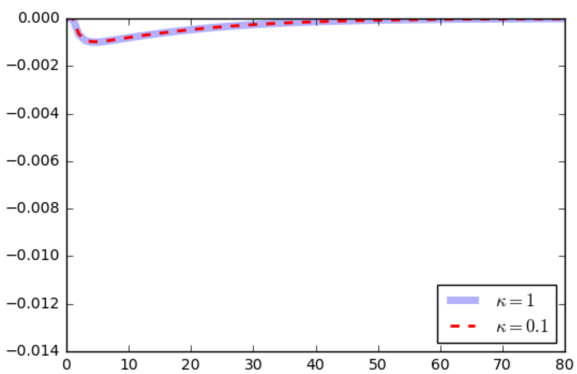
Figure 10 (continued): Impulse responses in general equilibrium (GE) and partial equilibrium (PE)



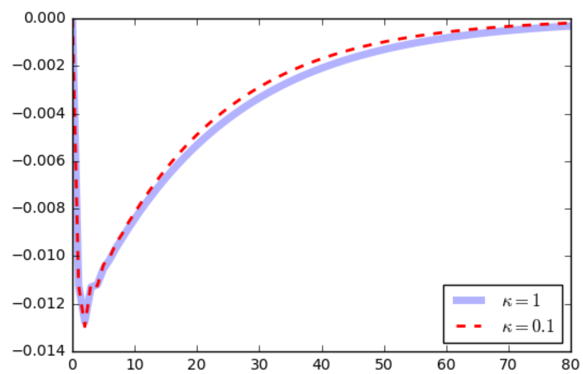
(g) $\tilde{\pi}$ (GE)



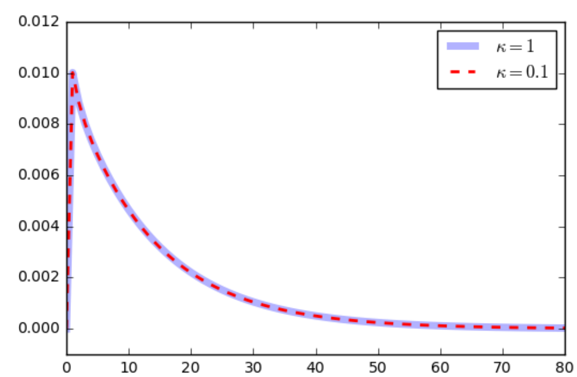
(h) $\tilde{\pi}$ (PE)



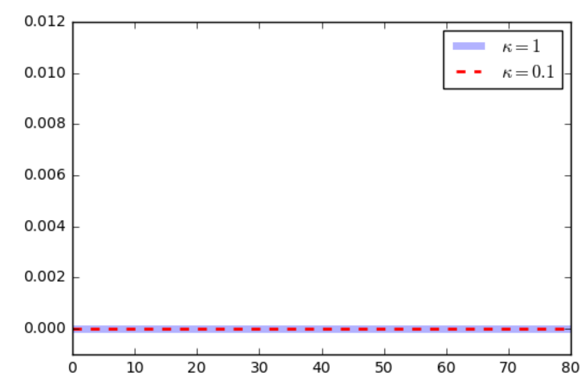
(i) P_X (GE)



(j) P_X (PE)



(k) W (GE)

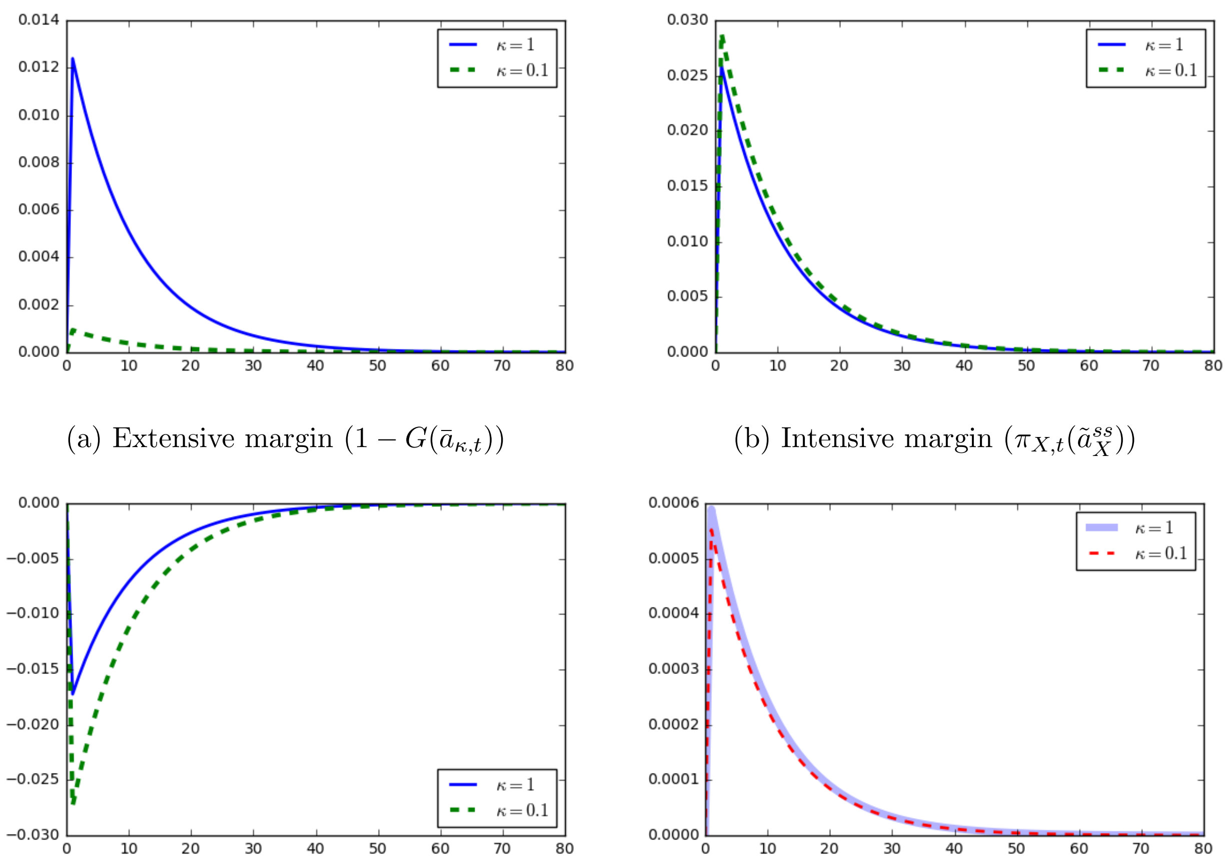


(l) W (PE)

Figure 11 confirms this by comparing the extensive margin, intensive margin, and the selection effect when W is constant. The responses are level deviations normalized as in

Figure 3. Same as the baseline in Figure 3, the extensive margin is more sensitive when $\kappa = 1$, while the selection effect is more sensitive when $\kappa = 0.1$. The intensive margin responds slightly more sensitively when $\kappa = 0.1$, but this pattern is not as significant as in the other two channels. However, the magnitude of the responses is much larger than the baseline since firms are now subject to only the productivity gain without any increase in production costs. This, in turn, implies that the scale of the total export profit $\tilde{\Pi}_X$, which plays a crucial role in affecting the aggregate variables, becomes larger as well. As a result, the aggregate variables move quantitatively differently depending on κ since the scale of the difference in the total export profit is not trivial anymore.

Figure 11: Responses of extensive margin, intensive margin, and selection (constant W)



(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$

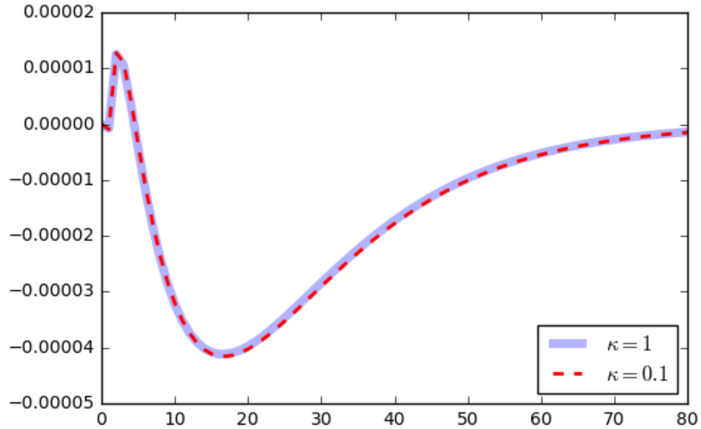
(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$

(c) Selection $(\tilde{a}_{X,t})$

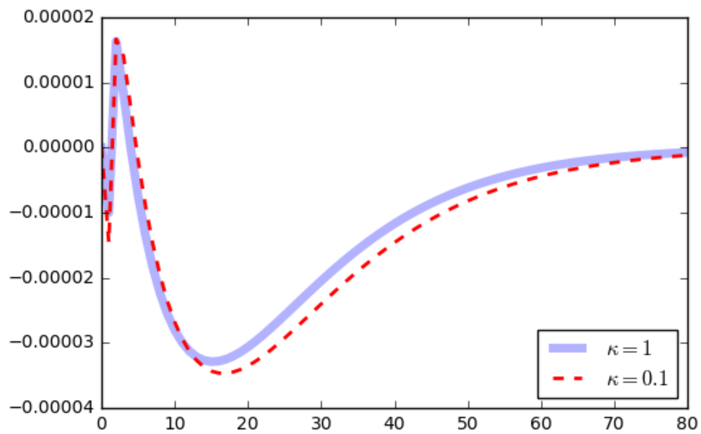
(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t})$

Figure 12 corroborates this and shows the different responses of $\tilde{\Pi}_X$ depending on κ in the baseline, when $\alpha = 15.6$, and when W is held constant. In panel (c), the gap between the responses is as much as 0.005% of steady state GDP at its peak. This is much greater than those in panel (a) and panel (b).

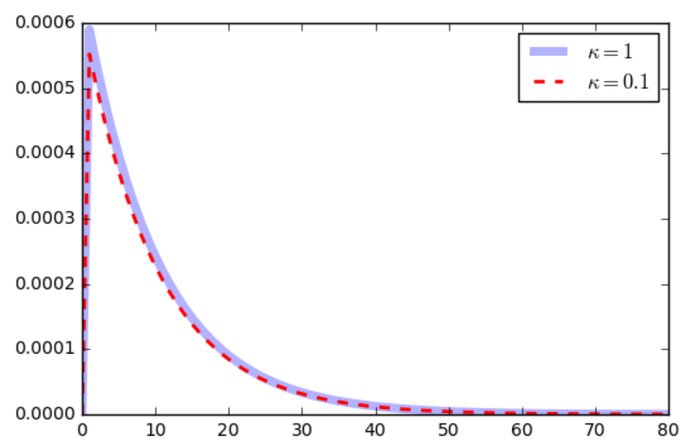
Figure 12: Response of $\tilde{\Pi}_X$ to a productivity shock



(a) $\alpha = 5.6$



(b) $\alpha = 15.6$



(c) Constant W

This result can also be understood analytically. Recall that

$$
\begin{aligned}
\frac{\partial \tilde{\Pi}_X}{\partial A} = & \underbrace{-g(\bar{a}_\kappa)\tilde{\pi}_X \frac{\partial \bar{a}_\kappa}{\partial A}}_{\text{Extensive margin, }>0} \\
& + \underbrace{(1-G(\bar{a}_\kappa))\left[\frac{\sigma-1}{\sigma}\left(\frac{p_X(\tilde{a}_X)}{P^*}\right)^{1-\sigma}\frac{q_X^{rem}}{A} + (1-\mu)\frac{WF_X}{A^2}\right]}_{\text{Intensive margin, }>0} \\
& + \underbrace{(1-G(\bar{a}_\kappa))\left[\frac{\sigma-1}{\sigma}\left(\frac{p_X(\tilde{a}_X)}{P^*}\right)^{1-\sigma}\frac{q_X^{rem}}{\tilde{a}_X}\frac{\partial \tilde{a}_X}{\partial A}\right]}_{\text{Selection effect, }<0}.
\end{aligned}
$$

Now, consider the partial derivative of the total export profit with respect to the wage:

$$
\begin{aligned}
\frac{\partial \tilde{\Pi}_X}{\partial W} = & \underbrace{-g(\bar{a}_\kappa)\tilde{\pi}_X \frac{\partial \bar{a}_\kappa}{\partial W}}_{\text{Extensive margin, }<0} \\
& + \underbrace{(1-G(\bar{a}_\kappa))\left[-\frac{\sigma-1}{\sigma}\left(\frac{p_X(\tilde{a}_X)}{P^*}\right)^{1-\sigma}\frac{q_X^{rem}}{W} - (1-\mu)\frac{F_X}{A}\right]}_{\text{Intensive margin, }<0} \\
& + \underbrace{(1-G(\bar{a}_\kappa))\left[\frac{\sigma-1}{\sigma}\left(\frac{p_X(\tilde{a}_X)}{P^*}\right)^{1-\sigma}\frac{q_X^{rem}}{\tilde{a}_X}\frac{\partial \tilde{a}_X}{\partial W}\right]}_{\text{Selection effect, }>0}.
\end{aligned}
\tag{40}
$$

It can be similarly decomposed into the effect on the extensive margin, intensive margin, and selection. However, note that the sign of each effect is the opposite to the case of a change in A. This implies that in general equilibrium, if the wage increases in response to a positive productivity shock, the scale of the effect of the shock on the extensive margin, intensive margin, and selection is downsized. This analytical prediction is consistent with Figures 11 and 12. The main lesson from the exercise in this subsection can be summarized as follows. In response to a productivity shock, the wage adjustment in general equilibrium mitigates the responses of the extensive margin, intensive margin, and selection so that they can sufficiently offset each other to hold $\tilde{\Pi}_X$ quantitatively insensitive to the degree of financial development.

5.6 Financial development and labor supply

As shown in the previous subsection, the wage rate's adjustment is important in determining the effect of financial development on the economy in general equilibrium. Hereinbefore, labor supply is perfectly inelastic as it is exogenously given as L. As a result, the wage rate increases exactly as much as labor demand increases. This extreme assumption might generate the nearly complete insensitivity of the macro variables to financial development in the baseline exercise. However, even if labor supply is not perfectly inelastic, the argument that wage adjustment in general equilibrium downsizes the effect of a productivity shock on the extensive margin, intensive margin, and selection effect is still valid as long as a positive productivity shock leads to an increase in the wage rate. The extent to which the wage adjustment cancels out the effects of trade finance frictions depends on the labor market structure and in particular, is closely related to the elasticity of labor supply. To confirm this and generalize the results from the main exercises, in this subsection I endogenize labor supply and repeat the exercises, varying the elasticity of labor supply. In addition, I show that the role of the firm productivity dispersion identified in the main exercises is still in effect under a more general setup regarding the labor market.

I first drop the constant relative risk aversion utility assumption in the baseline and instead adopt the Greenwood-Hercowitz-Huffman (GHH) preferences (Greenwood et al., 1988), leading to the following household problem:

$$\max_{C_t, L_t, B_{t+1}, x_{t+1}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{1-\gamma} \left(C_t - \rho \frac{L_t^{1+\frac{1}{\lambda}}}{1+1/\lambda} \right)^{1-\gamma}$$

subject to

$$
\begin{aligned}
& P_t C_t + P_t^T B_{t+1} + \frac{\nu}{2} P_t^T B_{t+1}^2 + \tilde{v}_t (M_{D,t} + M_{E,t}) x_{t+1} \\
= & W_t L_t + P_t^N Y^N + (1 + r_t^*) P_t^T B_t + (\tilde{v}_t + \tilde{\pi}_t) M_{D,t} x_t + T_t
\end{aligned}
$$

and

$$
0 \leq L_t \leq 1.
$$

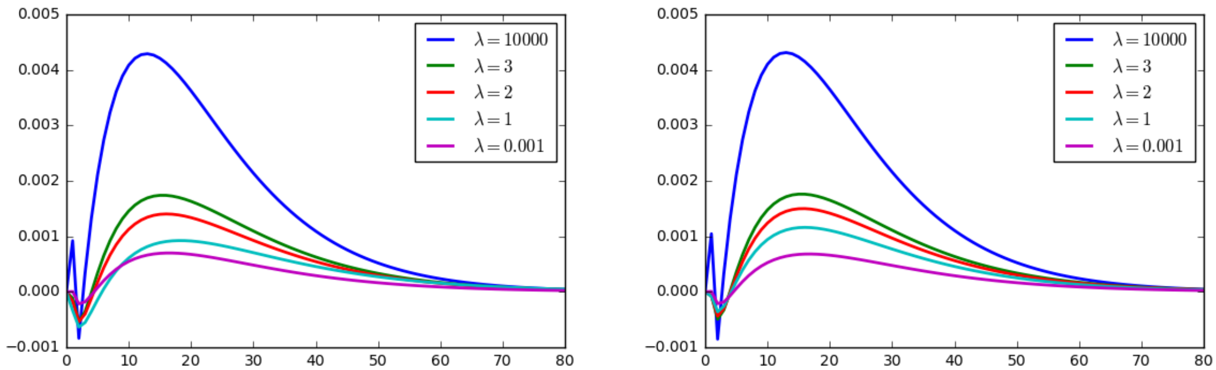
Now, the household also chooses how much labor it supplies (L_t) in each period. The first order condition for L_t gives the labor supply schedule as follows:

$$
L_t = \rho^\lambda \left(\frac{W_t}{P_t} \right)^\lambda . \tag{41}
$$

The elasticity of labor supply is equal to λ. Note that as $\lambda \to 0$, labor supply is perfectly inelastic and it converges to the baseline case. Figures A.31–A.35 present the impulse responses of the aggregate variables, extensive and intensive margins, selection effect, and total export profit by κ when λ is set to 0.001. All of them look very similar to those in the baseline where labor supply is exogenously given as 1.

In the previous subsection, to show the importance of the wage adjustment, I compare the baseline results to an extreme case where W is held fixed. Here, I generalize the result and associate it with the elasticity of labor supply λ. Figure 13 presents the responses of the effective marginal cost of production (W/A) to a 1% increase in A by λ and κ. A lower λ implies a lower elasticity of labor supply and a steeper labor supply curve. As a result, for both values of κ, W responds less sensitively as λ becomes greater. This is translated into higher sensitivity of $\frac{W}{A}$ when λ is high, and it implies that the downsizing effect of the wage adjustment on the extensive margin, intensive margin, and selection effect becomes less significant as λ gets higher.

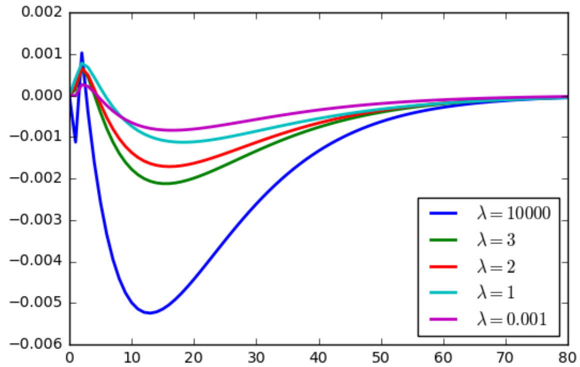
Figure 13: Response of $\frac{W}{A}$ with different λ



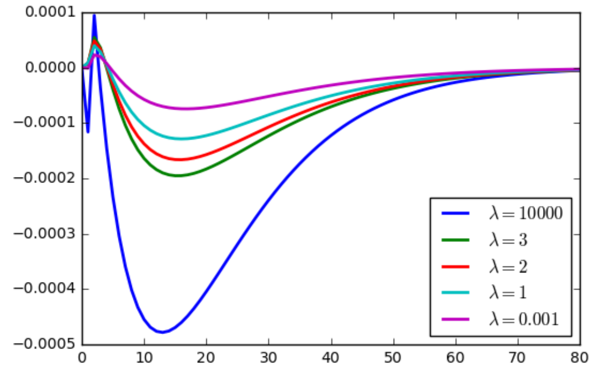
(a) $\kappa = 1$ (b) $\kappa = 0.1$

Figure 14 presents the responses of the extensive margin, selection effect, and total export profit by λ and κ. The figure confirms that the magnitude of the responses becomes greater when the elasticity of labor supply becomes higher so that the adjustment in W is small. As a result, when the elasticity of labor supply is high, the difference in the total export profit depending on the degree of trade finance frictions becomes large enough to affect the aggregate economy.

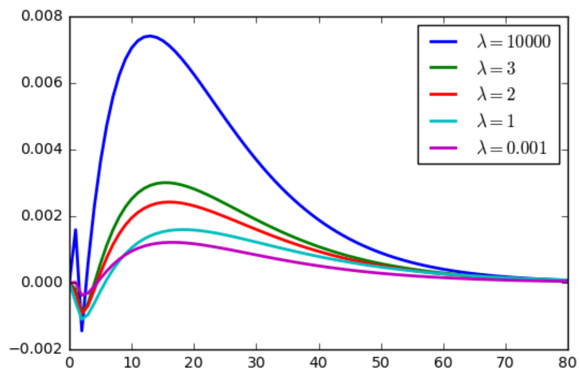
Figure 14: Responses of the extensive margin, selection and total export profit by λ



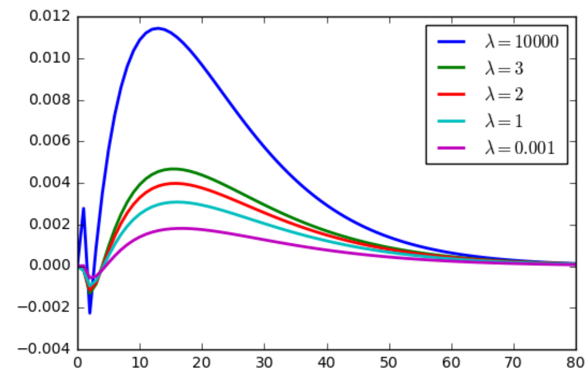
(a) $1 - G(\bar{a}_\kappa)$ ($\kappa = 1$)



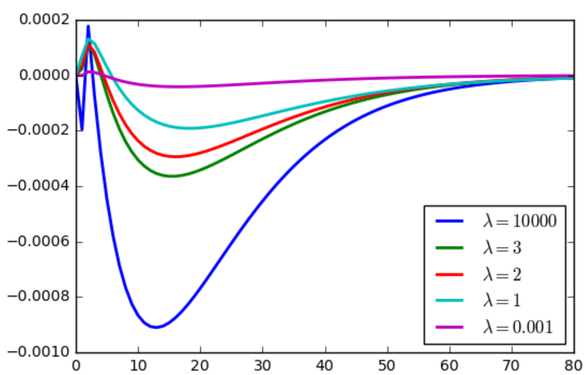
(b) $1 - G(\bar{a}_\kappa)$ ($\kappa = 0.1$)



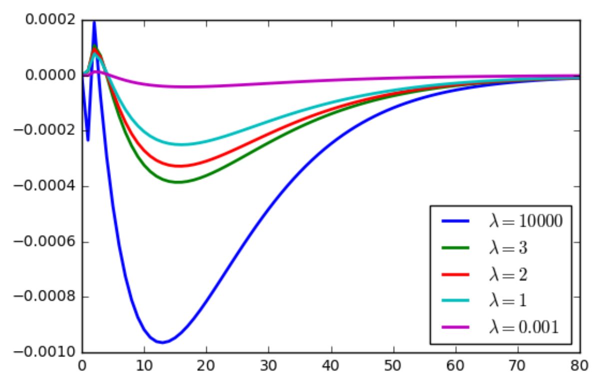
(c) $\tilde{a}_X$ ($\kappa = 1$)



(d) $\tilde{a}_X$ ($\kappa = 0.1$)



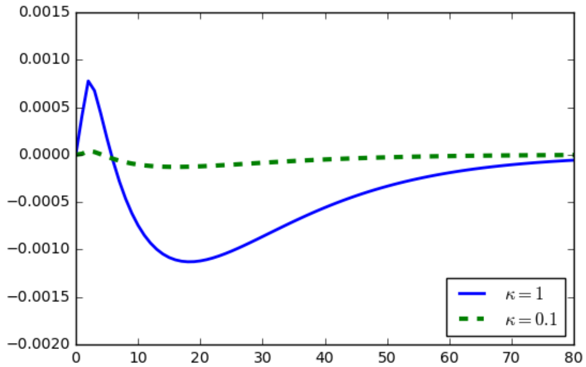
(e) $\tilde{\Pi}_X$ ($\kappa = 1$)



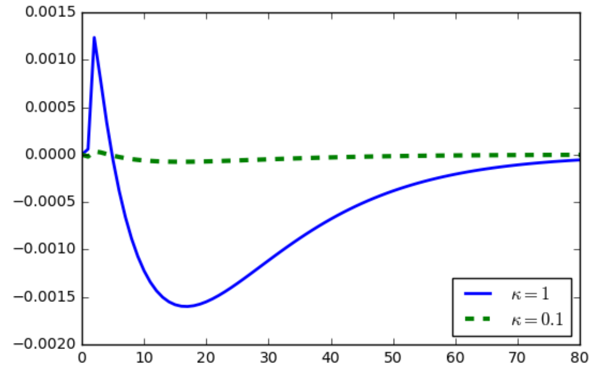
(f) $\tilde{\Pi}_X$ ($\kappa = 0.1$)

Next, I find that the effect of less dispersion in firm productivity can be generalized to an environment with a more general structure of labor market. A previous subsection finds that when firm productivity is less dispersed, the difference in the extensive margin depending on κ becomes greater, while that in the selection becomes smaller. This channel still operates in a more realistic setup where labor supply is endogenously determined in general equilibrium. This is confirmed in Figure 15, which shows the responses of the extensive margin, selection and total export profit by α when $\lambda = 1$.

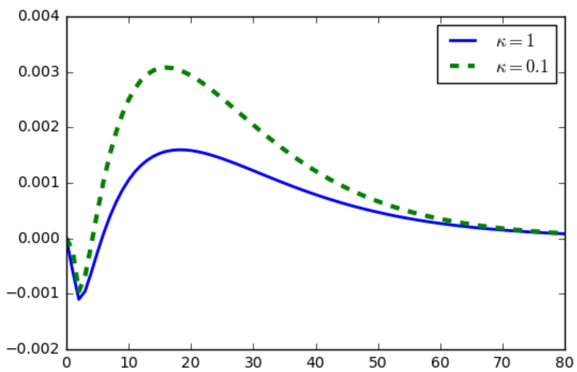
Figure 15: Responses of the extensive margin, selection and total export profit when $\lambda = 1$



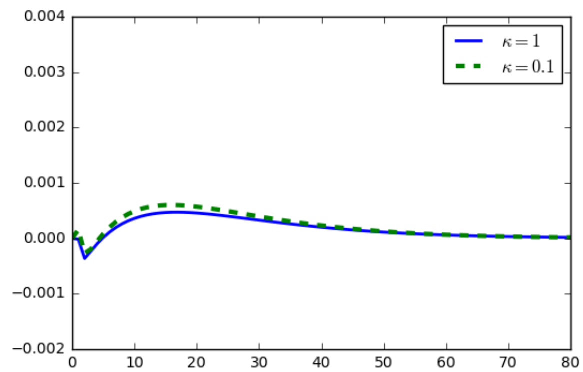
(a) $1 - G(\bar{a}_\kappa)$ ($\alpha = 5.6$)



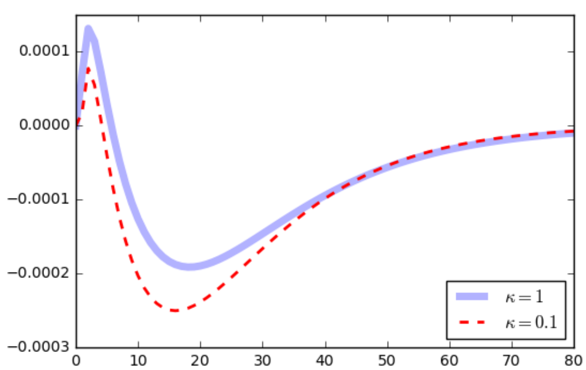
(b) $1 - G(\bar{a}_\kappa)$ ($\alpha = 15.6$)



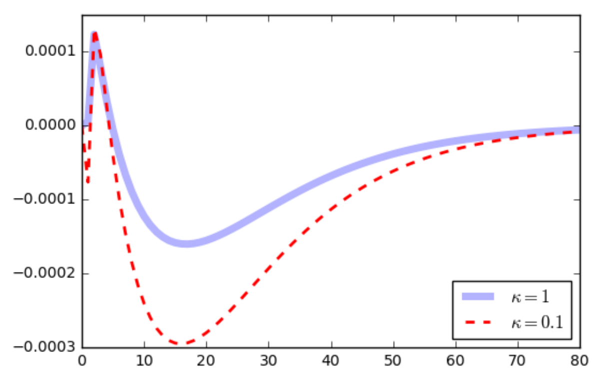
(c) $\tilde{a}_X$ ($\alpha = 5.6$)



(d) $\tilde{a}_X$ ($\alpha = 15.6$)



(e) $\tilde{\Pi}_X$ ($\alpha = 5.6$)



(f) $\tilde{\Pi}_X$ ($\alpha = 15.6$)

5.7 Robustness checks and additional exercises

In this subsection, I discuss a battery of robustness tests of the main findings. I test the sensitivity of the results to the size of the elasticity of substitution between varieties, type of a shock, zero capital accounts, exclusion of the non-tradable sector, and alternative calibration for κ and foreign demand. The results are consistent with those from the main exercises.

5.7.1 Small σ

The estimate for the elasticity of substitution between varieties σ differs across studies. In the baseline, I set $\sigma = 6$, which is taken from Broda and Weinstein (2006). However, macro trade papers including Bernard et al. (2003) suggest a much lower estimate (e.g., $\sigma = 3.8$). As a robustness check, I repeat the main exercises with a lower σ. I set σ to 2.5, and this corresponds to a markup of 67%. Then, I calibrate other parameters to match the key moments. α is now set to 2.1 to match the standard deviation of log sales of US plants. Figures A.5 and A.6 show the responses (percentage deviations from steady state) of the macro variables when $\kappa = 1$ and $\kappa = 0.1$, respectively. As in the baseline, κ doesn't have significant effect on the responses.

Figures A.7 and A.8 present the responses of the extensive margin, intensive margin, selection effect, and total export profit, each in level deviations and in percentage deviations from steady state. The main results from the baseline are still observed. In level deviations, the extensive margin is more sensitive when $\kappa = 1$, while the selection effect is more sensitive when $\kappa = 0.1$, and the total export profit is quantitatively invariant to κ.

Figure A.9 shows the responses (level deviations) of the three channels and the total export profit when α is high. Compared to Figure A.7, the difference in responses of the extensive margin is larger, while that of the selection effect is smaller. As a result, the total export profit responds differently depending on κ. Figure A.10 corroborates that when α is high, financial development affects the aggregate variables as well. All these results are consistent with the baseline analysis. Hence, the main results are robust to different calibrations of σ.

5.7.2 P^* shock

In the baseline, all the responses are to a 1% positive productivity shock. I repeat the same exercise with a 1% increase in the foreign price index P^*. Figures A.11 and A.12 present responses (percentage deviations from steady state) to a 1% positive P^* shock when $\kappa = 1$ and $\kappa = 0.1$. Figures A.13 and A.14 show the responses of the three channels and $\tilde{\Pi}_X$ in level deviations and percentage changes. Consistent with the baseline results, the extensive margin (selection effect) is more (less) sensitive in level deviations when $\kappa = 1$, and the response of $\tilde{\Pi}_X$ does not depend on κ. In percentage changes, κ does not have a significant impact on any variable. This exercise confirms that the main results are not limited to a productivity shock.

5.7.3 Zero capital account

The main results still hold when there is no capital flow in the economy. I repeat the main exercise with an extremely high bond adjustment cost ($\nu = 10000$). Figures A.15 and A.16 present the percentage deviations with different κ. Unlike other exercises, the responses of the exports and imports coincide since unbalanced trade is extremely costly. But still, the main results about the role of financial development are robust. The patterns in the responses of the three channels and the total export profit are still consistent with the baseline as shown in Figures A.17 and A.18.

5.7.4 Exclusion of the non-tradable sector

In the main exercise, I assume a general model with both the tradable and the non-tradable sector. As a robustness test, I repeat the exercise excluding the non-tradable sector.

For this, I set the weight on tradable goods ω to 1.[17] Figures A.19 and A.20 compare the impulse responses depending on κ, and Figures A.21 and A.22 present the responses of the extensive margin, intensive margin, selection effect, and total export profit. The results are consistent with the baseline analysis.

5.7.5 Intermediate κ

As a further robustness check, I set the degree of financial development to a moderate value of 0.55. This is the average of 0.1 and 1 used in the baseline analysis. The main results are robust as Figures A.23–A.26 confirm.

5.7.6 Foreign demand

Last, I use an alternative calibration of foreign variables. In the baseline, the foreign demand parameter q_X^{rem} is set to 5. I test the robustness of the main results by setting q_X^{rem} to 15. The results are summarized in Figures A.27–A.30, and the main findings are not sensitive to different calibrations of foreign demand.

6 Conclusion

In this paper, I build a small open economy general equilibrium model that incorporates trade finance frictions. In the model, to export, firms should pay upfront fixed export costs composed of domestic and foreign labor by borrowing money from international lenders. The amount of money that firms can borrow depends on the degree of financial development of the home country. As long as the financial market is not perfectly developed, such a constraint generates non-exporters that would otherwise export in a frictionless economy.

The main findings are twofold. The first finding is theoretical: in partial equilibrium, when some part of export fixed costs should be paid in foreign input, RER depreciation

[17] In computation, I use $\omega = 0.9999$.

affects the extensive margin via two channels. On the one hand, the classic price competitive channel loosens the trade finance constraint and increases the extensive margin of exports. On the other hand, the fixed cost valuation channel can act as a tightening force on the constraint. Hence, the effect of RER depreciation on the extensive margin of exports is ambiguous and is determined by the relative strength of the two channels. In turn, the effect of RER on the average total profit of domestic firms is also ambiguous.

Second, quantitative exercises show that in general equilibrium, when a financial market is less developed, firms' export activity is hampered and the extensive margin of exports decreases. At the same time, the increase in the average productivity of exporters offsets this effect in the aggregate. As a result, the effect of trade finance frictions on the aggregate economy is subdued. If the dispersion of firm productivity is small and firms are concentrated around a low level of productivity, financial development may have some aggregate implications. Meanwhile, the adjustment in the wage rate downsizes the magnitude of the extensive margin channel and the selection channel, further reducing the role of trade finance frictions on the aggregate economy. The strength of such a downsizing effect is closely related to the elasticity of labor supply: as the elasticity of labor supply becomes lower, the wage adjusts more in response to changes in labor demand, and therefore the downsizing effect becomes stronger.

The quantitative results from the main exercises in the paper should be interpreted with caution. The model abstracts from some potentially important aspects with which trade finance frictions may interact. For example, firms may use some of their assets as collateral as in Chaney (2016). Still, the main implication of the paper about the selection channel offsetting the extensive margin channel, productivity dispersion affecting the relative strength of those channels, and the wage adjustment in general equilibrium downsizing the magnitude of those channels would be valid in richer models. Hence, one should interpret the results as evidence that the effect of trade finance frictions on the aggregate economy is not as significant as on firm-level outcomes due to several offsetting mechanisms in general equilibrium.

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A Appendices

A.1 Derivation of equations

A.1.1 Derivation of equation (17) from equation (10)

$$\begin{aligned}
\tilde{v}_t &= \beta(1-\psi)\mathbb{E}_t\left[\frac{P_t}{P_{t+1}}\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}(\tilde{v}_{t+1}+\tilde{\pi}_{t+1})\right] \\
&= \beta(1-\psi)\mathbb{E}_t\left[\frac{P_t}{P_{t+1}}\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}\tilde{\pi}_{t+1}\right] + \beta^2(1-\psi)^2\mathbb{E}_t\left[\mathbb{E}_{t+1}\left[\frac{P_t}{P_{t+2}}\left(\frac{C_{t+2}}{C_t}\right)^{-\gamma}\tilde{\pi}_{t+2}\right]\right] \\
&\quad + \beta^2(1-\psi)^2\mathbb{E}_t\left[\mathbb{E}_{t+1}\left[\frac{P_t}{P_{t+2}}\left(\frac{C_{t+2}}{C_t}\right)^{-\gamma}\tilde{v}_{t+2}\right]\right] \\
&= \mathbb{E}_t\sum_{s=0}^{\infty}[\beta(1-\psi)]^s\frac{P_t}{P_{t+s}}\left(\frac{C_{t+s}}{C_t}\right)^{-\gamma}\tilde{\pi}_{t+s}.
\end{aligned}$$

A.1.2 Derivation of equaiton (31)

Total-differentiate equation (27) to get

$$\begin{aligned}
d\bar{a}_{\kappa,t} &= \frac{\sigma}{\sigma-1}\frac{\tau w_t}{A_t}\left(\frac{\sigma\mathcal{F}_t}{q^{rem}_{X,t}}\right)^{\frac{1}{\sigma-1}}\left(\frac{1}{\kappa}\right)^{\frac{1}{\sigma-1}}\left[\frac{1}{P^*_t}dP_t - \frac{P_t}{P^{*2}_t}dP^*_t\right. \\
&\quad\left. + \frac{P_t}{P^*_t}\frac{F_X}{(\sigma-1)\mathcal{F}_t}\left((1-\mu)\frac{w_t}{A_t}dP_t + \mu\frac{w^*_t}{A^*_t}dP^*_t\right)\right] \\
&\approx \frac{\sigma}{\sigma-1}\frac{\tau w_t}{A_t}\left(\frac{\sigma\mathcal{F}_t}{q^{rem}_{X,t}}\right)^{\frac{1}{\sigma-1}}\left(\frac{1}{\kappa}\right)^{\frac{1}{\sigma-1}}\left[\frac{1}{P^*_t}\left(-\frac{P^2_t}{P^*_t}de_t\right) - \frac{P_t}{P^{*2}_t}P_t de_t\right. \\
&\quad\left. + \frac{P_t}{P^*_t}\frac{F_X}{(\sigma-1)\mathcal{F}_t}\left((1-\mu)\frac{w_t}{A_t}\left(-\frac{P^2_t}{P^*_t}de_t\right) + \mu\frac{w^*_t}{A^*_t}P_t de_t\right)\right].
\end{aligned}$$

Rearranging the equation gives

$$\frac{\partial\bar{a}_{\kappa,t}}{\partial e_t} = \frac{\sigma}{\sigma-1}\frac{\tau w_t}{A_t}\left(\frac{\sigma\mathcal{F}_t}{q^{rem}_{X,t}}\right)^{\frac{1}{\sigma-1}}\left(\frac{1}{\kappa}\right)^{\frac{1}{\sigma-1}}\left[-\frac{2}{e^2_t} + \frac{P_t}{e^2_t(\sigma-1)}\frac{F_X}{\mathcal{F}_t}\left(-(1-\mu)\frac{w_t}{A_t} + \mu\frac{w^*_r}{A^*_t}e_t\right)\right].$$

A.2 Additional impulse response functions

Figure A.1: Responses (level deviation from steady state) to an A shock of 1 unit ($\kappa = 1$)

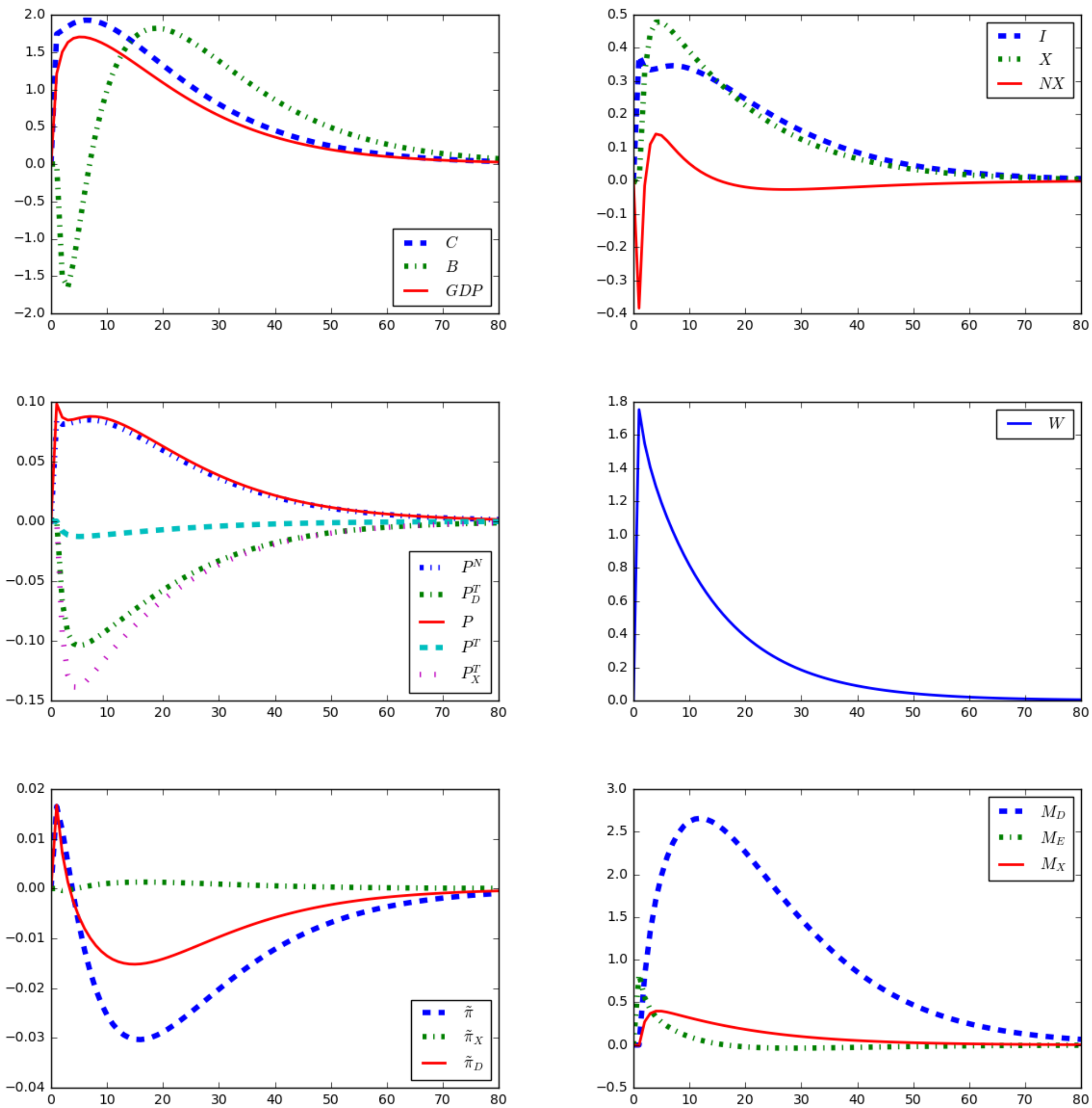


Figure A.2: Responses (level deviation from steady state) to an A shock of 1 unit ($\kappa = 0.1$)

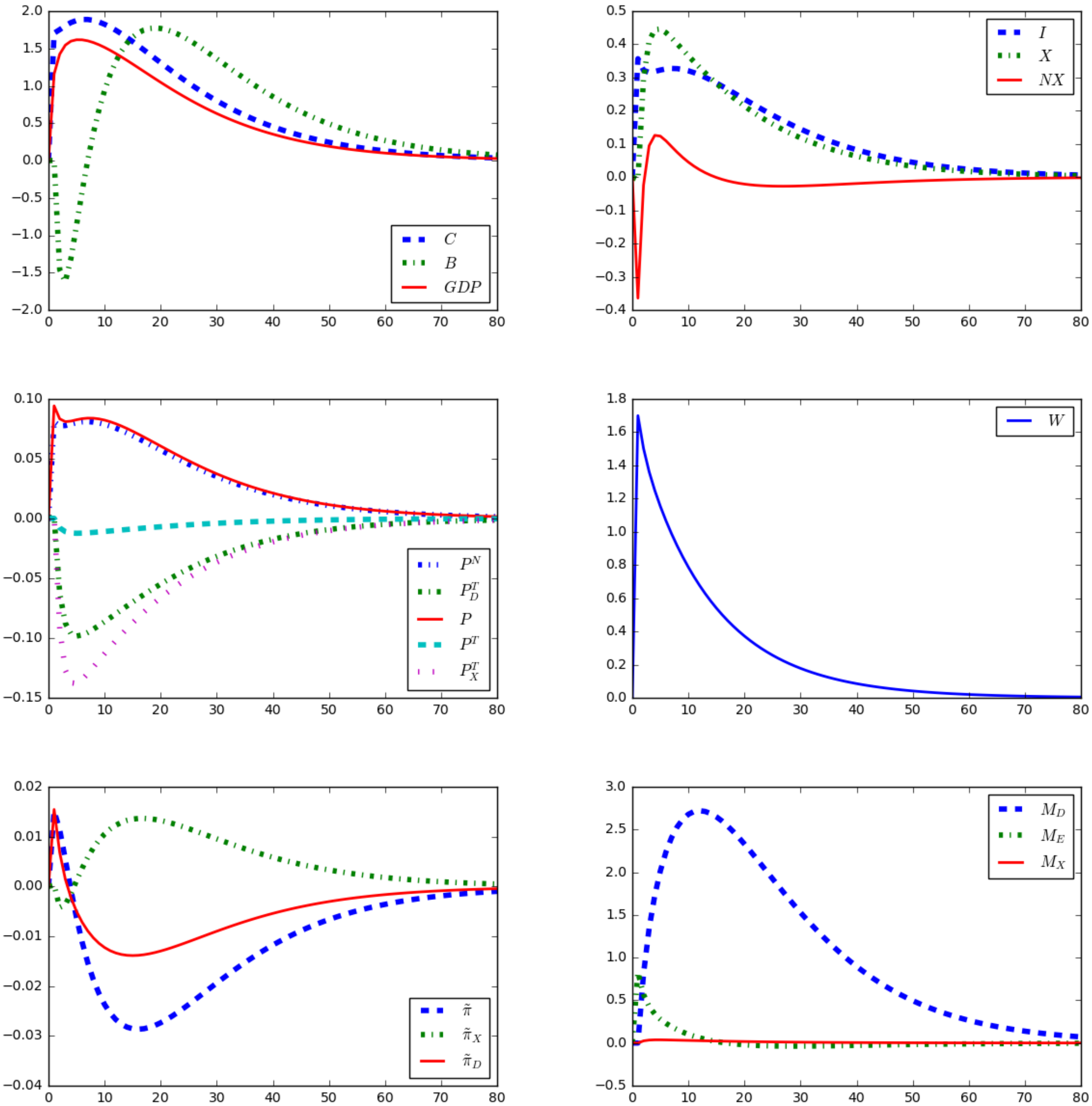
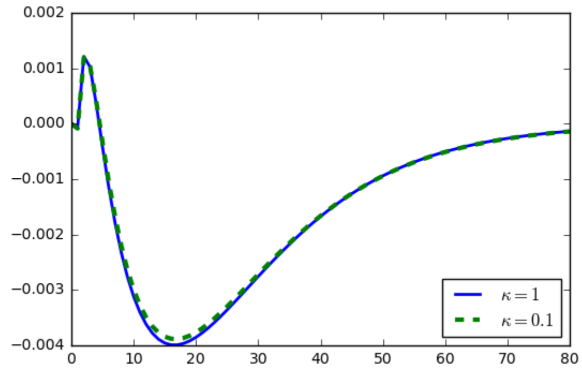
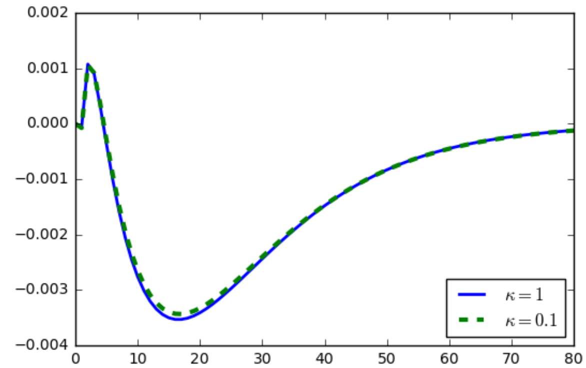


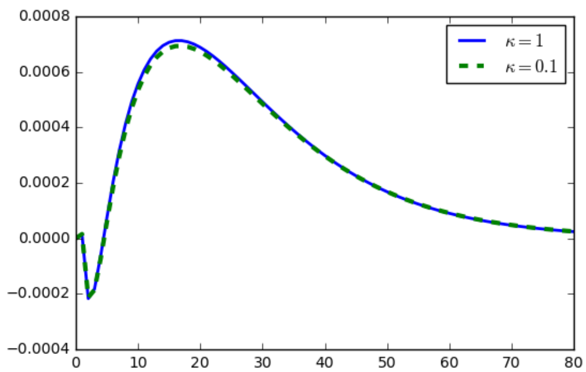
Figure A.3: Responses (percentage deviation from steady state) of extensive margin, intensive margin, and selection



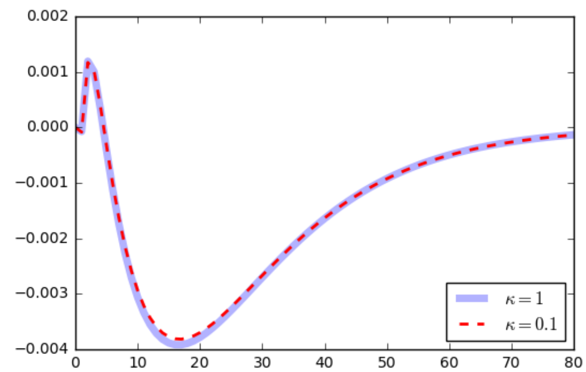
(a) Extensive margin $(1-G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$

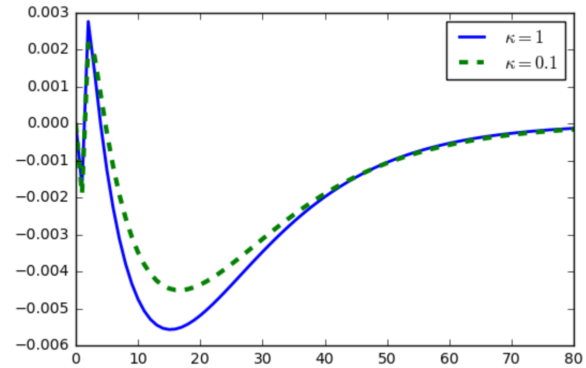


(c) Selection $(\tilde{a}_{X,t})$

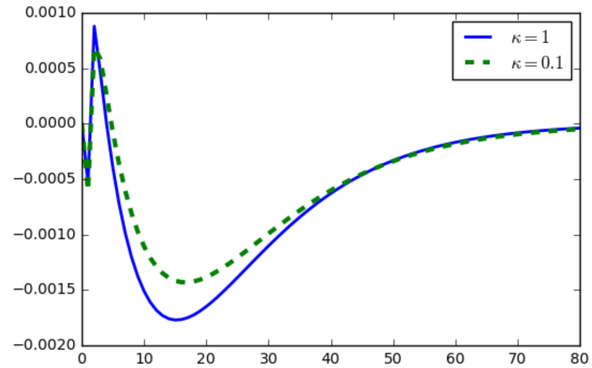


(d) Total export profit $((1-G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t})$

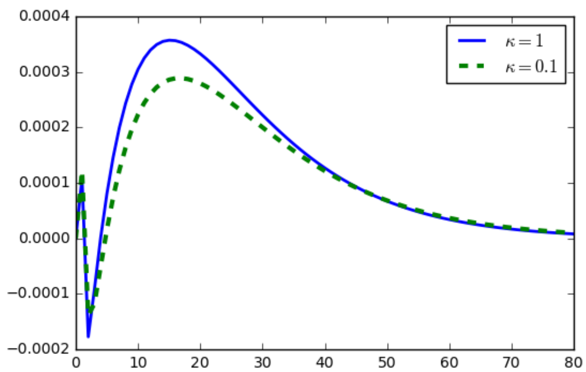
Figure A.4: Responses (percentage deviation) of extensive margin, intensive margin, and selection ($\alpha = 15.6$)



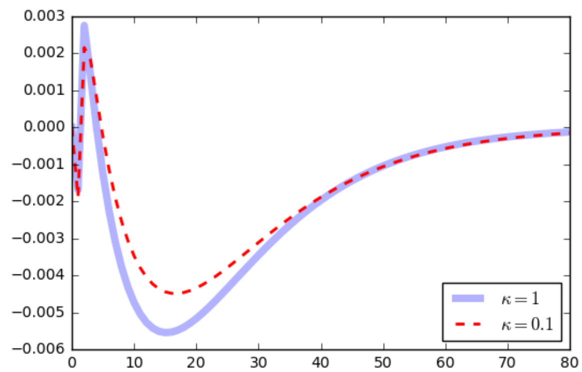
(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$



(c) Selection $(\tilde{a}_{X,t})$



(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t})$

Figure A.5: Response to an A shock of 1% ($\sigma = 2.5$, $\kappa = 1$)

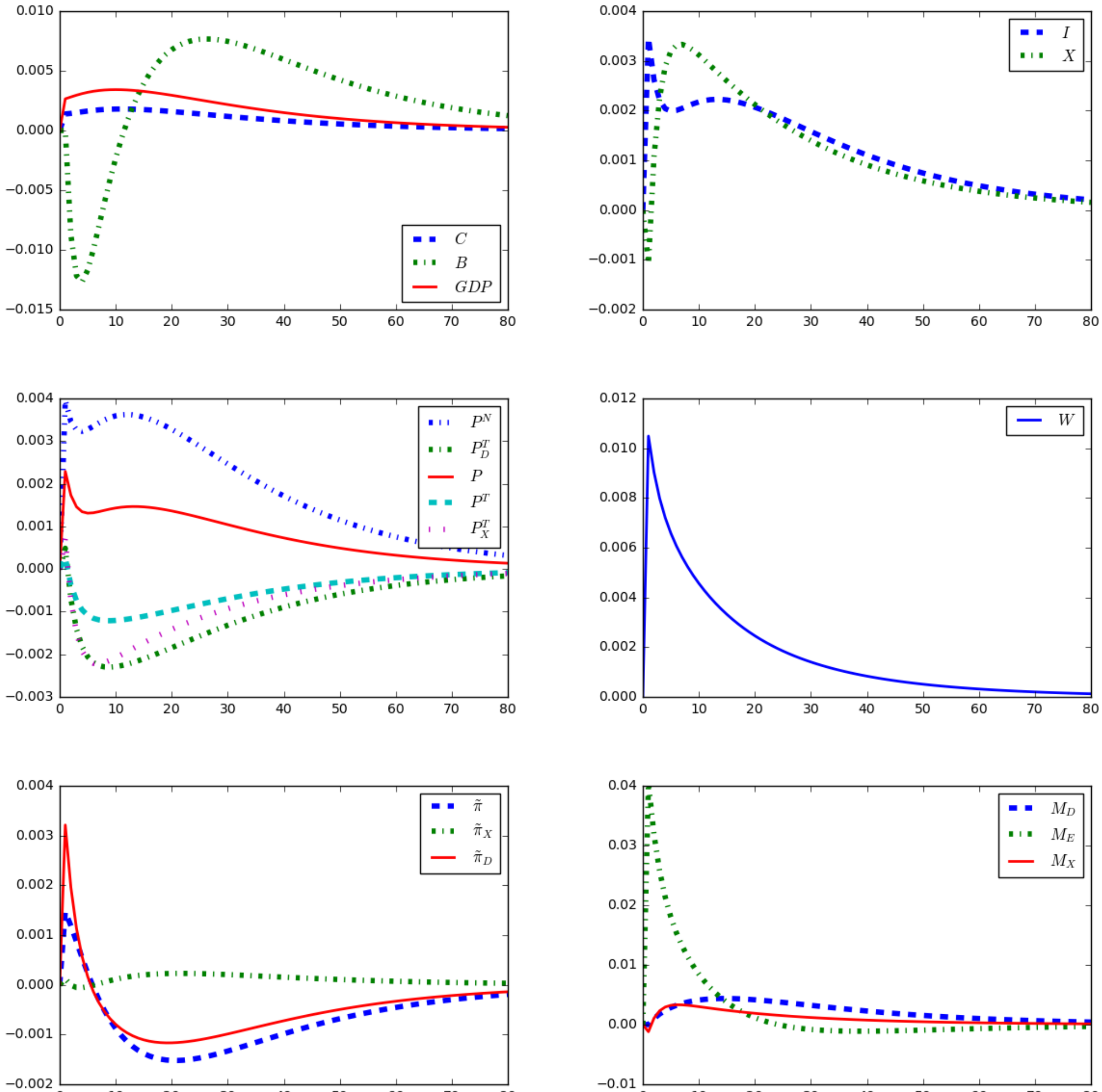


Figure A.6: Responses to an A shock of 1% ($\sigma = 2.5$, $\kappa = 0.1$)

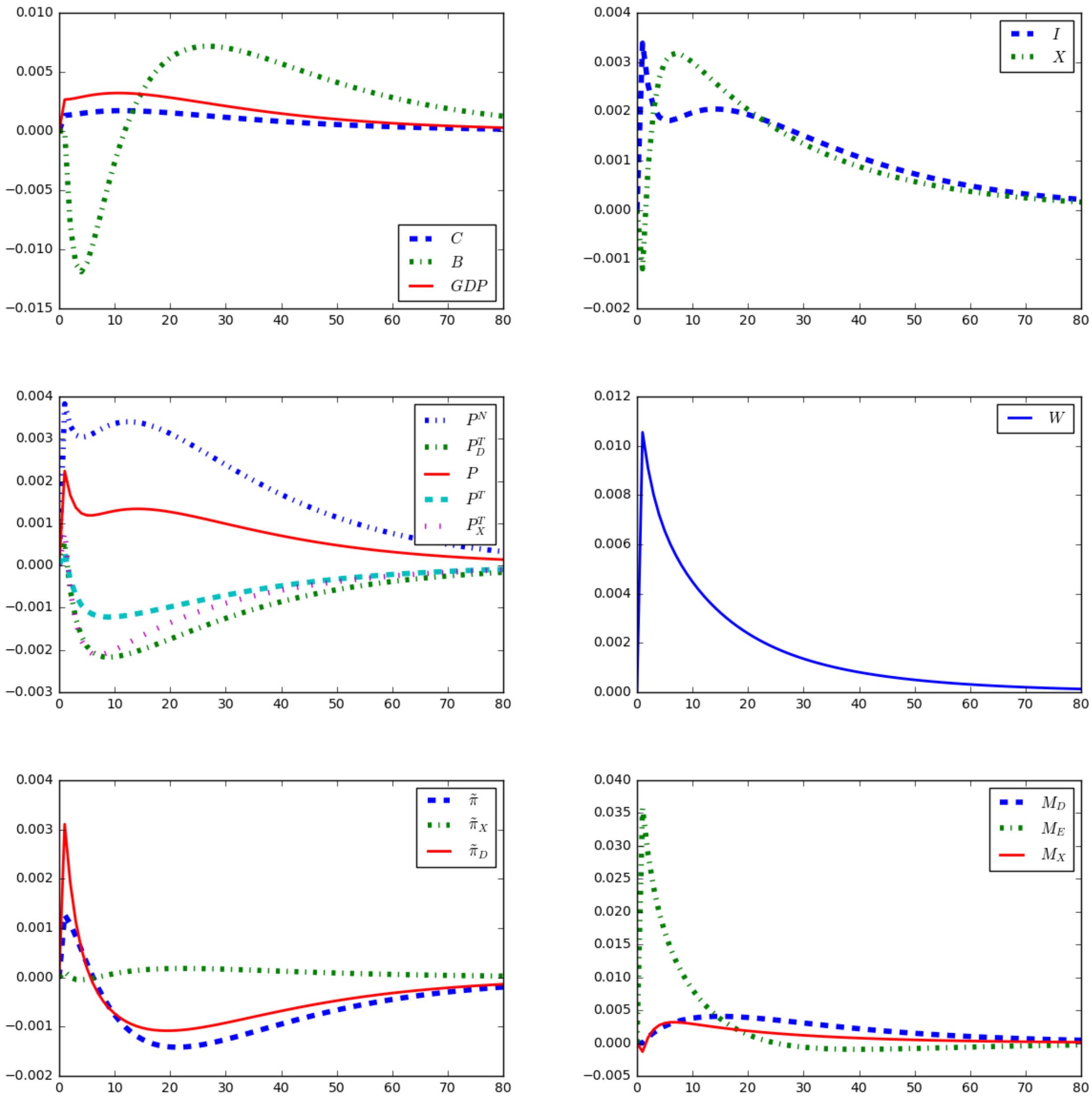
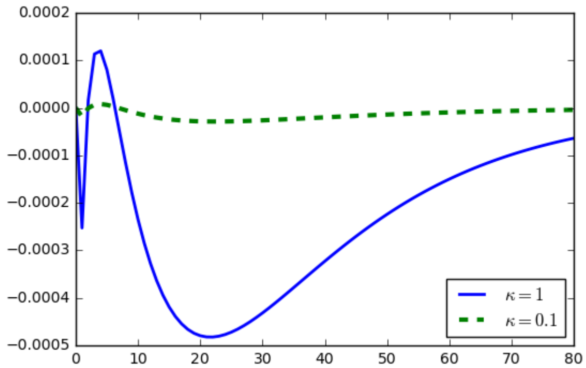
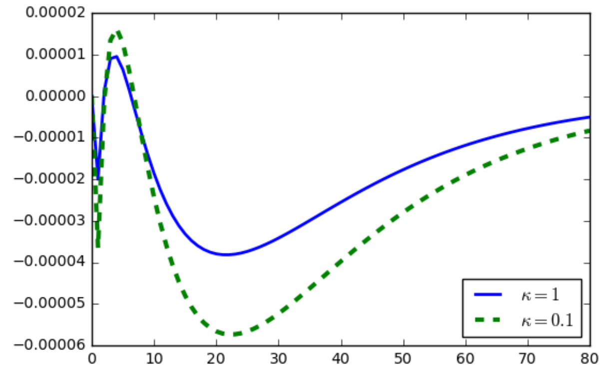


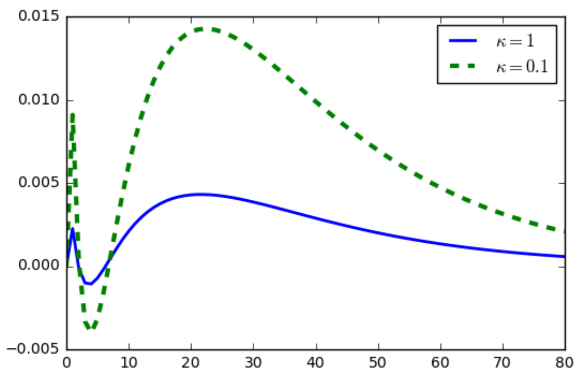
Figure A.7: Responses (level deviation) of extensive margin, intensive margin, and selection ($\sigma = 2.5$)



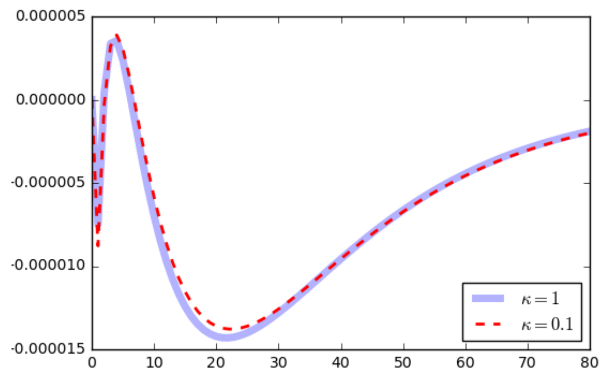
(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$

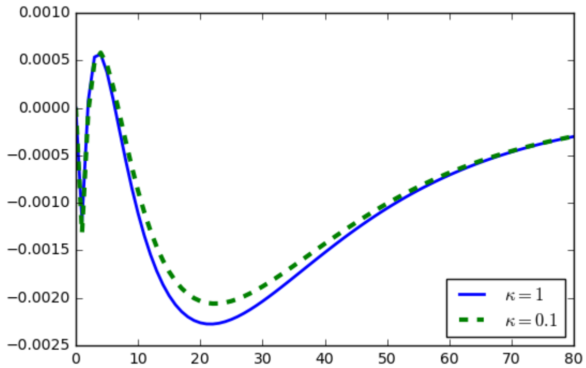


(c) Selection $(\tilde{a}_{X,t})$

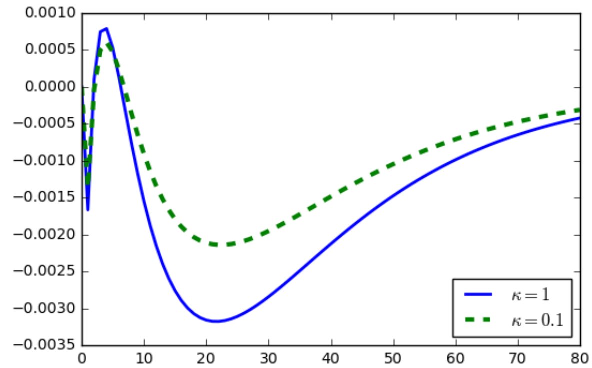


(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t})$

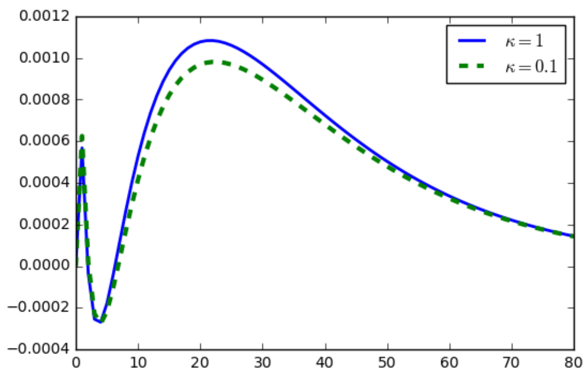
Figure A.8: Responses (percentage deviation) of extensive margin, intensive margin, and selection ($\sigma = 2.5$)



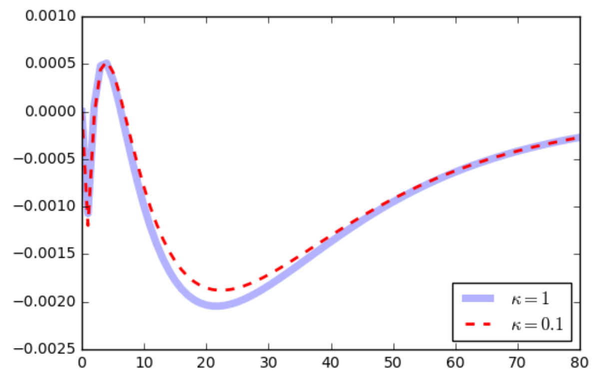
(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$

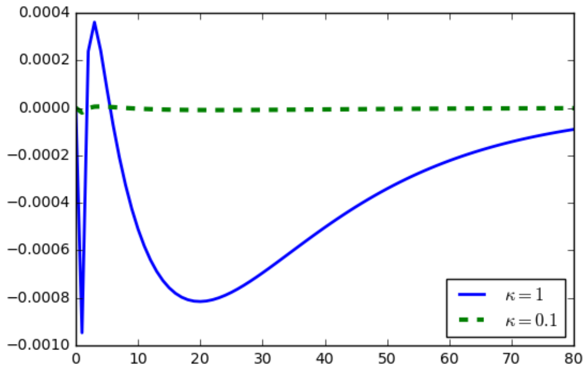


(c) Selection $(\tilde{a}_{X,t})$

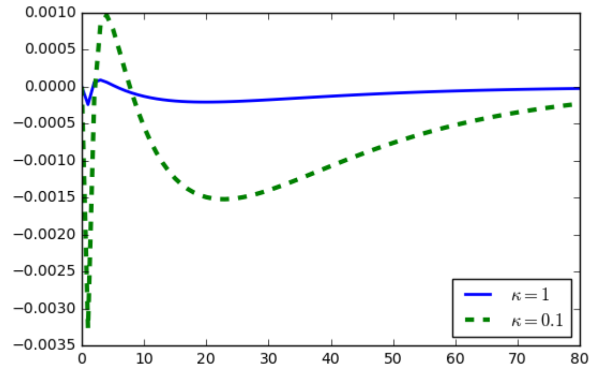


(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t})$

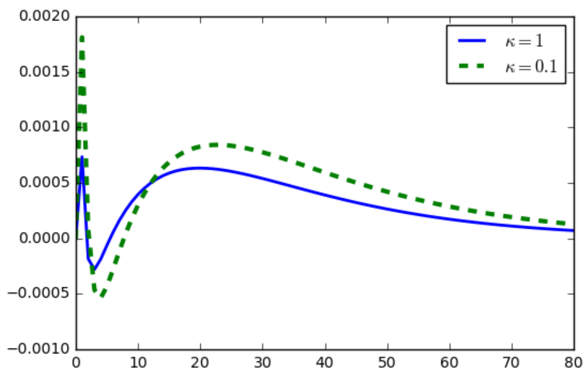
Figure A.9: Responses (level deviation) of extensive margin, intensive margin, and selection ($\sigma = 2.5$, $\alpha = 7.1$)



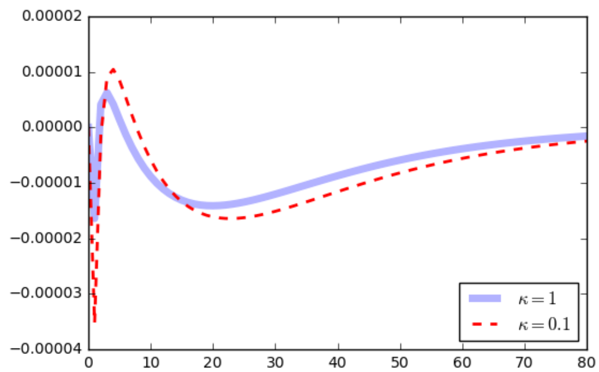
(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$

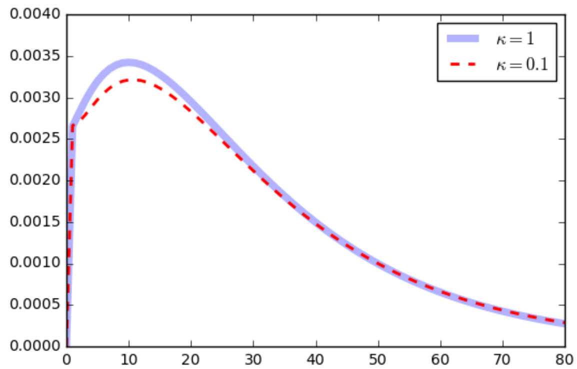


(c) Selection $(\tilde{a}_{X,t})$

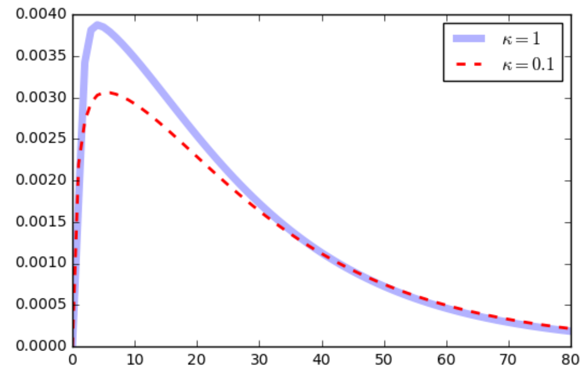


(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t})$

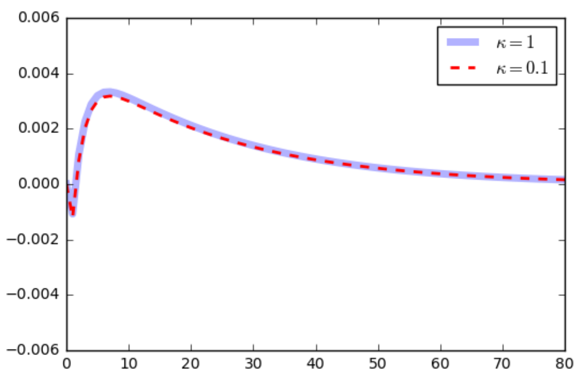
Figure A.10: Impulse responses with different α and κ ($\sigma = 2.5$)



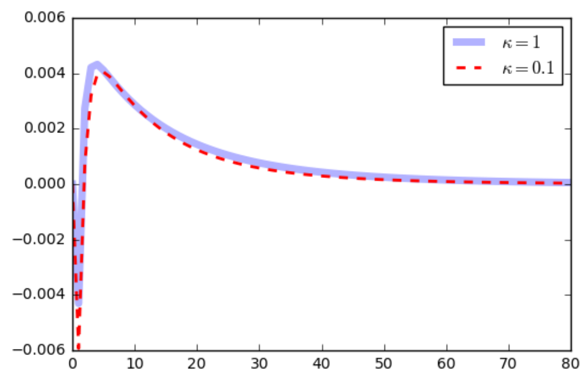
(a) GDP ($\alpha = 2.1$)



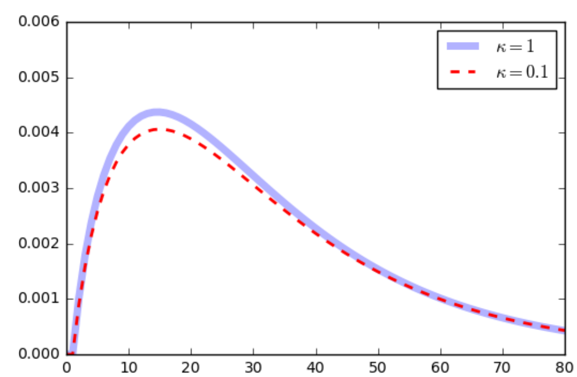
(b) GDP ($\alpha = 7.1$)



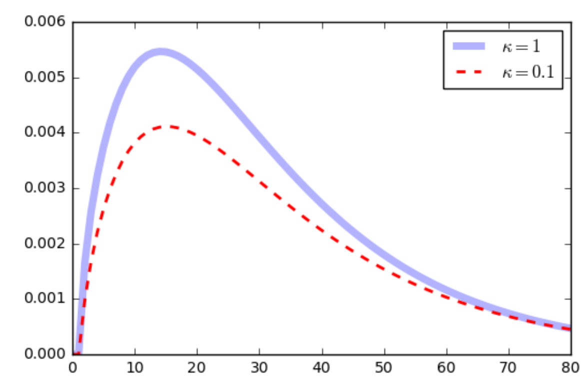
(c) X ($\alpha = 2.1$)



(d) X ($\alpha = 7.1$)

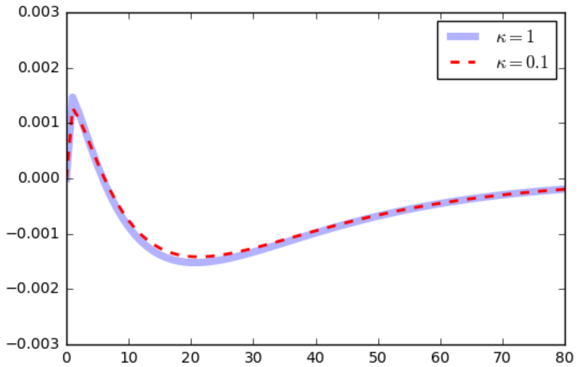


(e) M_D ($\alpha = 2.1$)

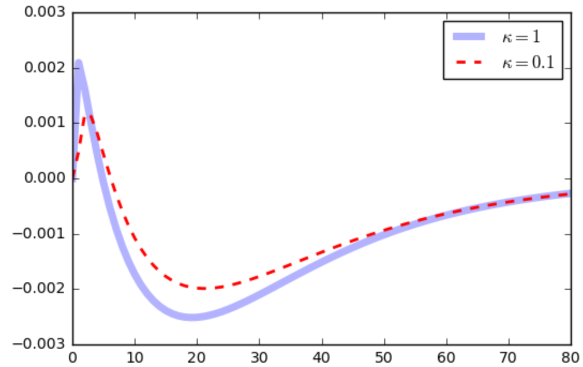


(f) M_D ($\alpha = 7.1$)

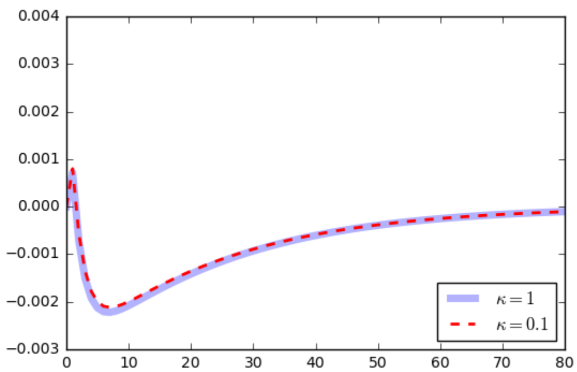
Figure A.10 (continued): Impulse responses with different α and κ ($\sigma = 2.5$)



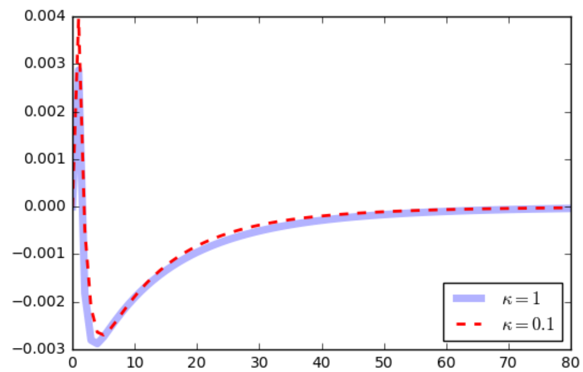
(g) $\tilde{\pi}$ ($\alpha = 2.1$)



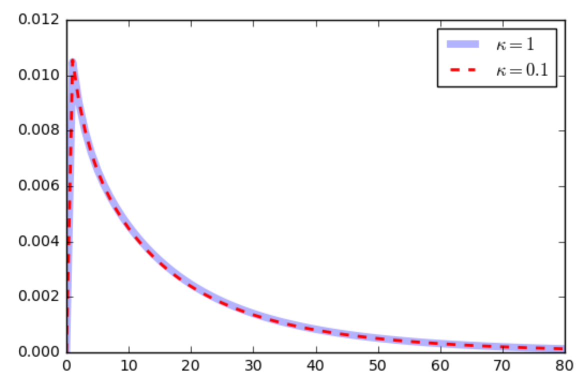
(h) $\tilde{\pi}$ ($\alpha = 7.1$)



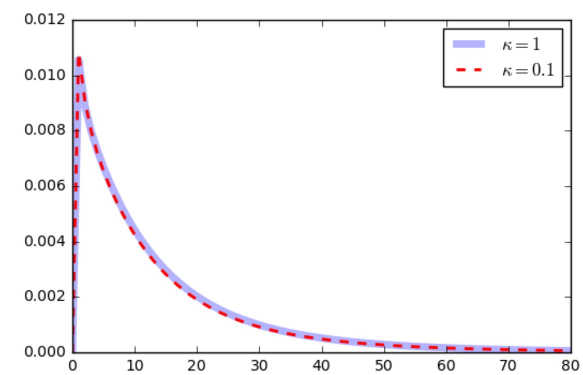
(i) P_X ($\alpha = 2.1$)



(j) P_X ($\alpha = 7.1$)



(k) W ($\alpha = 2.1$)



(l) W ($\alpha = 7.1$)

Figure A.11: Responses to a P^* shock of 1% ($\kappa = 1$)

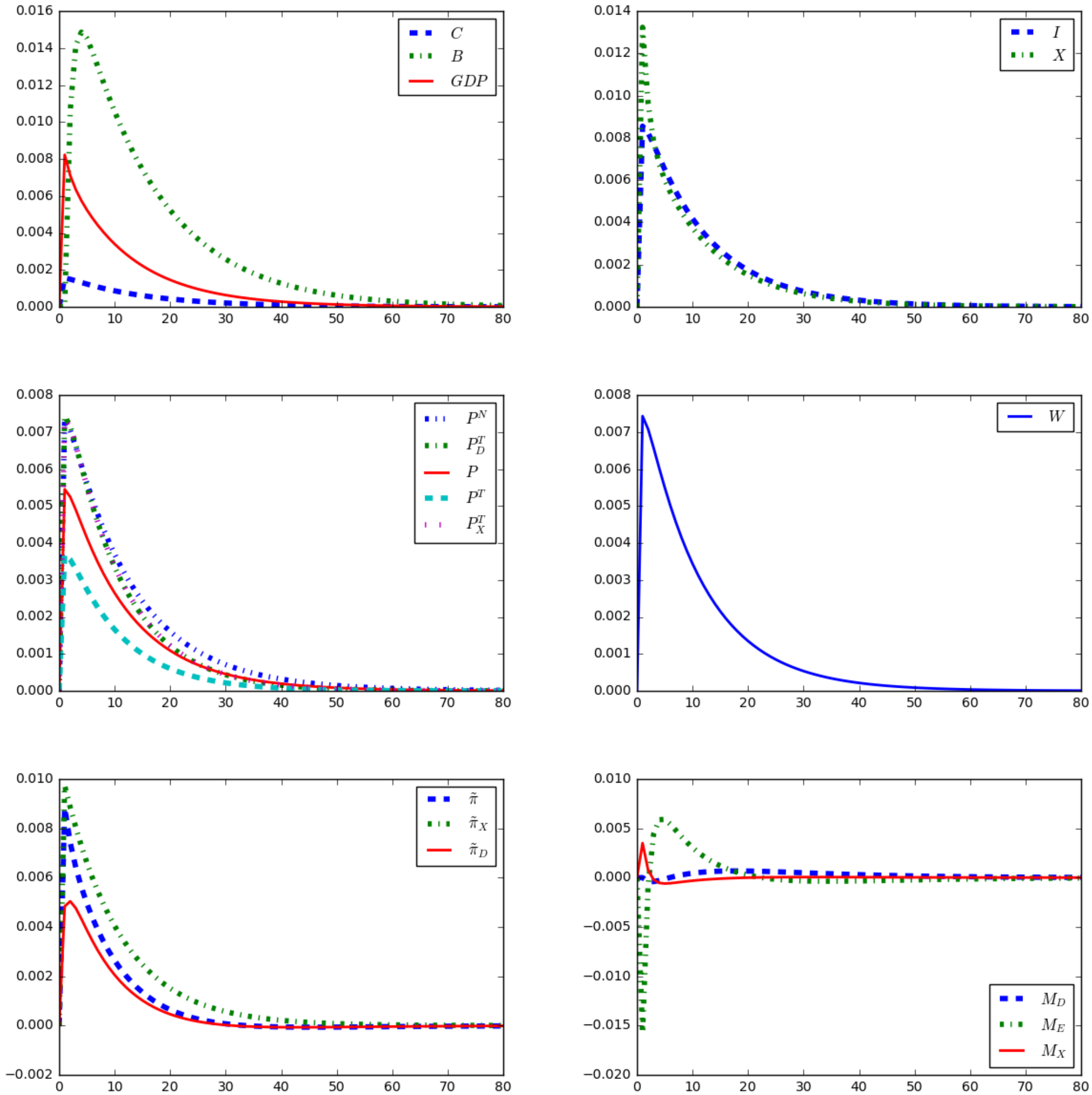


Figure A.12: Responses to a P^* shock of 1% ($\kappa = 0.1$)

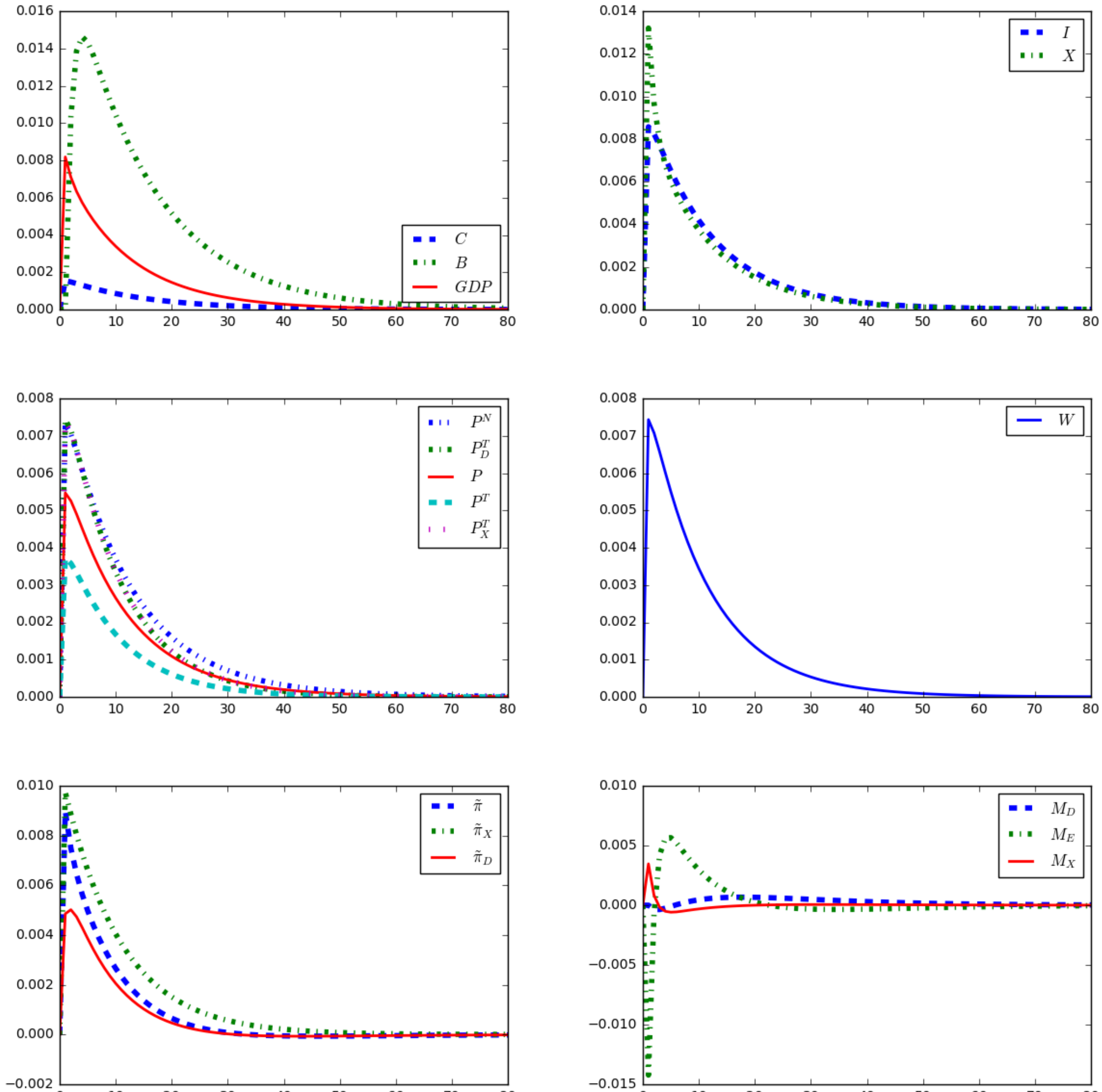
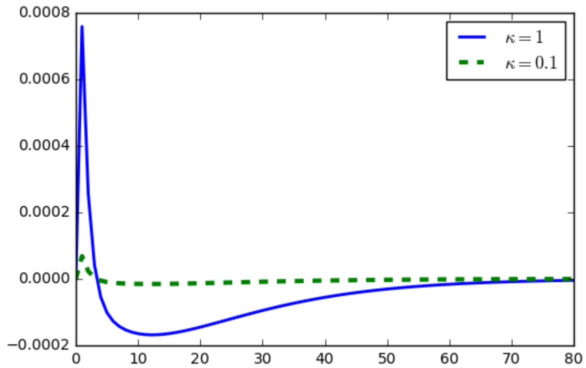
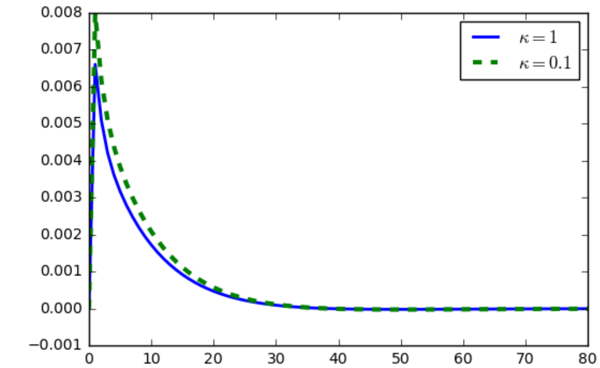


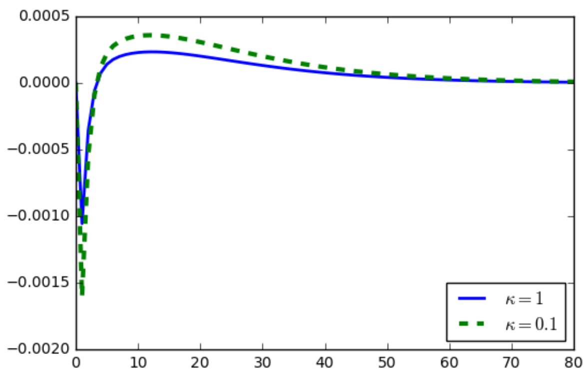
Figure A.13: Responses (level deviation) of extensive margin, intensive margin, and selection (P^* shock)



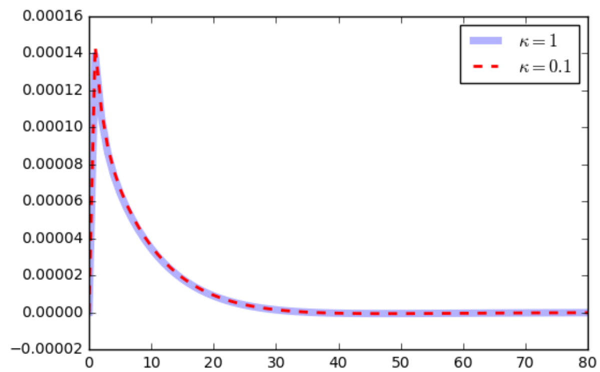
(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$

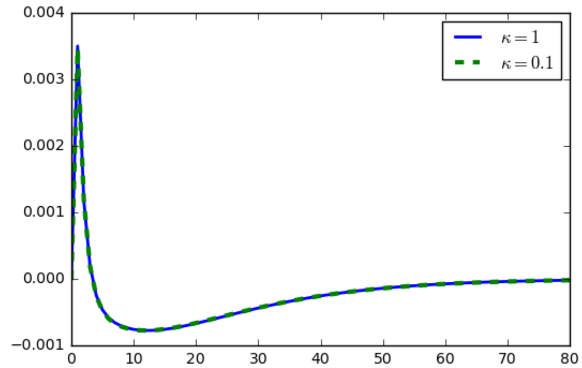


(c) Selection $(\tilde{a}_{X,t})$

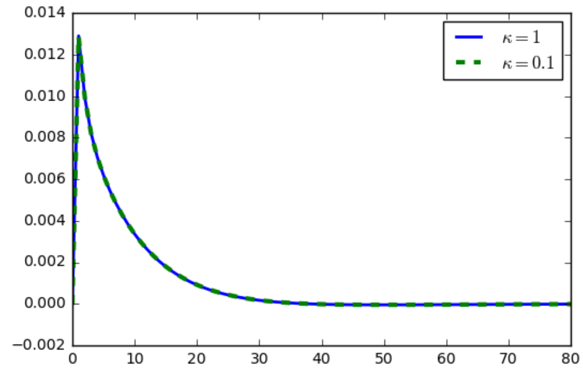


(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t})$

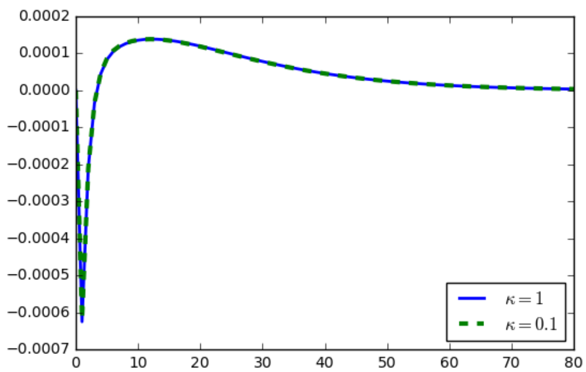
Figure A.14: Responses (percentage deviation) of extensive margin, intensive margin, and selection (P^* shock)



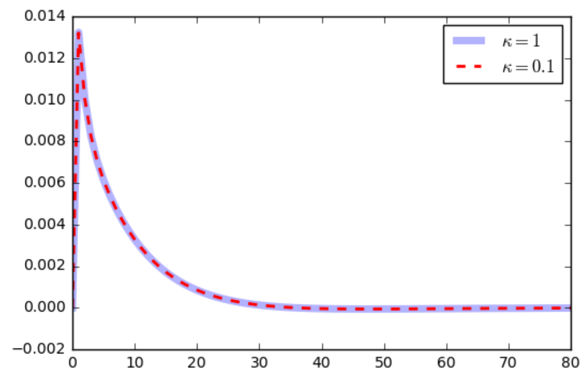
(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$



(c) Selection $(\tilde{a}_{X,t})$



(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t})$

Figure A.15: Responses to an A shock of 1% with zero CA ($\kappa = 1$)

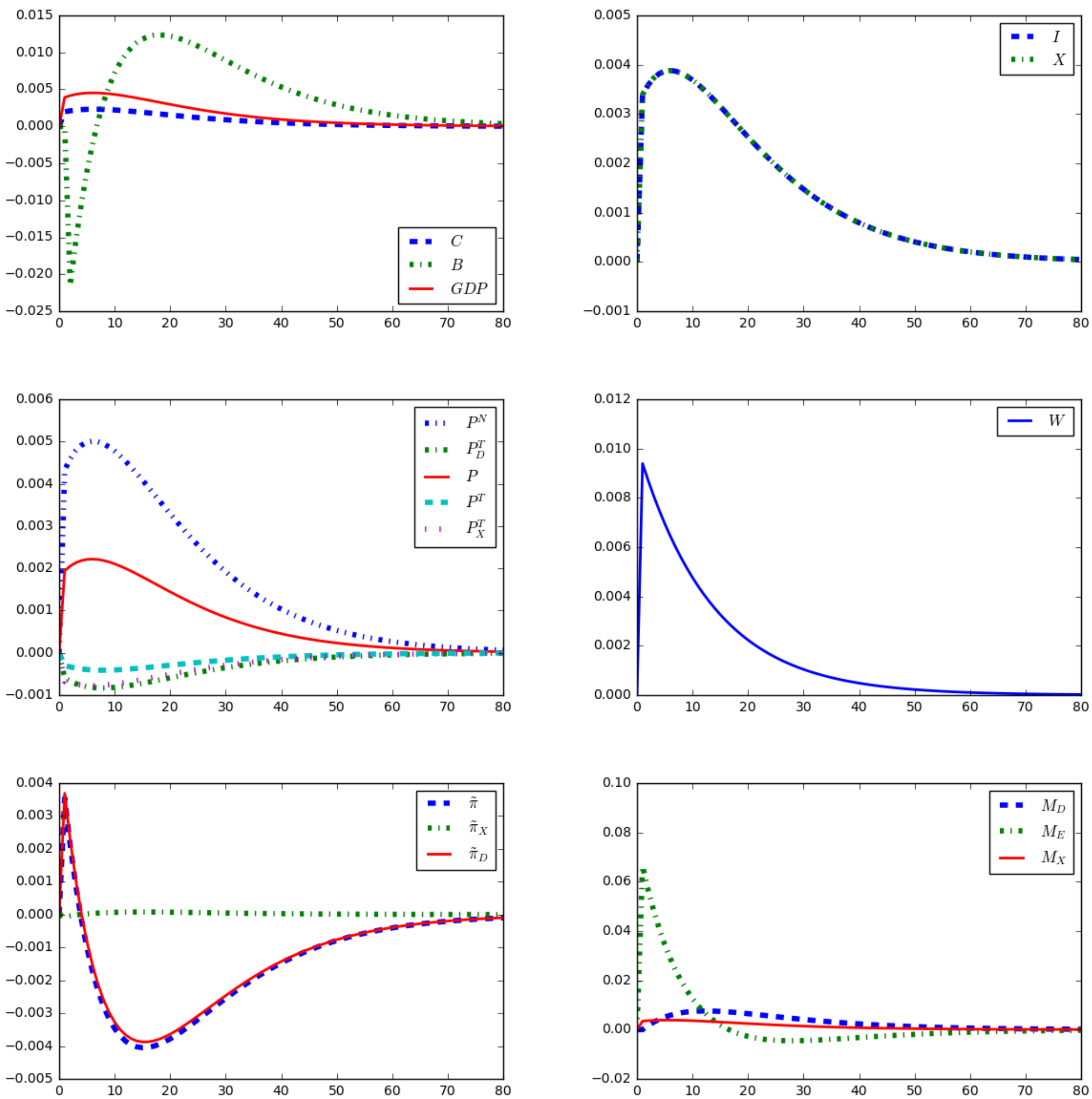


Figure A.16: Responses to an A shock of 1% with zero CA ($\kappa = 0.1$)

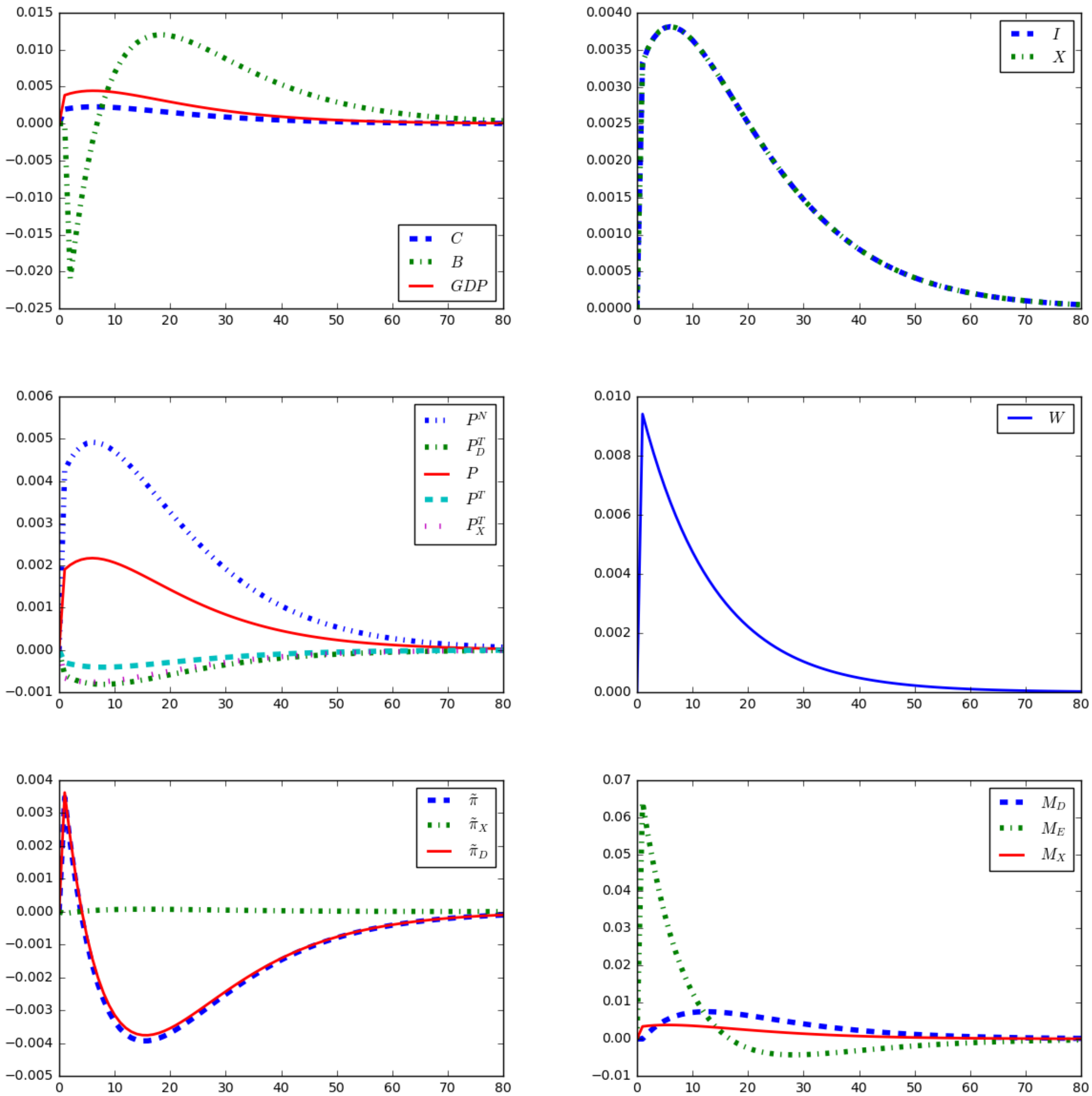
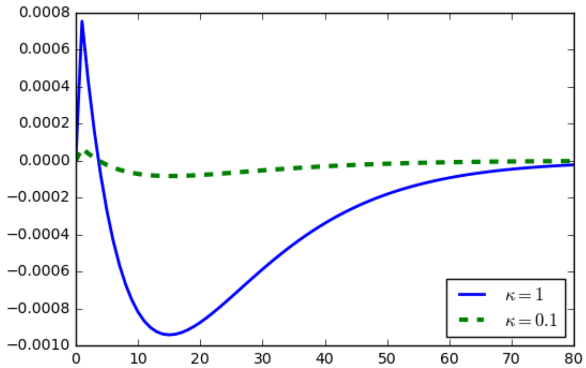
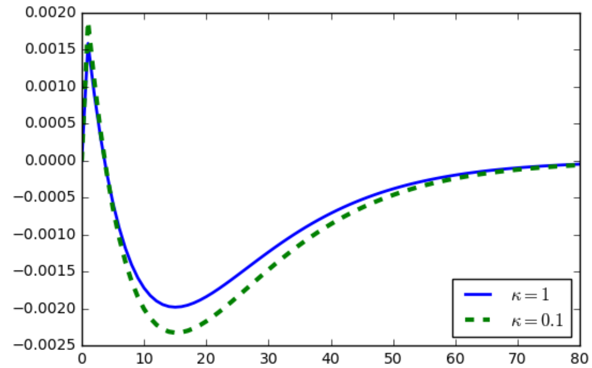


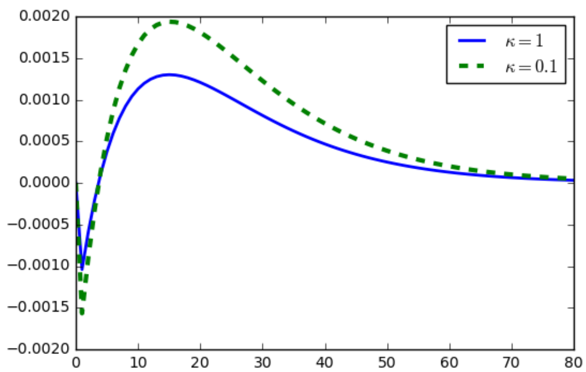
Figure A.17: Responses (level deviation) of extensive margin, intensive margin, and selection (zero CA)



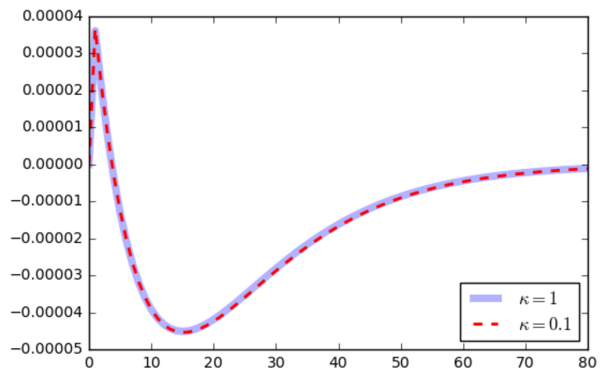
(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$

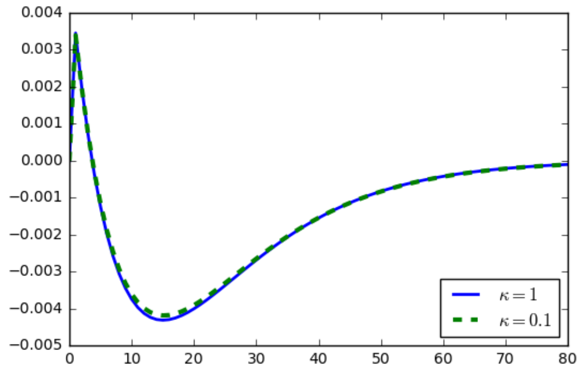


(c) Selection $(\tilde{a}_{X,t})$

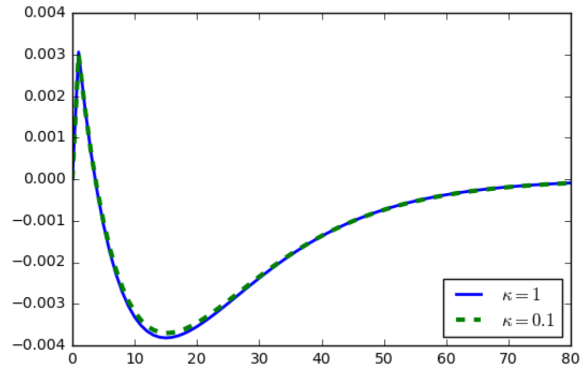


(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t})$

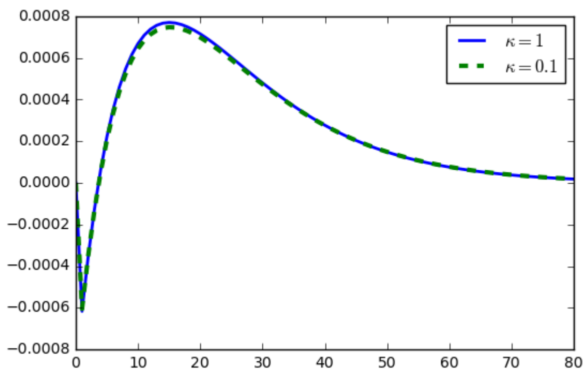
Figure A.18: Responses (percentage deviation) of extensive margin, intensive margin, and selection (zero CA)



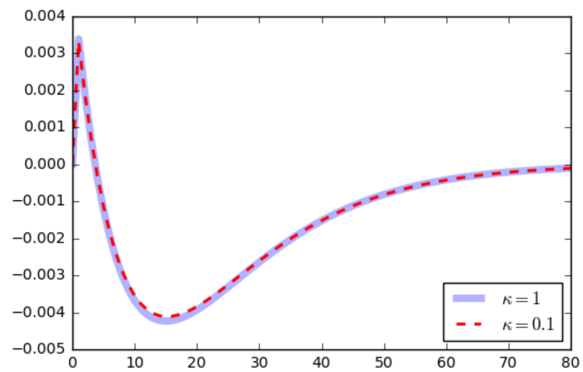
(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$



(c) Selection $(\tilde{a}_{X,t})$



(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t})$

Figure A.19: Responses to an A shock of 1% without the nontradable sector ($\kappa = 1$)

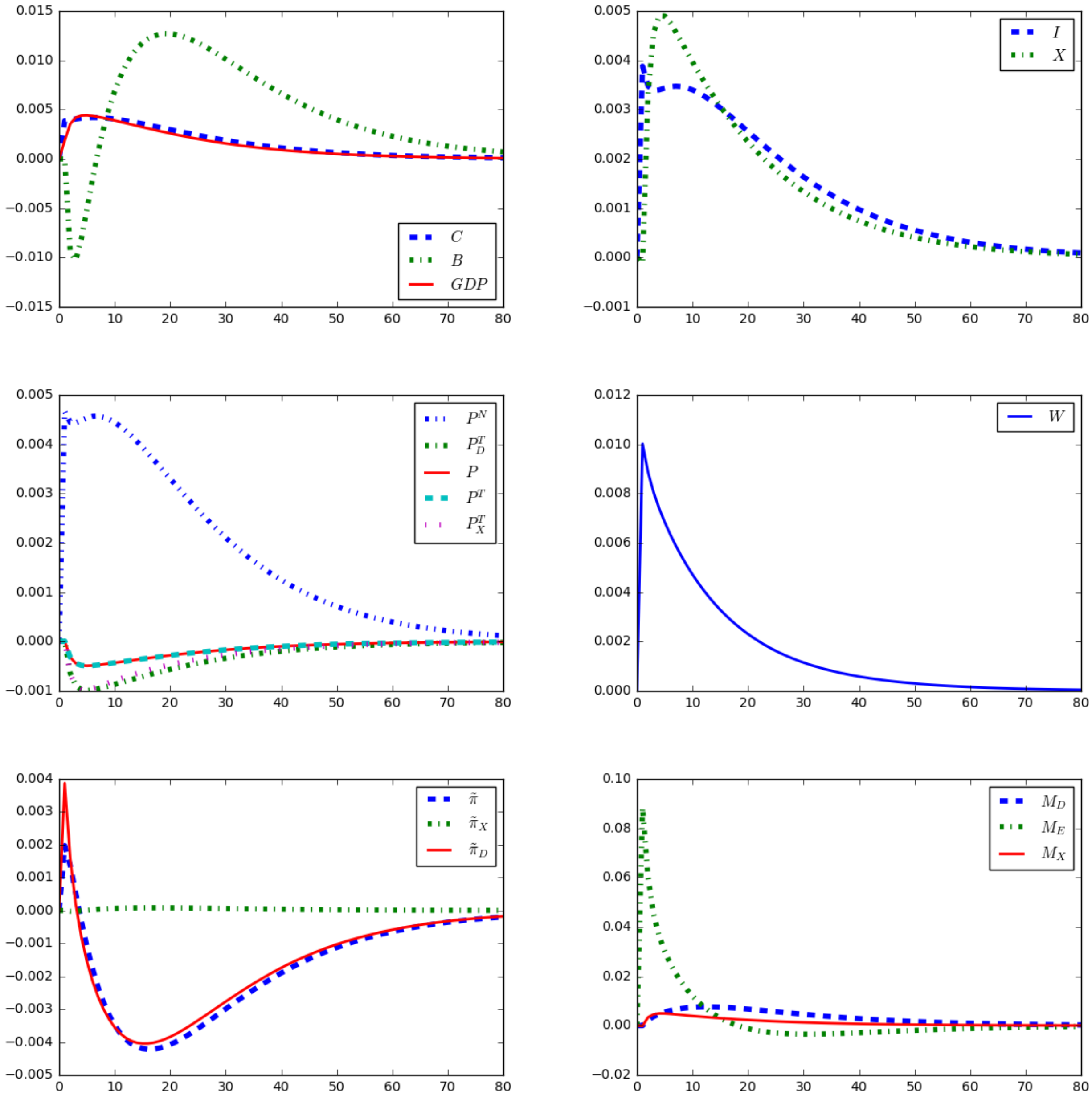


Figure A.20: Responses to an A shock of 1% without the nontradable sector ($\kappa = 0.1$)

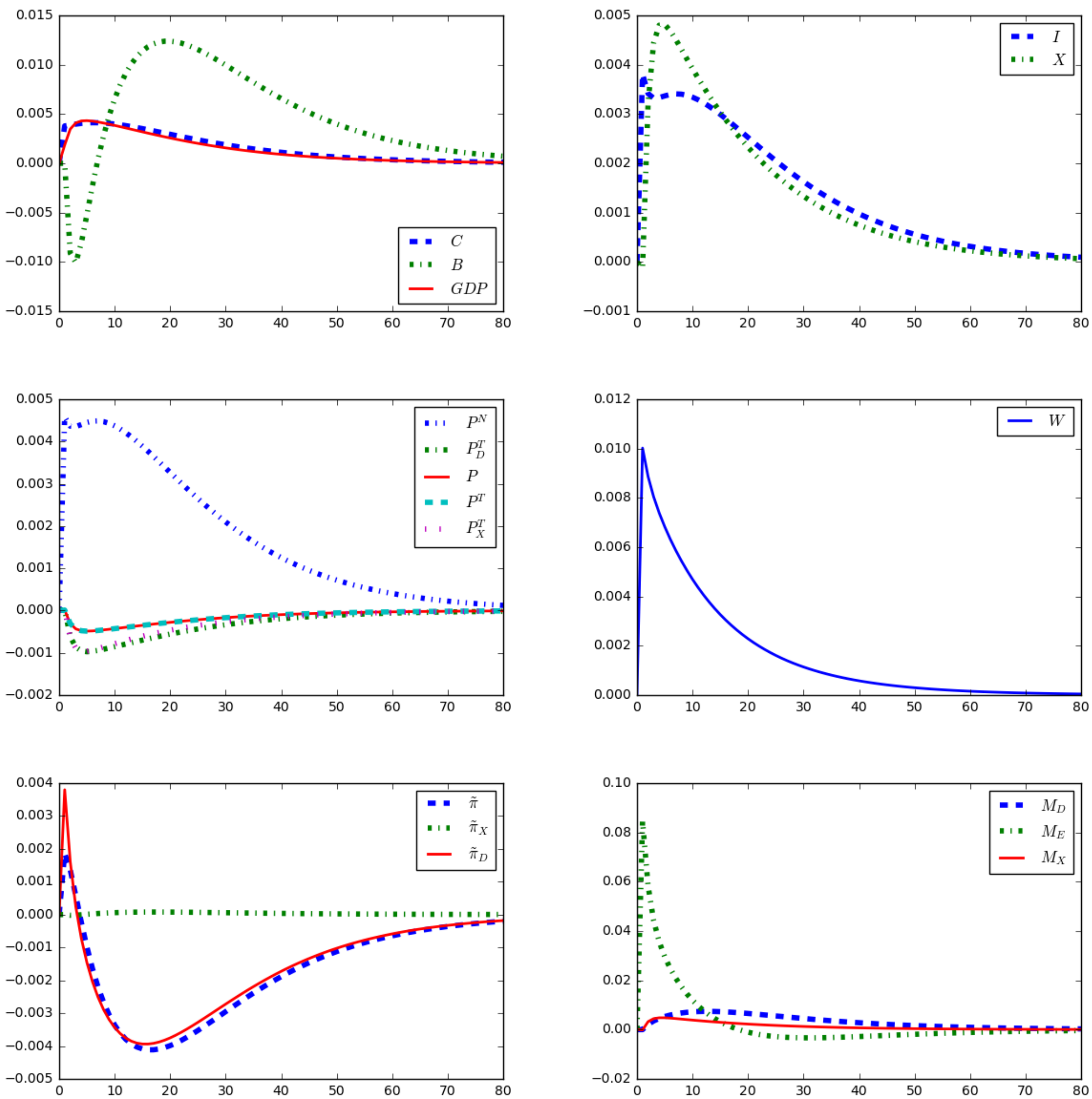
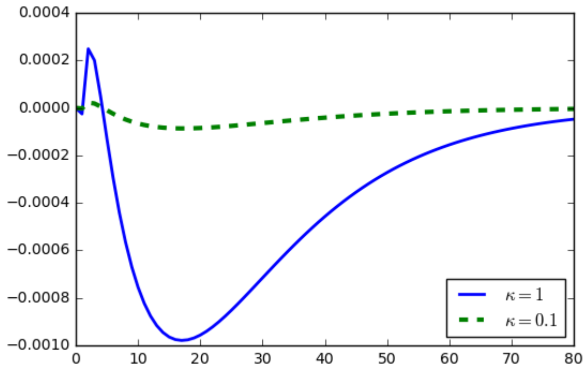
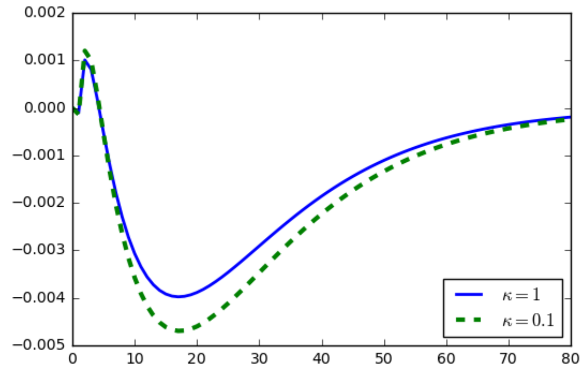


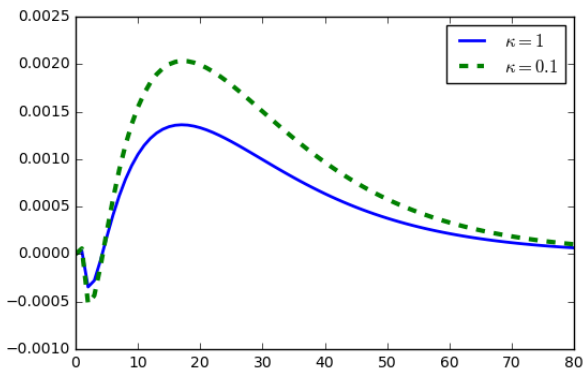
Figure A.21: Responses (level deviation) of extensive margin, intensive margin, and selection (without nontradables)



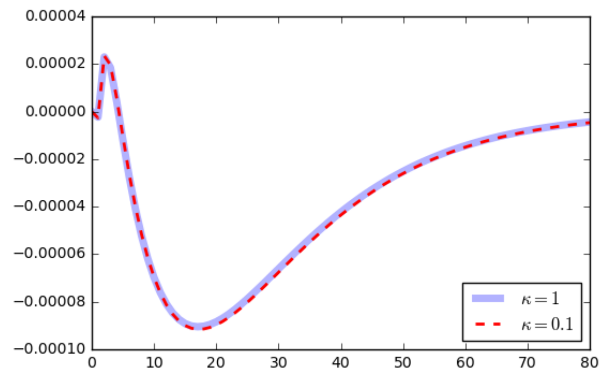
(a) Extensive margin $(1-G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$

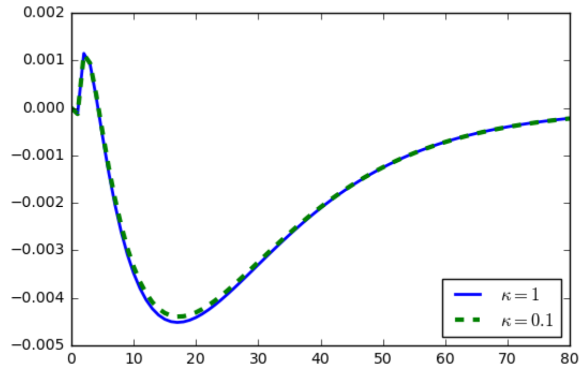


(c) Selection $(\tilde{a}_{X,t})$

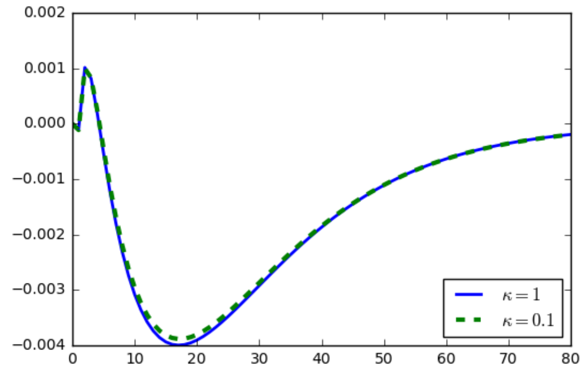


(d) Total export profit $((1-G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t})$

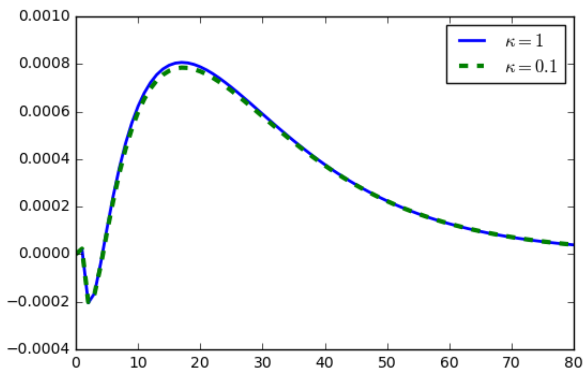
Figure A.22: Responses (percentage deviation) of extensive margin, intensive margin, and selection (without nontradables)



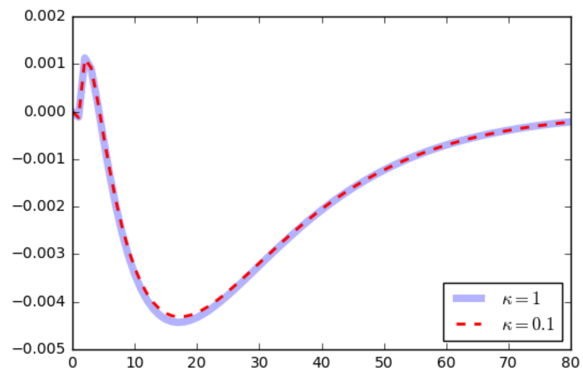
(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$



(c) Selection $(\tilde{a}_{X,t})$



(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t})$

Figure A.23: Responses to an A shock of 1% ($\kappa = 1$)

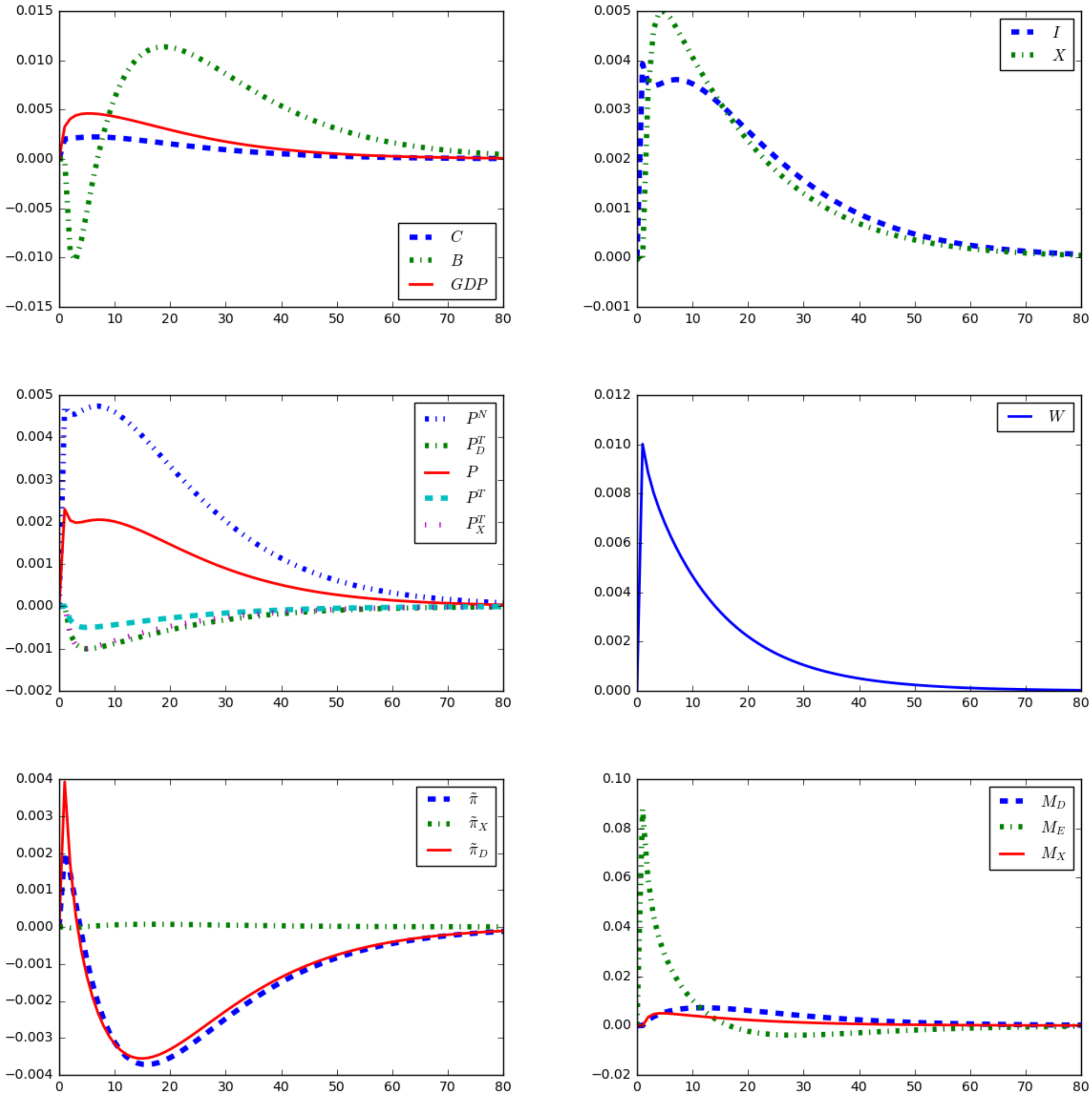


Figure A.24: Response to an A shock of 1% ($\kappa = 0.55$)

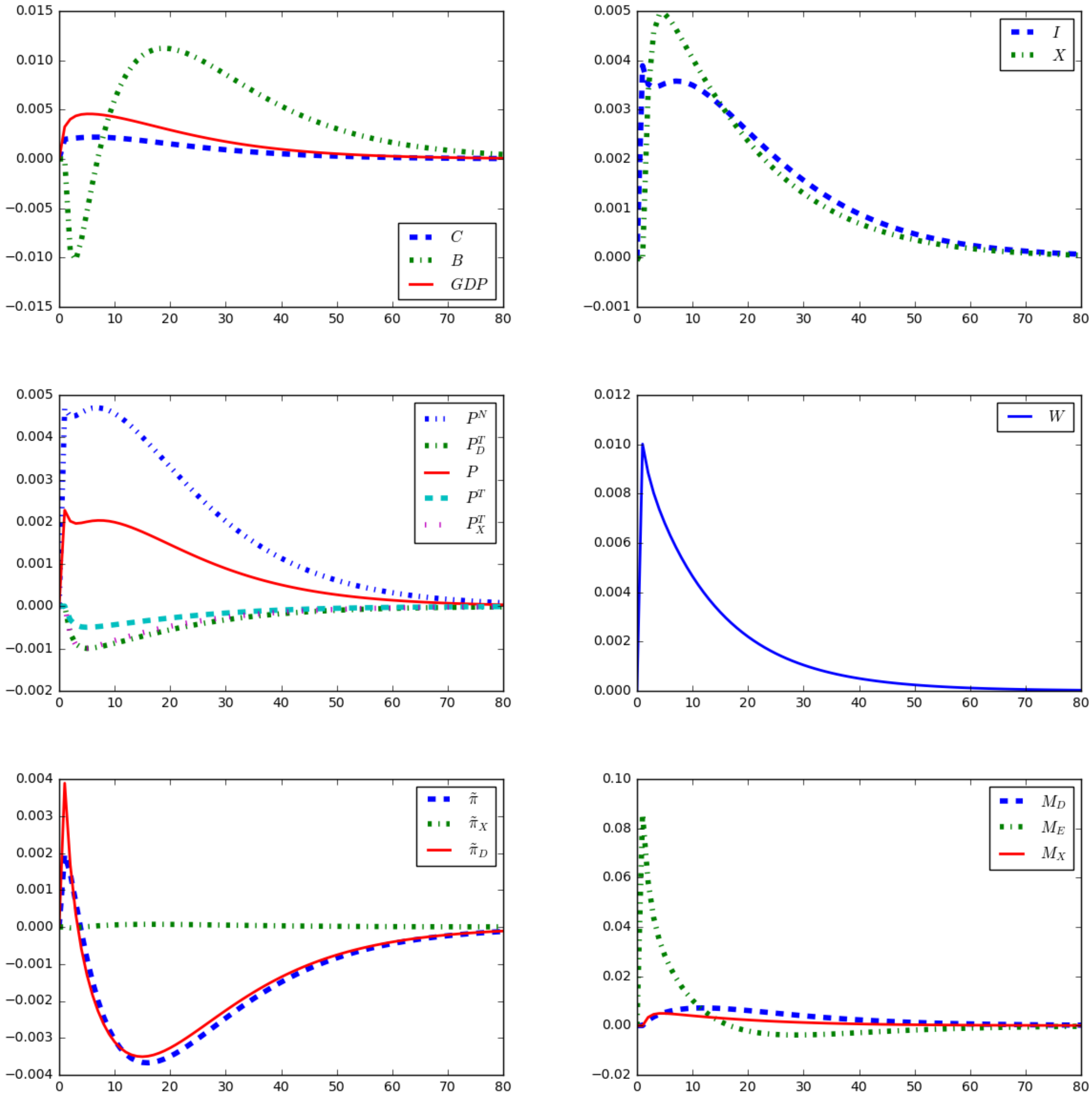
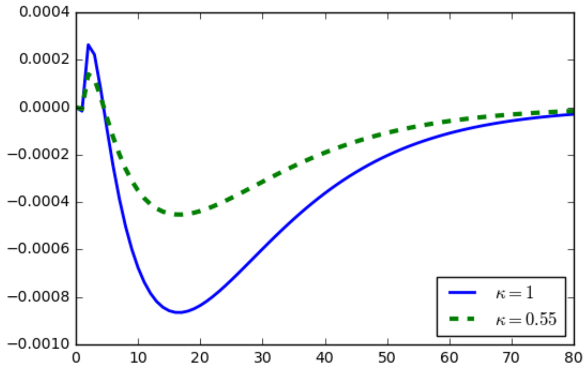
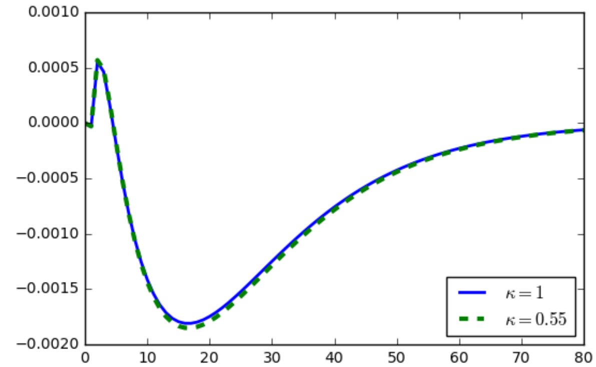


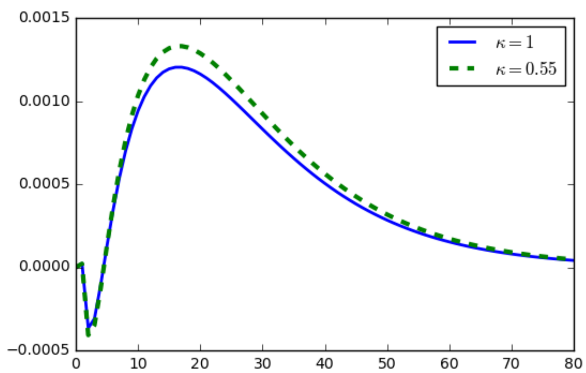
Figure A.25: Responses (level deviation) of extensive margin, intensive margin, and selection



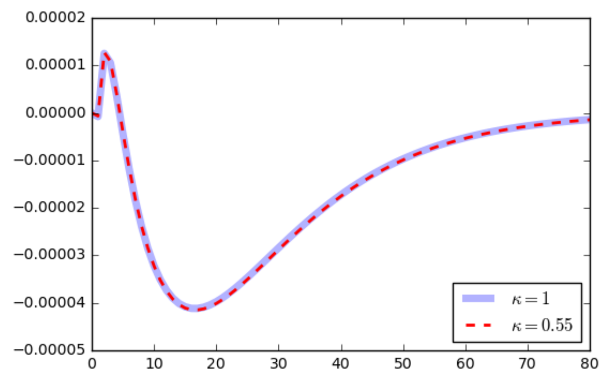
(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$

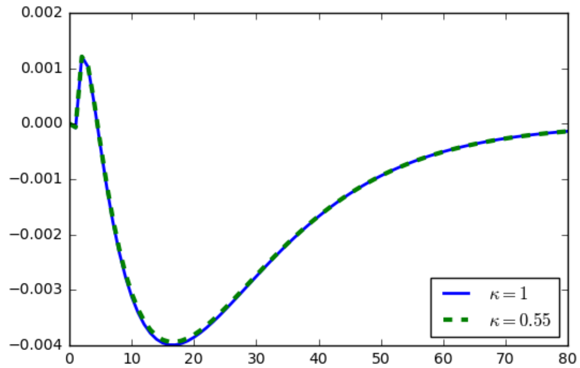


(c) Selection $(\tilde{a}_{X,t})$

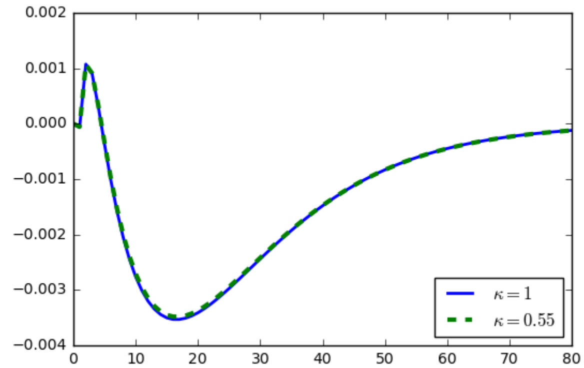


(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t})$

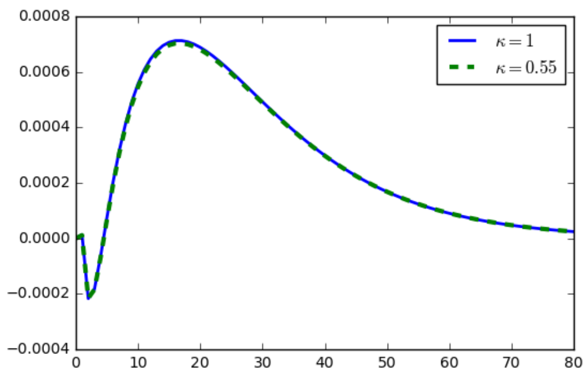
Figure A.26: Responses (percentage deviation) of extensive margin, intensive margin, and selection



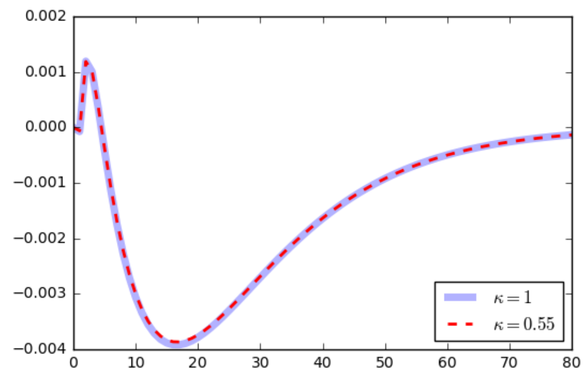
(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$



(c) Selection $(\tilde{a}_{X,t})$



(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t})$

Figure A.27: Responses to an A shock of 1% ($\kappa = 1$, $q_X^{rem} = 15$)

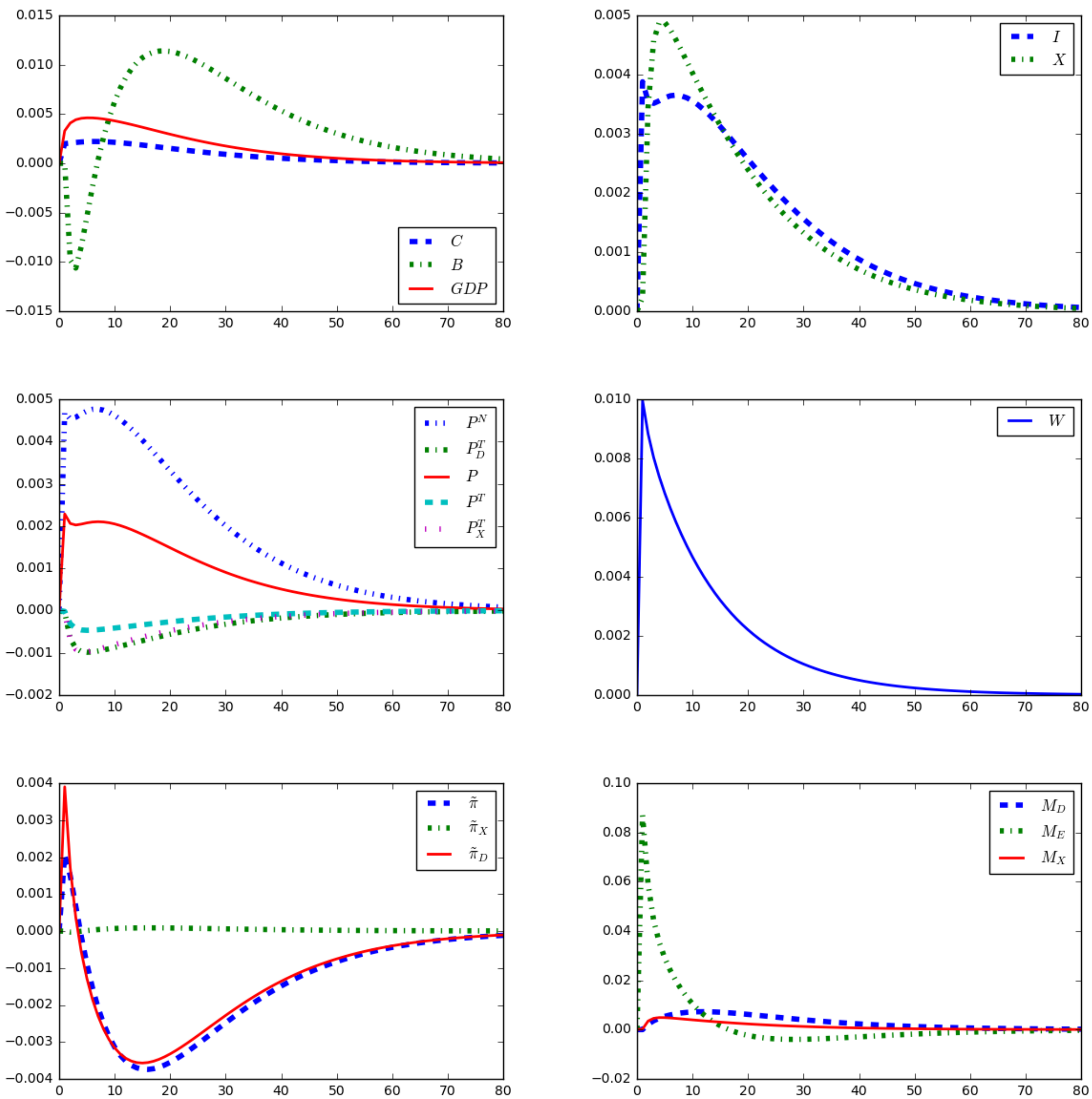


Figure A.28: Responses to an A shock of 1% ($\kappa = 0.1$, $q_X^{rem} = 15$)

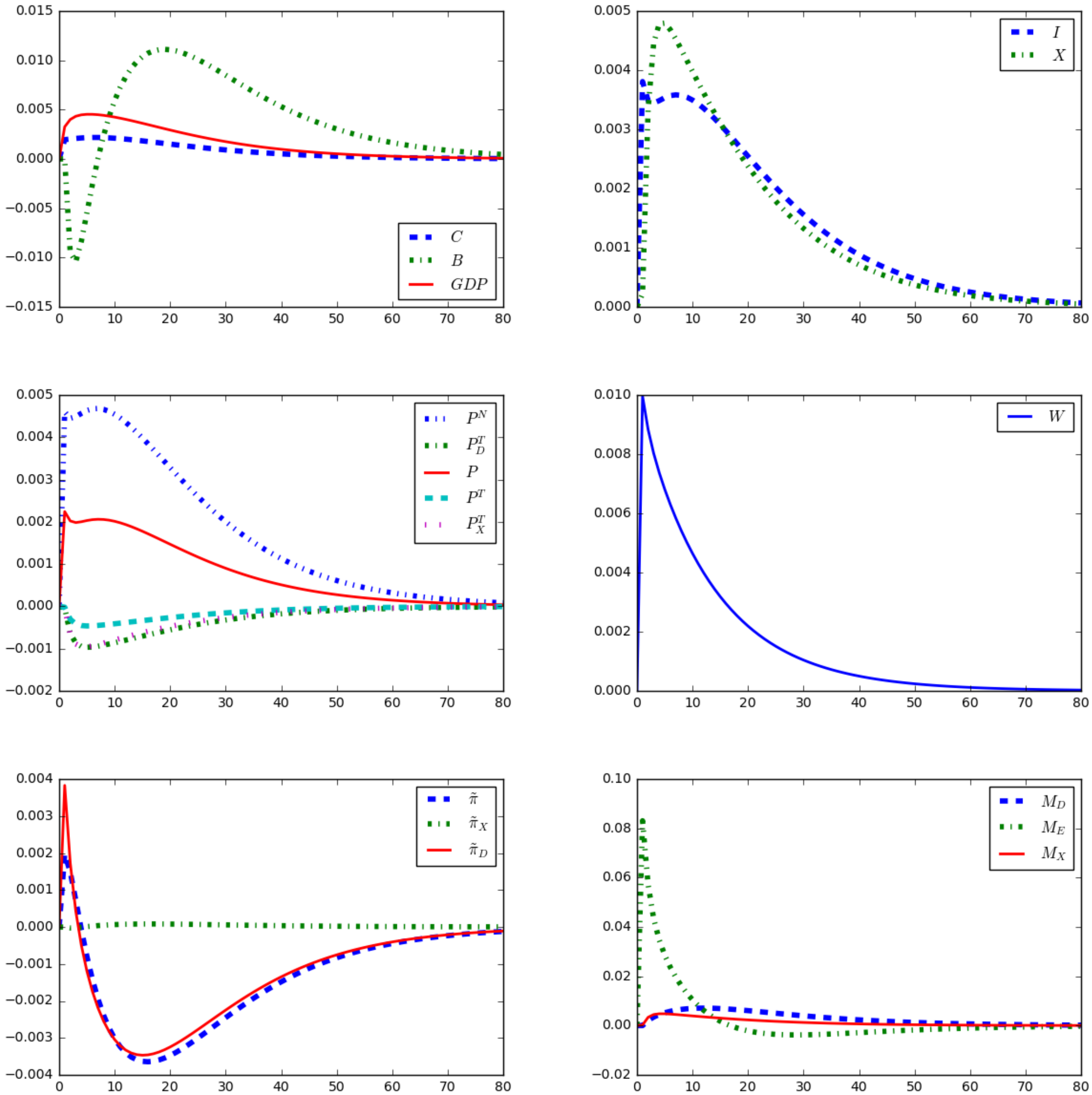
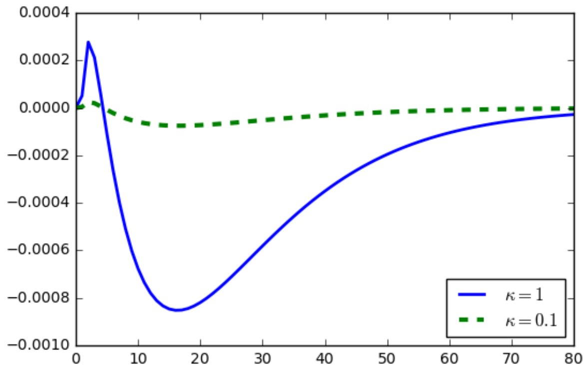
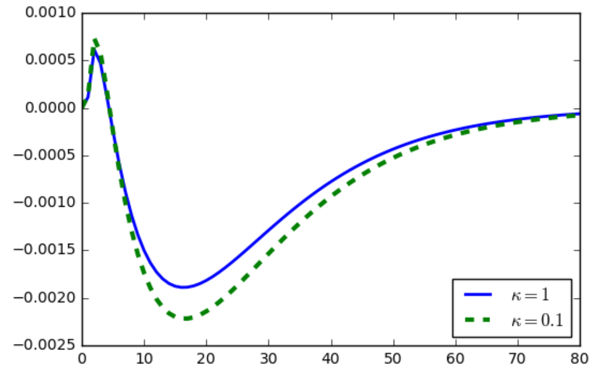


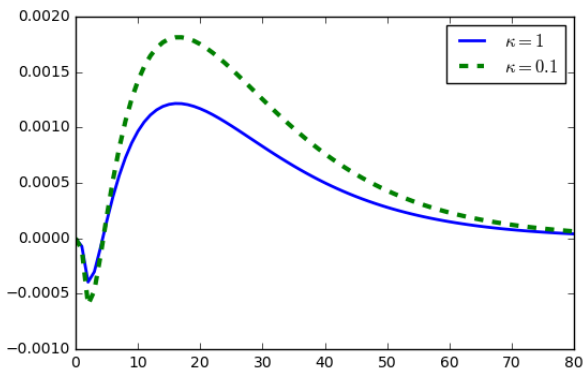
Figure A.29: Responses (level deviation) of extensive margin, intensive margin, and selection ($q_X^{rem} = 15$)



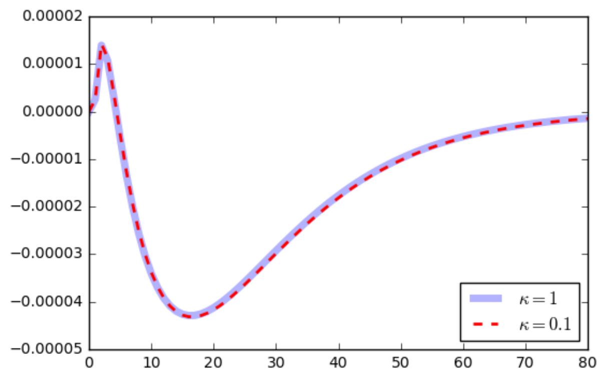
(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$

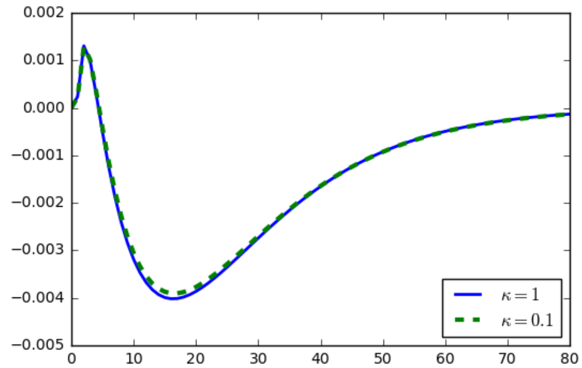


(c) Selection $(\tilde{a}_{X,t})$

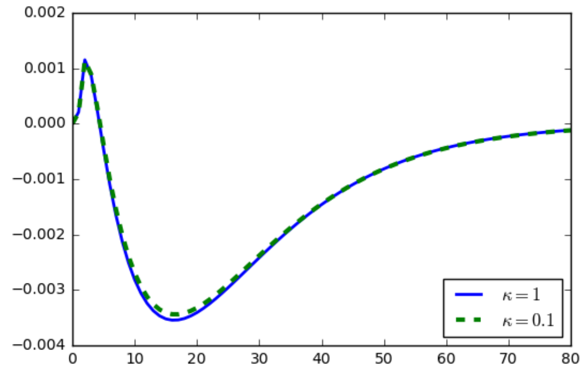


(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t})$

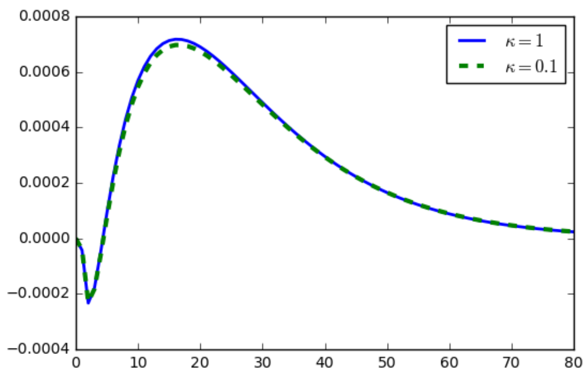
Figure A.30: Responses (percentage deviation) of extensive margin, intensive margin, and selection ($q_X^{rem} = 15$)



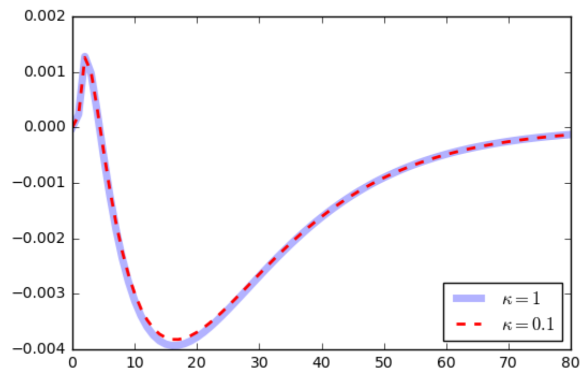
(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$



(c) Selection $(\tilde{a}_{X,t})$



(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{X,t})$

Figure A.31: Responses to an A shock of 1% (GHH, $\lambda = 0.001$, $\kappa = 1$)

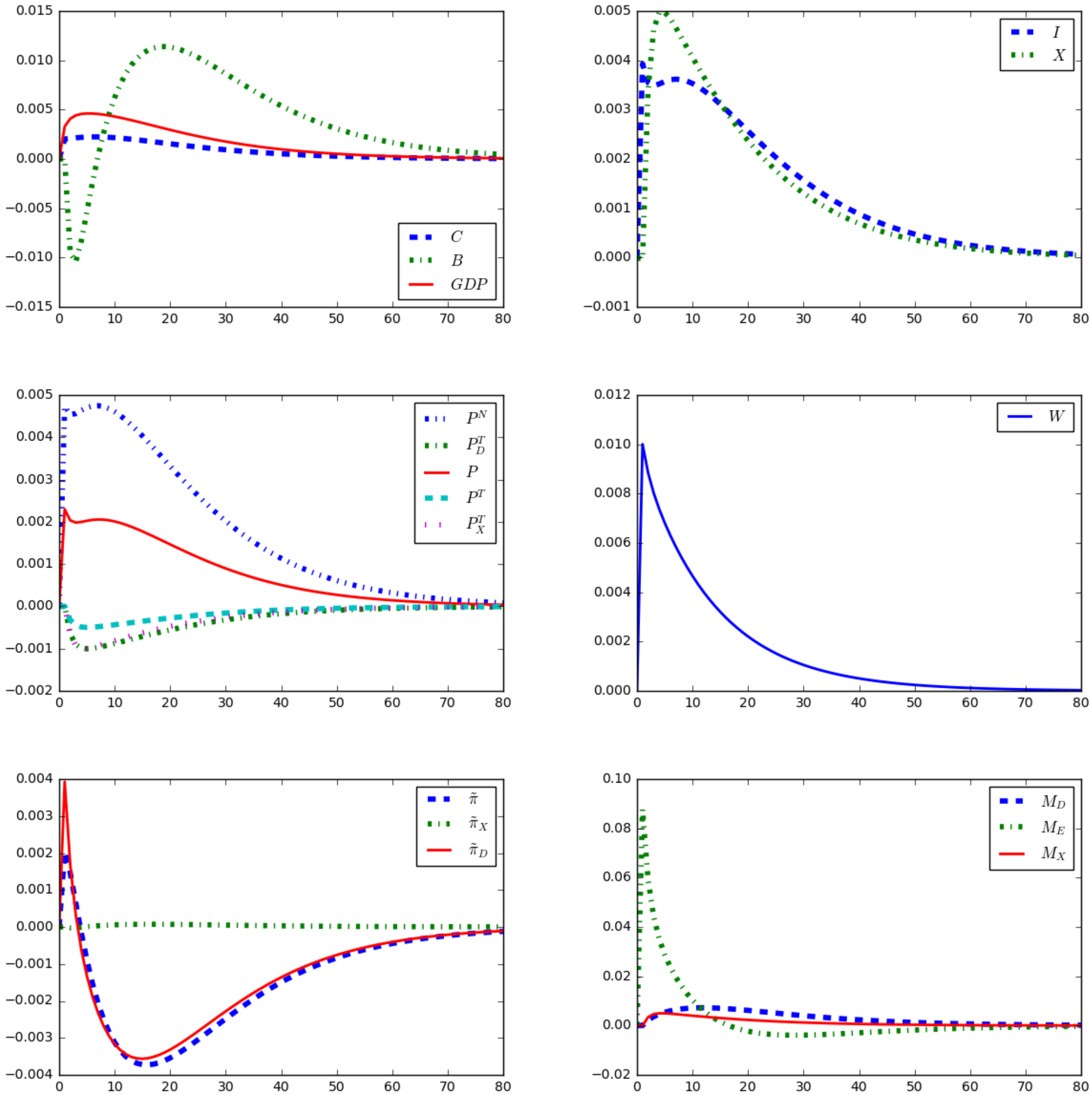


Figure A.32: Responses to an A shock of 1% (GHH, $\lambda = 0.001$, $\kappa = 0.1$)

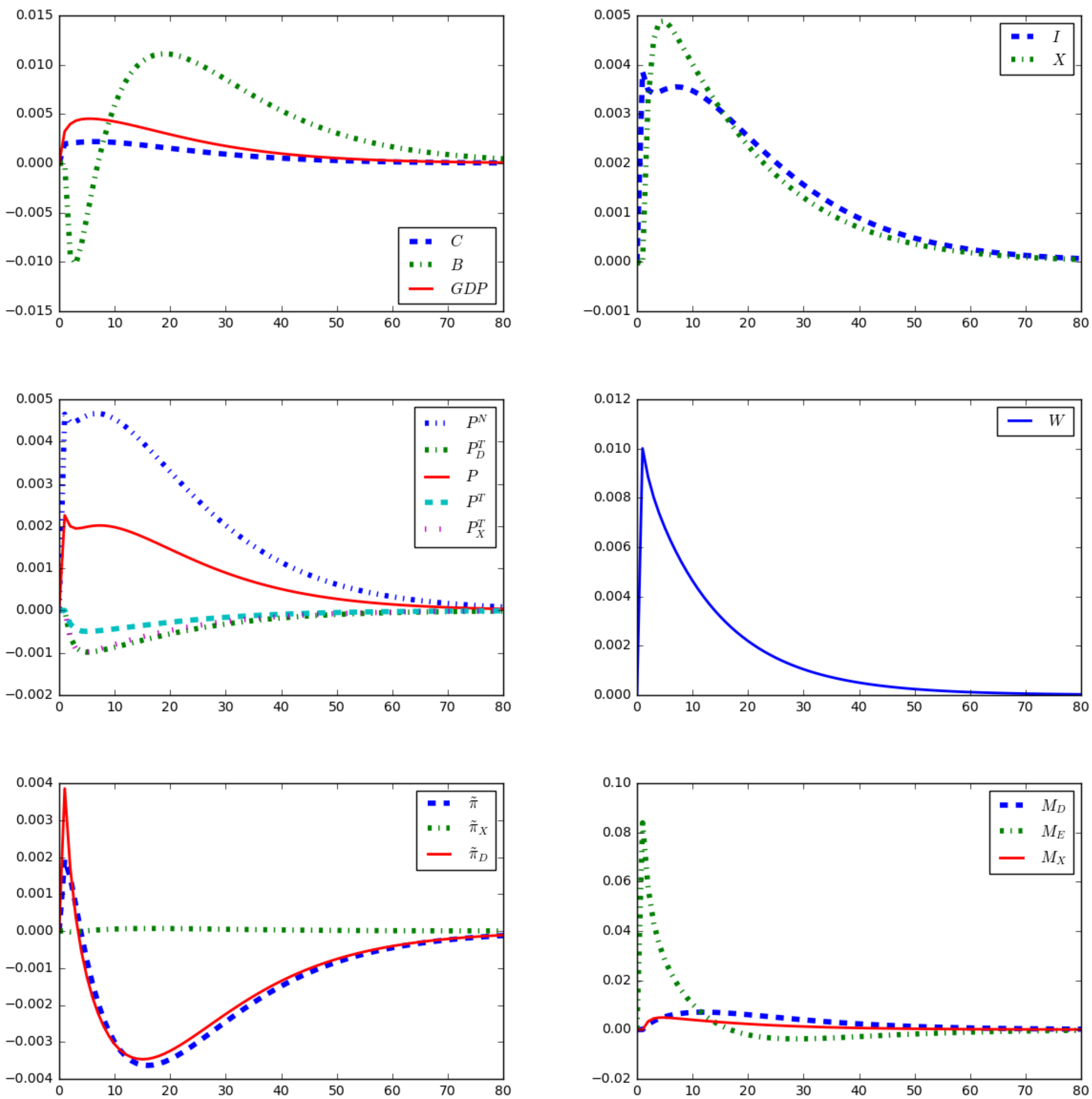
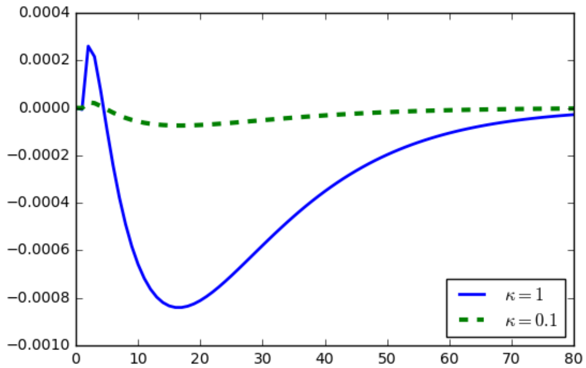
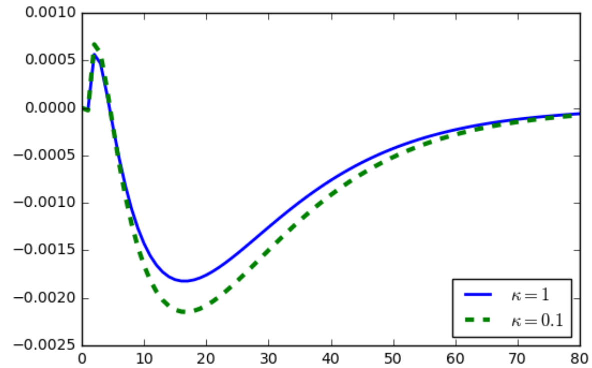


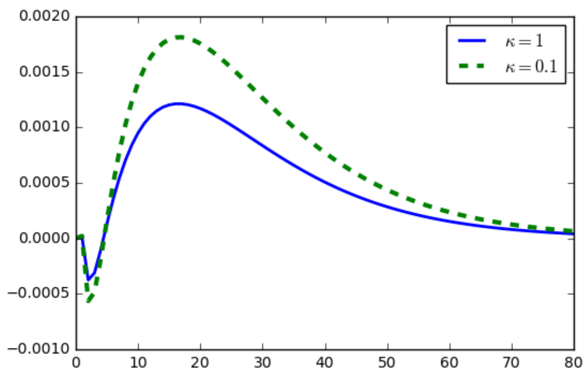
Figure A.33: Responses (level deviation) of extensive margin, intensive margin, and selection (GHH, $\lambda = 0.001$)



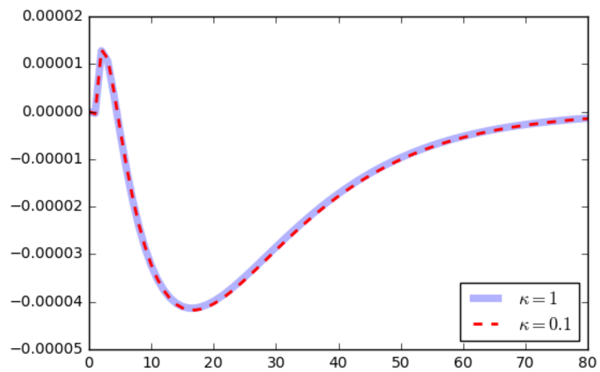
(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$

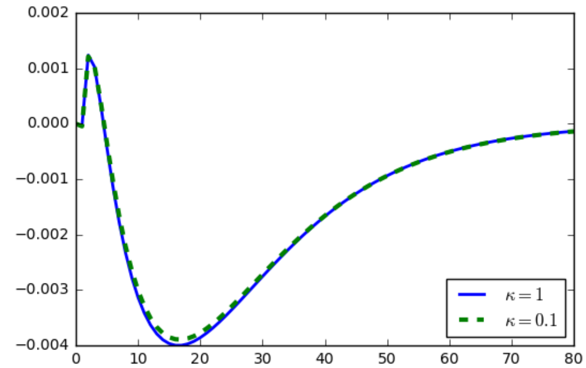


(c) Selection $(\tilde{a}_{X,t})$

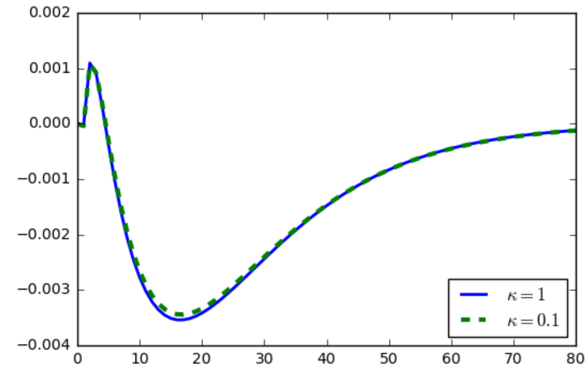


(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{\kappa,t})$

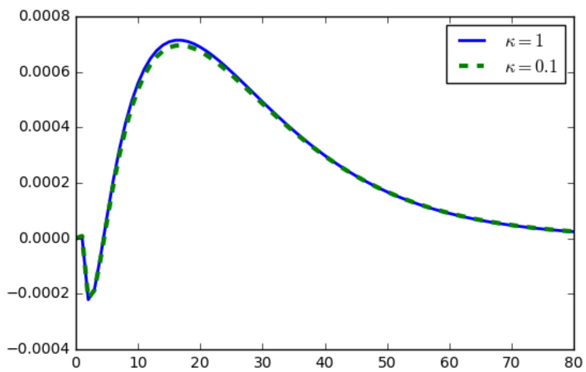
Figure A.34: Responses (percentage deviation) of extensive margin, intensive margin, and selection (GHH, $\lambda = 0.001$)



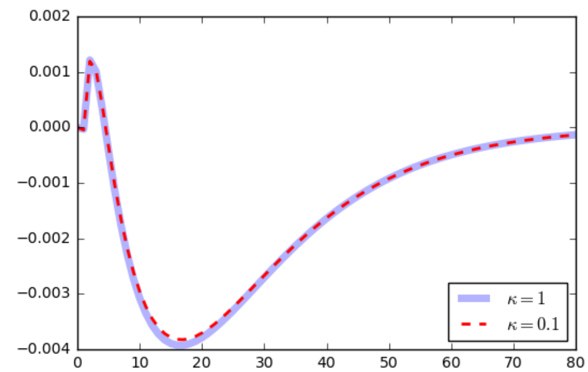
(a) Extensive margin $(1 - G(\bar{a}_{\kappa,t}))$



(b) Intensive margin $(\pi_{X,t}(\tilde{a}_X^{ss}))$

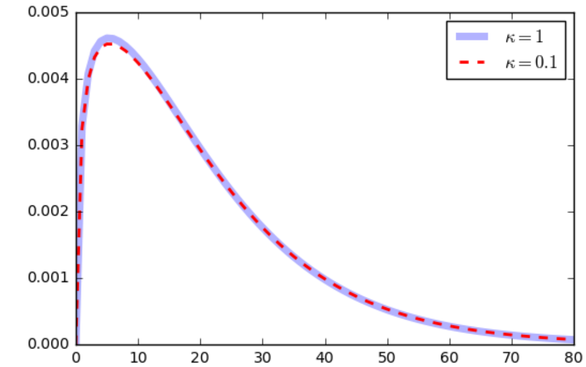


(c) Selection $(\tilde{a}_{X,t})$

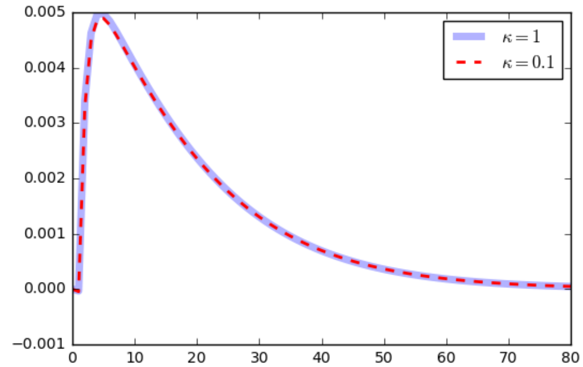


(d) Total export profit $((1 - G(\bar{a}_{\kappa,t}))\tilde{\pi}_{\kappa,t})$

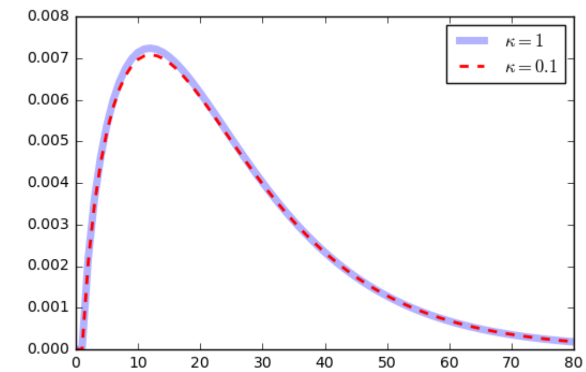
Figure A.35: Impulse responses (GHH, $\lambda = 0.001$)



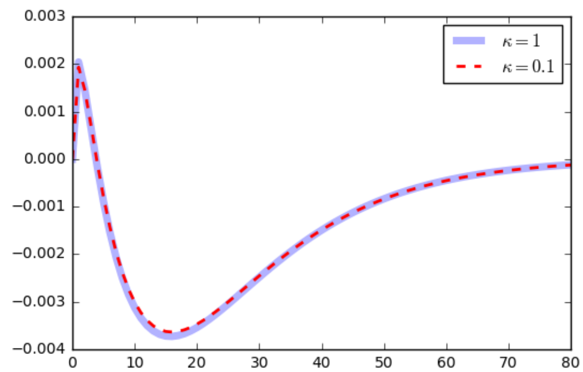
(a) GDP



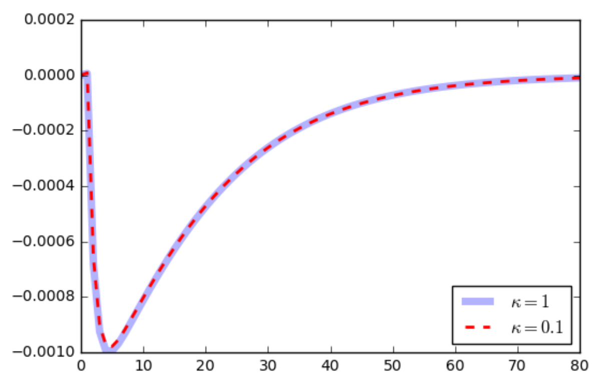
(b) X



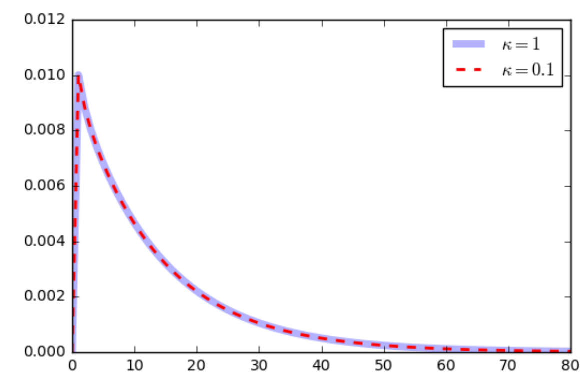
(c) M_D



(d) $\tilde{\pi}$



(e) P_X



(f) W