THREE ESSAYS IN APPLIED ECONOMICS

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Abstract

In this thesis, I apply economics analysis tools in various settings. My three essays in applied economics study the Great Trade Collapse in 2008-2009, policymaker's choice of intellectual property rights enforcement, and households' fertility decision under a cash-incentive pro-natalist policy.

Chapter 1, "Financial Shocks, Supply-chain Relationships and the Great Trade Collapse", studies the Great Trade Collapse during 2008-2009 using a two-country business cycle model enhanced with long-term supply-chain relationships. With limited resources, firms choose whether to invest in the domestic market or foreign market. In the model, firms endogenously reallocate scarce resources from international to domestic supply-chains, which are acquired and maintained at lower cost. Under a financial shock (mimicking the event of financial crisis), firms reallocate resources back home and drive the total trade to GDP ratio to fall.

Chapter 2, "Productivity, Political Economy, and Intellectual Property Rights", examines how policymakers' political considerations lead to a sub-optimal level of intellectual property rights enforcement. Assuming stricter intellectual property rights enforcement would lead to more firms adopting frontier technology. Without any political constraint, policymakers would maximize the level of enforcement. However, due to the resistance from low productivity firms, policymakers may make a trade-off between staying in power and strict intellectual property rights enforcement, and choose a weak Intellectual Property Rights enforcement.

My last chapter, Chapter 3, "Baby Bonus, Anyone? Examining Heterogeneous Responses to a Pro-Natalist Policy", examines the heterogeneous response of having a child to a universal pro-natalist program in Quebec, using the Census Masterfile. Here, family make trade-off between having children and forgone income due to rearing child, childcare, etc. In particular, we find that mid-income households and highly-educated women responded the most. Also, the policy affects both completed fertility and birth spacing.

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Contents

List of Figures

List of Tables

Declaration of Academic Achievement

Chapter 1 is co-authored with Professor Alok Johri. I am the sole author for Chapter 2. Chapter 3 is co-authored with Natalie Malak and Md Mahbubur Rahman. I participated in all stages of the research.

Introduction

In the Oxford dictionary, the term trade-off is defined as "balance achieved between two desirable but incompatible features". This term, trade-off, outlines the fundamental of applied economics and economists often use the term cost and benefit to capture tradeoffs. My thesis investigates the explanatory power of this concept by applying it to various settings ranging from households level decision to aggregate economy level decision. In particular, Chapter 1 examines the Great Trade Collapse during 2008 to 2009, Chapter 2 studies the political economy of intellectual property rights, and Chapter 3 studies the effect of a pro-natalist policy in Quebec.

Chapter 1 titled "Financial Shocks, Supply-chain Relationships and the Great Trade Collapse" studies the collapse in trade relative to GDP during 2008-09, which was unusually large historically. Moreover, it is puzzling relative to the predictions of canonical two-country models (e.g., Backus et al. (1992)). In a calibrated two country business cycle model enhanced with customer capital where firms must build supply chain relationships, we show that credit shocks can cause a fall in the trade-GDP ratio (43 percent of the observed value). The key mechanism involves an endogenous reallocation of scarce marketing resources from international to domestic supply-chains, which are acquired more cheaply. In particular, the firms make a trade-off between investing in the home market and investing the foreign market. Previous literature provides a few explanation to Great Trade Collapse. For example, Alessandria et al. (2010a) attribute that the inventory cycle plays an important role in the event. Amiti and Weinstein (2011) and Chor and Manova (2012) conclude that tightening the trade specific finance may have played a role in the Great Trade Collapse.

"Productivity, Political Economy, and Intellectual Property Rights", Chapter 2 of this thesis, is a theoretical work studying the relationship between intellectual property rights (IPRs) and productivity. A large amount of the difference in per capita income across countries is due to the high dispersion in productivity. Lucas (1988) and Prescott (1998) make a good illustration of this point. Nations with high productivity tend to have high levels of property rights protection and vice-versa (see (Aghion et al., 2015) and (Eicher and Newiak, 2013)). I developed a model in which the level of property rights is chosen by the policymaker and is simultaneously determined by the proportion of firms that decide to invest in frontier technologies. Firms that choose not to invest in the latest technology can copy older, less efficient technologies but are subject to state's enforcement. Non-frontier firms can influence the probability of the policymaker staying in power. Therefore, policymakers who would prefer an economy with high levels of investment in high productivity technologies (and high levels of property rights enforcement) may still choose low levels due to political economy considerations.

Under the assumption that higher level of intellectual property rights enforcement leads to higher productivity, the policymaker has to choose either stay in power for a longer period and earn smaller rent each period or stay in power for a shorter period but earn larger rent each period. I show that there can exist two equilibria. The existence depends on the substitutability of goods in the market and the political influence of non-frontier firms. The reason behind the existence of two equilibria is best describe as a choice of policymaker in Bai and Lagunoff (2011): "if the current ruler chooses his preferred policy, he then sacrifices future political power; yet if he wants to preserve his future power, he must sacrifice his present policy objective." This idea is sometime refereed as the "Faustian trade-off"

In Chapter 3, "Baby Bonus, Anyone? Examining Heterogeneous Responses to a Pro-

Natalist Policy", we examine the impact of the Allowance for Newborn Children, a universal baby bonus offered by the Canadian province of Quebec. Milligan (2005) provides an early assessment of the policy and find there is an average positive effect. Using the Census Masterfile, we estimate the heterogeneous effect of the allowance for Newborn Children applying the Difference-in-Difference approach on different sub-group in the population. In particular, we focus on different income, education, immigrant, and birth order groups. Ang (2015) and Kim (2012) also studies the heterogeneous effect of the policy. This chapter improve on our understanding of the pro-natalist policy in a few dimensions. Milligan (2002) and Kim (2012, 2014) are using the public-use census file to conduct the studies. Unfortunately, the public-use census files contain only 2% of the population answered the long-form Census. Also, it indicates only if a child under the age of six is present on the census day, not the actual age. With access to Census Masterfile we know the exact date of birth. Moreover, unlike past papers, a larger sample size allows us to examine the heterogeneous response to the Allowance for Newborn Children policy and to estimate meaningful marginal effects. Ang (2015) addresses the effect of the ANC on birth order, but does not delve into the spacing of births, changes in completed fertility, or sex preference and does not delve into the heterogenous effect on different groups except for birth parity, as we do.

If the responses are different across households with different characteristics, the cost of such pro-natalist policy could be reduced by focusing on sub-groups that response the most. Also, if the policy encourage household with low income to have more children, it may have a negative effect on intergenerational inequity as these households have less resources to invest in their children. Raute (2017) has similar motivation in her study on Germany's pro-natalist policy. In a modern economy, as female's labour force participation increases, a household has to choose to work or bearing a child. Consistent with Becker's quality and quantity model (see (Becker and Lewis, 1973) and (Becker and Tomes, 1976)), we find a hump shape response by income group, with the greatest response from mid-income families.

Women with some post-secondary education respond more to the policy than those who do not. We also find a large response for third or higher-order births for which the bonus was more generous. There is an effect in term of both completed fertility and birth spacing. These findings suggest pro-natal policies can successfully increase fertility and be cost-effectively structured by targeting specific households. For example, by giving to only the middle-income group, the government can save around 33 percent of the cost. Also, these findings suggest that the low income group does not respond a lot to the policy.

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Chapter 1

Financial Shocks, Supply-chain Relationships and the Great Trade Collapse

1.1 Introduction

World trade displayed an unusually large collapse during the Great Recession of 2008-2009 even after accounting for the unusually large recession experienced by the world. In the US, total trade as measured by the sum of real exports and imports fell to about 13% below trend while output fell 2.8% below trend. In this paper, we focus on the behaviour of the trade to GDP ratio in what follows in order to highlight the severity of the trade collapse during the Great Recession. Figure 1.1 reports the percentage deviation from trend for this ratio, calculated using the Hodrick-Prescott filter over the post-war period. The trade to GDP ratio fell to a trough that was 10.3% below trend, which is unprecedented in recent decades (the average trough in the trade-GDP ratio for all US recessions since 1947 is 6.5%).[1]

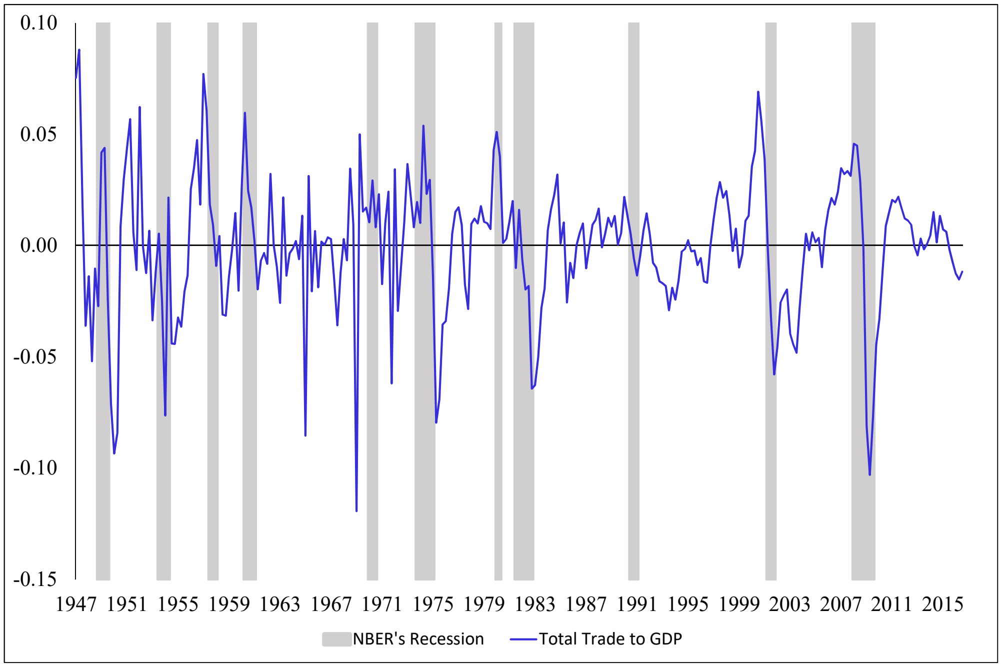

Figure 1.1: Trade to GDP ratio over time

Note: Quarterly trade and GDP data is detrended using the HP-filter with smoothing parameter of 1600.
Source: U.S. Bureau of Economic Analysis

Interestingly, this unusually large collapse in trade is difficult to reconcile with the quantitative predictions of canonical two-country business cycle models calibrated to the U.S., in that trade fell much more than would be predicted by the fall in overall economic activity or domestic absorption. Levchenko et al. (2010) shows that the “trade wedge" between the actual data and the canonical model’s prediction is extremely large during the recent collapse period.

In order to offer further insight into the unusually large drop in the trade-GDP ratio, we build a quantitative dynamic general equilibrium model in which an aggregate shock that tightens credit, reduces demand for both domestic and foreign intermediate goods, however, an endogenous reallocation of marketing inputs towards the domestic market by intermediate

[1]Figure 1.12 in Appendix shows a similar graph for 20 countries during the year 2005 to 2010.

producers causes cross-border trade to fall more than within-border trade and thus, more than GDP. Our model involves a world with trading frictions in which producers cannot sell directly to the end user. Instead, they must deal with other firms which are part of the distribution network of the economy, whom we call middlemen. Both producers and middlemen incur expenses in building long term supply chain relationships that allow produced goods to be sold to the eventual user. Below, we discuss details of our modeling strategy while also highlighting the related quantitative models.

We explore the trade collapse in a two-country real business cycle model where firms must spend resources in order to build a stock of supply-chain relationships (i.e., relationships where firms are the customers of other firms) to sell their product. As an example, think of firms that operate in the wholesale market as opposed to the retail market. Producers must convince these wholesale firms to carry their products and spend substantial amount of resources to do so.[2] Some examples of occupations that fall into this category of activity, taken from the Occupation Employment Statistics are: marketing managers; sales managers; advertising and promotions managers; parts salespersons; advertising sales agents; sales representatives, wholesale and manufacturing.[3]

In our two-country framework which builds on and modifies Drozd and Nosal (2012), intermediate good firms wish to sell their product in both countries and therefore must accumulate a stock of relationship capital on both sides of the border.[4] A key feature of the accumulation process is an efficiency parameter that governs the relative ease of building new supply-chain relationships in any market. In our analysis, it is always more expensive to add relationships in the foreign market as compared to the domestic market, perhaps due

[2]Since Levchenko et al. (2010) provides evidence that the trade collapse was concentrated in intermediate good sectors, we model trade as occurring solely in intermediate goods that are combined together to produce the final good using a standard CES technology.

[3]Related models with this form of trading friction can be found in Gourio and Rudanko (2014); Drozd et al. (2014). See also Antràs and Costinot (2011).

[4]Drozd and Nosal (2012) discuss the importance of enduring producer-supplier relationships, the costs of switching and the implications of this form of friction for breaking the law of one price in two-country business cycle models. Gourio and Rudanko (2014) provides additional motivation and evidence.

to language or cultural barriers or an additional information burden. In response to a fall in demand for their product driven by tightening credit availability to wholesalers in both markets, firms choose to invest less in maintaining and building relationship capital which in turn means less sales and production overall. Moreover, due to the differentially higher cost of building relationships in the foreign market, firms choose to reallocate a greater share of the shrunken marketing resources away from the foreign market and towards the domestic market.[5] As a result, relationship capital falls more in the foreign market than in the domestic market and these disruptions in international supply-chains, in turn, imply that cross-border trade shrinks more than domestic trade.

The fall in wholesalers' demand for the firm's product is driven by a credit shock that reduces their ability to borrow in both countries. The wholesale sector firms are modeled as agents of a middleman who spends resources to get matched with both home country and foreign producers. The middleman's agents are a proxy for the substantial amount of resources spent by the economy in matching buyers and sellers. For example, in 2008, value added by the private wholesale trade sector in the U.S. was 6 percent of GDP. It fell by 5 percent from this level during the recession and slowly recovered to the same level over the next few years. We have in mind the idea that tighter credit conditions for the wholesale sector led to the exit of firms, the closing of some locations, the abandonment by firms of some product lines and the firing of staff during the great recession, all of which would impede the ability of producers to sell their product. In the model, the middleman must pay matching costs in advance of payments so there is a need for working capital. Given an enforceability problem, lenders limit the amount of working capital loans available to the middleman. In turn, it limits their ability to form new supply chain relationships which limits the amount of goods that can be purchased from producers. A shock that exogenously tightens the enforceability constraint,

[5] Eaton et al. (2014) models and quantifies these types of search costs and studies their impact on export dynamics. Arkolakis (2010) studies exporter's entry and exit dynamics using market penetration costs that are convex, ie., firms have to pay higher costs to reach additional customers.

causes the middleman to reduce the amount of resources spent on matching with producers, which in turn reduces the number of newly formed matches for a given amount of marketing expenditure by producers. As a result, there is a decline in the amount of relationship capital. The reallocation of marketing resources exacerbates the trade collapse while mitigating the fall in domestic sales so that trade falls much more than GDP. Figure 1.2 presents data on the number of employees in US wholesale trade in deviations from trend. The approximately 3.62% fall in employees relative to trend during the Great Recession is consistent with the model mechanism described above.

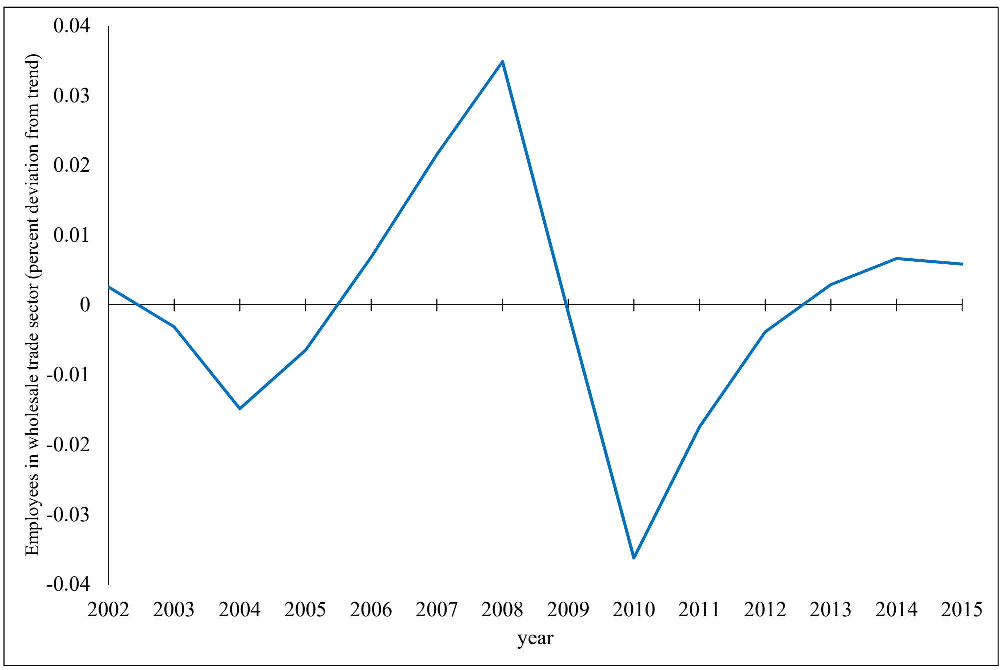

Figure 1.2: % Employees in Wholesale Trade Sector, Deviation from Trend

Note: The trend is calculated using HP-filter with smoothing parameter of 6.25.
Source: Occupational Employment Statistics (OES) Survey.

While there is no direct data that separates out the value added by marketing departments of firms, we can use employment data to get a sense of the magnitudes involved. Using data from the Occupational Employment Statistics collected by the Bureau of Labor Statistic, we can get a measure of the relative size of the marketing sector expenditure on employees to total expenditure on employees using the occupations mentioned above. Between 2008 and 2009, the relative wage bill of these occupations to total wage bill of all occupations fell by 2% indicating a decline in marketing expenses of the economy relative to the overall decline of the whole economy which is consistent with the mechanism outlined here.

We now provide more details about the shock that drives the trade collapse in our model. The severity of the financial crisis accompanying the Great Recession, makes financial shocks a natural candidate cause of the downturn in economic activity. Dynamic general equilibrium models with this feature can be found in Gilchrist and Zakrajšek (2012), Gunn and Johri (2013), Jermann and Quadrini (2012), Kalemli-Ozcan et al. (2013), Kollmann et al. (2011), and Kollmann (2013) among others.[6] To illustrate the co-movement between aggregate short term credit market activity and the trade collapse, we plot in Figure 1.3 the percentage deviations from trend of our measure of credit shocks (discussed later), non-financial commercial paper outstanding and the trade-GDP ratio for the period 2005-2014. As seen in Figure 1.3, these series fall about 30% while the trade-GDP ratio falls 10% percent below trend. Note also that the measures of credit lag the trade-GDP ratio by one quarter. This is confirmed by the fact that the one quarter ahead correlation between non financial commercial paper and the trade-GDP ratio rises to 0.78 while the contemporaneous correlation is only 0.31.[7] Our interpretation of this lead-lag pattern is that the turmoil in financial markets towards the end of 2008 epitomized by the collapse of Lehmann Brothers acted as a news shock which created expectations of tighter credit conditions in the near future. We explore the quantitative implications of this interpretation by augmenting our shock process to allow for one quarter ahead news shocks.

Following the two-country business cycle literature, we parametrize the model to assess its

[6]The importance of binding leverage constraints in the international transmission of shocks is explored in Devereux and Yetman (2010).

[7]In Appendix Figure A1, we report another often used measure of the health of the financial system, the spread between Libor and US T-bill rate. Once again, the rise in the spread is accompanied with a fall in the trade-GDP ratio.

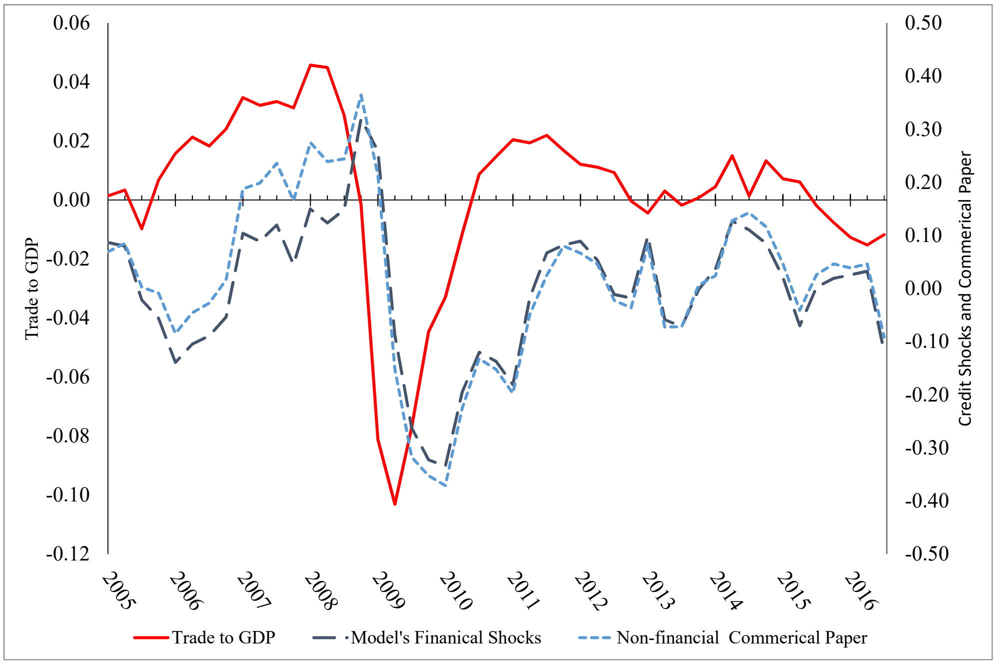

Figure 1.3: % Deviation from Trend: Trade to GDP Ratio and Credit Measures

Note: The trend is calculated using HP-filter with smoothing parameter of 1600.
Source: U.S. Bureau of Economic Analysis and Board of Governors of the Federal Reserve System (US).

quantitative ability to generate movements in the trade-GDP ratio in response to plausibly sized credit shocks. Our credit shock is chosen to deliver the observed 3.62% decline in wholesale sector employment discussed above. In response, a calibrated version of the model successfully generates a 4.5% fall in the trade-GDP ratio below steady state levels while being consistent with a number of stylized facts of that episode.[8] In section 1.3, we show the impact of both contemporaneous and news shocks on model variables which differ mainly in the timing of the trade collapse. In response a news shock that causes expected declines in the ability of firms to borrow next period, in our model, the middleman immediately cuts back on the number of agents sent out into the matching market. This leads to an immediate decline in trade even though credit has yet to decline.

Contrary to our approach, some empirical studies focus on tightening credit conditions

[8]In order to generate the entire observed collapse in the trade-GDP ratio of 10%, the model requires a 17.6% fall in credit. By comparison non-financial commercial paper fell 37% below trend.

that are worse for the financing of exports and imports relative to the rest of the economy. For example, Amiti and Weinstein (2011) and Chor and Manova (2012) provide evidence that tighter conditions in trade specific finance may have played a role in the trade collapse. They argue that exporters are more reliant on trade credit than domestic producers and therefore suggest that difficulty in obtaining trade credit may have been responsible for the unusually large fall in international trade. Levchenko et al. (2010), on the other hand, casts doubt on the trade-credit story, finding that more trade-credit intensive sectors did not display larger trade collapses. Influenced by these mixed findings and by the economy wide scope of the credit collapse, our model does not rely on a differentiated drop in credit to importers or exporters relative to domestic trade. Given the perceived imminent implosion of global financial markets around the collapse of Lehman Brothers and the almost complete freezing up of inter-bank credit flows, we find it more natural to focus on financial shocks that symmetrically affect all trade, whether domestic or international and look for an endogenous mechanism to cause a disproportionate fall in cross-border trade.[9] To the extent that trade credit fell more than other forms of credit during the financial crisis, this mechanism would further contribute to the mechanism explored in our paper.

Our paper complements the short existing business cycle literature which offers alternative explanations for the trade collapse. For example, Alessandria et al. (2010b) provides evidence and a general equilibrium model in which the inventory cycle plays an important role in generating a trade collapse in response to an exogenous rise in the interest rate paid by firms. Alessandria et al. (2010a) provides more detail on modeling the inventory cycle. Novy and Taylor (2014) uses an inventory cycle model to generate trade fluctuations driven by uncertainty shocks. In addition, our model contributes to the short list of open economy business cycle models with news shocks such as Beaudry et al. (2011), Durdu et al. (2013), Jaimovich and Rebelo (2008), and Kamber et al. (2017). Our news shocks differ from these in

[9] Given the global nature of the financial crisis, we model the two countries in a symmetric way, so that both receive the same financial shock.

that fluctuations are driven by financial news shocks whereas most models in this literature contain TFP news shocks (see Beaudry and Portier (2014) for a literature review and Schmitt-Grohé and Uribe (2012) for an estimated model with news shocks to several processes.). An exception in which a news shock to bank balance sheets can cause a recession can be found in Gunn and Johri (2015). News shocks in a model with financial enforceability constraints can also be found in Gortz and Tsoukalas (Forthcoming). Our model with relationship capital is an example of the few two-country models with forms of intangible capital. Another example in a monetary model can be found in Johri and Lahiri (2008) where firms' accumulation of organizational capital helps to explain the dynamics of real exchange rates.

The rest of the paper proceeds as follows. Section 1.2 describes the model. Section 1.3 provides our quantitative results and also outlines different variants of the model that highlight the importance of various model elements in delivering the trade collapse and shows the sensitivity of the quantitative model to several key parameters. Section 1.4 concludes.

1.2 Model

Our model consists of two ex-ante symmetric countries, home and foreign, each of which has a stand-in household that supplies labor and capital to competitive firms in exchange for wage and rental payments. Since we are interested in studying the impact of credit shocks in the wholesale market, final goods production is delegated to the household in each country and as such they own a CES technology for converting intermediate goods into final goods for consumption and investment purposes. Both countries are subject to productivity shocks and credit shocks which are the only sources of uncertainty.[10] A large number of identical firms, of unit measure, produce country-specific tradable intermediate goods which are called the domestic good (d) and the foreign good (f). There is a product market friction that makes

[10] Productivity shocks are included in the model for calibration of certain parameters. They cannot, by themselves, generate a trade collapse in a recession in either our model or in Drozd and Nosal (2012).

sales between the households and the tradable good firms non-trivial. A middleman who intermediates between the household and producers must incur expenses in order to match with producers of both countries.[11] Time is discrete and has an infinite horizon. An asterisk denotes variables in the foreign country. In what follows, we develop various agent's problems from the domestic country's perspective, while the foreign country agent's problems are only discussed where necessary.

1.2.1 The Household

In each period, the household maximizes expected discounted lifetime utility by using their income to purchase units of the domestic and foreign good (d_t and f_t respectively) which are in turn converted into the final consumption-investment good using an in-house technology. In addition, households borrow using units of a non-state contingent, one-period, internationally traded bond, D_{t+1} which must be repaid the next period. Income is obtained by choosing hours worked, N_t, renting out capital held, K_{t-1}, to firms taking prices as given. Lifetime expected discounted utility is given by:

$$\sum_{t=0}^{\infty} \beta^t E_t \left\{ \frac{\left(C_t^{\psi}(1-N_t)^{1-\psi}\right)^{1-\sigma}}{(1-\sigma)} \right\}. \tag{1.1}$$

In period t, the budget constraint of the household is given by

$$w_t N_t + r_t K_{t-1} + Q_t D_{t+1} + \Pi_t^M + \Pi_t^F \geq P_{d,t} d_t + P_{f,t} f_t + D_t. \tag{1.2}$$

where all prices are expressed in term of the domestic final good.

P_d and P_f refer to the price of the domestic and foreign good charged by the middleman.

[11] The middleman can be thought of as wholesalers or distributors who have a lower cost of matching with producers. Previous work with middlemen in an international context can be found in Ahn et al. (2011) and Bai et al. (2017).

The household receives labor income at wage rate, w_t and capital rental income at the rate, r_t. Additionally, as owners of all firms, the household receives lump-sum transfers of profits from the middleman, Π^M, and firms, Π^F. The household also makes within period loans to the middleman to cover their matching cost. Following Jermann and Quadrini (2012), we assume the loan does not pay out any interest and is returned at the end of the period, therefore we omit notation for it here. The household can smooth consumption by using the international bond where Q_t is the price of the bond and D_{t+1} is the amount of bonds the household can buy or sell. Our notation implies that D_t is a loan that must be returned in period t.

After the household purchases the domestic and foreign intermediate goods from the middleman, it uses the following technology to combine d_t and f_t into the final good, G_t.

$$G_t = \left(\omega d_t^{\frac{(\gamma-1)}{\gamma}} + (1-\omega) f_t^{\frac{(\gamma-1)}{\gamma}}\right)^{\frac{\gamma}{\gamma-1}}, \quad \gamma > 0 \quad \text{and} \quad 1 > \omega > 0, \tag{1.3}$$

where γ determines the long-run trade elasticity, and ω determines the home bias. In turn, G is allocated between investment, I_t, and consumption, C_t.

$$G_t = C_t + I_t. \tag{1.4}$$

Physical capital, K_{t-1}, follows a standard law of motion,

$$K_t = (1-\delta_K)K_{t-1} + I_t \quad , \quad 0 < \delta_K < 1. \tag{1.5}$$

The foreign household is identical except for the bond price, which is written as Q_t/e_t since the bond is traded in units of home country's final good. Here e_t denotes the real exchange rate in term of the consumption in the home country.

1.2.2 Intermediate Producer's Problem

Producers in any country hire labor and capital and use a standard, constant return to scale production function to produce output for sale in both the home country and the foreign country. Since all firms in a country are the same, anticipating a symmetric equilibrium in which all firms make the same decision, we eschew firm specific notation. To simplify the problem, we first solve for the unit cost function:

$$v_d = \min_{k,n}\{w_t n_t + r_t k_{t-1} \quad \text{s.t} \quad z_t n_t^{1-\alpha} k_{t-1}^{\alpha} = 1\}, \tag{1.6}$$

where z_t is an exogenous technology shock following an AR(1) process

$$\log z_t = \rho_z \log z_{t-1} + \epsilon_{z,t} \quad \text{, where} \quad 0 < \rho_z < 1, \tag{1.7}$$

and v_d is also the marginal cost for the economy since the production function is constant returns to scale.

The key departure from a canonical two-country model such as Backus et al. (1992) is the requirement that firms must build relationships with the middleman before any sales can be made. These relationships are made with the agents of the middleman through a matching process that requires an input from firms which we call marketing costs. We interpret marketing in a broad sense to include sales material, brochures, expenses on trade shows and on sales staff, non transportation related distribution costs, destination-specific packaging, costs to tailor the product for the counterpart, and so forth.

Taking marginal cost, v_d, from the problem above, firms choose both the quantity of goods to produce and how much to spend on marketing in order to maximize their discounted profit stream:

$$\max E \sum_{t=0}^{\infty} Q_t \left\{ (q_{d,t} - v_{d,t}) d_t + (e_t q^*_{d,t} - v_{d,t}) d^*_t - \zeta_d v_{d,t} a_{d,t} - e_t v_{f,t} \zeta^*_d a^*_{d,t} \right\}.$$

The first term, $(q_{d,t} - v_{d,t})$, is the markup from selling one unit of the good, d, to the domestic middleman while the second term, $(e_t q^*_{d,t} - v_{d,t})$, represents the markup from selling to the middleman in the foreign country after adjusting for the exchange rate, each multiplied by the units sold at home and abroad respectively. The third and fourth terms measure the total marketing cost in the home and foreign country. Firms must use factors in the country where they wish to build supply-chain relationships so foreign marketing costs must be converted using the exchange rate in the fourth term. The ratio, $\frac{\zeta^*_d}{\zeta_d}$, denotes the foreign to home marketing cost differential; a ratio greater than one represents a higher cost for firms to market in the foreign country. These cost differentials can arise because of language barriers, informational frictions that are more severe in cross border trade, extra costs to maintain an office abroad, the cost to hire a foreign agent to run the marketing, and so forth.

Domestic producers maintain two lists of supply-chain relationships at home and abroad separately. Given the number of agents in the matching market (determined by the middleman, see below) and the marketing expense of producers, $\pi_{dt} h_t$ new relationships get added to the domestic list, H_d, which evolves according to:

$$H_{d,t} = (1 - \delta_h) H_{d,t-1} + \pi_{dt} h_t - \phi \left(\frac{a_{d,t}}{a_{d,t-1}} - 1 \right)^2 a_{d,t-1}, \tag{1.8}$$

where δ_h is an exogenous separation rate governing the loss of relationships. The adjustment cost term implies it is costly to vary marketing expenses and this is useful for calibrating the model. An analogous accumulation equation for relationships in the foreign market is :

$$H^*_{d,t} = (1 - \delta_h) H^*_{d,t-1} + \pi^*_{dt} h^*_t - \phi \left(\frac{a^*_{d,t}}{a^*_{d,t-1}} - 1 \right)^2 a^*_{d,t-1}. \tag{1.9}$$

The size of the list determines the amount of goods the producer can sell. Specifically, sales cannot exceed the number of supply-chain relationships with the middleman,

$$H_{d,t} \geq d_t \quad \text{and} \quad H^*_{d,t} \geq d^*_t. \tag{1.10}$$

The matching environment implies that producers must first match with an agent sent by a middleman, who will then deliver the new contract made to the middleman. Bargaining over prices occurs between middleman and producer, and, in equilibrium, this new contact is added to the existing list of relationships. Domestic firms have to compete with foreign firms in matching with agents, h_t, sent by the middleman. To simplify the problem, only the marketing expense, a, of a firm determines the probability of matching.[12] A producer from the home country matches with a fraction of the agents operating in the domestic market, h_t, which is given by $\pi_d = \frac{a_{d,t}}{\bar{a}_{d,t}+\bar{a}_{f,t}} = \frac{a_{d,t}}{\bar{a}_t}$, where $\bar{a}$ refers to market averages. Similarly, foreign producers match with agents in the domestic market with probability $\pi_f = \frac{a_{f,t}}{\bar{a}_{d,t}+\bar{a}_{f,t}} = \frac{a_{f,t}}{\bar{a}_t}$. In the foreign market, the home producer matches with a fraction of the agents, h^*_t, given by $\pi^*_d = \frac{a^*_{d,t}}{\bar{a}^*_{d,t}+\bar{a}^*_{f,t}} = \frac{a^*_{d,t}}{\bar{a}^*_t}$ while $\pi^*_f = \frac{a^*_{f,t}}{\bar{a}^*_{d,t}+\bar{a}^*_{f,t}} = \frac{a^*_{f,t}}{\bar{a}^*_t}$ is the fraction of foreign agents that match with the foreign producer. We will refer to these fractions as matching market share in our discussion below.[13]

[12] Gourio and Rudanko (2014) and Shi (2016) provide an environment where firms can use price to attract customers. In our model, the relative amount of marketing expense is the sole source determining the market share.

[13] While our model shares many common features with Drozd and Nosal (2012), one way it differs is that marketing expenses are not accumulated as marketing capital. We can think of this difference as coming from a marketing capital depreciation rate of unity. Since we are not thinking about advertising expenses aimed at consumers where brand loyalty is a big concern but rather about expenses on salesman etc., this difference seems appropriate. In any case, allowing for a firm's marketing input to accumulate has little impact on the result. Sensitivity to this assumption can be obtained from the authors. Our paper also differs from Drozd and Nosal (2012), without major implications, in that the adjustment cost appears on the relationship capital accumulation equation.

1.2.3 The Middleman

In each country, the middleman sends out agents who are responsible for acquiring supply-chain relationships with intermediate goods producers from both countries. Once agents bring contacts to the middleman, an enduring relationship begins which involves a bilateral bargaining problem that determines the price, q_d or q_f, at which one unit of the good in question is traded.[14] We will refer to these prices as producer prices in the future. The middleman bargains over prices with all the old and new producers that they have a relationship with while also engaged in selling these acquired units of domestic and foreign goods to the household in competitive markets. The price differential between what the household pays and the producer prices allow the middleman to recover their costs and make a profit. The middleman chooses the number of agents, h_t, sent into the matching market after observing aggregate shocks. Random matching governs whether any individual agent will match with a home producer or a foreign producer but the law of large numbers implies that they can assess the ex-ante probability of matching with domestic good firm, π_d, and the foreign good firm, π_f. Each match leads to an exchange of one unit of the relevant good in period t as well as subsequent trades in the future until separation. The middleman incurs an increasing and convex matching cost based on the number of agents used, $\chi v_{d,t} h_t^2$.[15] In order to induce borrowing, we assume that these costs must be paid in advance of any trades by taking an intra-period loan which is limited by an enforcement constraint discussed below.[16]

[14]For a theoretical model of middlemen with posted prices rather than bargaining see Johri and Leach (2002).

[15]Agents may be thought of as locations or offices instead of as merely individuals. Our specification of costs implicitly assumes that the technology used in the production of agents is the same as that of producers so we can use the same economy-wide marginal cost function. This parsimonious specification helps to calibrate the model in the absence of detailed information about the wholesale sector of the economy. We also note that specifying the matching costs in terms of the final good had little impact on the results discussed in the next section.

[16]The introduction of convex costs faced by middleman which must be financed in advance with a within period loan and the introduction of a time-varying enforcement constraint differentiate our specification of the middleman from Drozd and Nosal (2012)

Taking the price at which households buy the goods (which we will refer to as customer prices), the results of the bargaining problem described below and the ex-ante probability of matching with domestic versus foreign producers as given, the middleman chooses the number of agents, h to maximize the expected stream of profits given by:

$$\Pi_t^M = (p_{d,t} - q_{d,t})H_{d,t} + (p_{f,t} - q_{f,t})H_{f,t} - \chi v_{d,t} h_t^2 + EQ_{t+1}\Pi_{t+1}^M, \tag{1.11}$$

subject to the borrowing constraint:

$$\psi_{f,t}\left[(p_{d,t} - q_{d,t})H_{d,t} + (p_{f,t} - q_{f,t})H_{f,t}\right] \geq \chi v_{d,t} h_t^2. \tag{1.12}$$

Using equations (1.8) and foreign counterpart, and the quadratic formula, the optimal h is

$$h = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}, \tag{1.13}$$

where $a = \frac{v_{d,t}\chi}{\psi_{f,t}} > 0$,

$$b = -\left[(p_{d,t} - q_{d,t})\pi_{d,t} + (p_{f,t} - q_{f,t})\pi_{f,t}\right] < 0,$$

and

$$c = -(1 - \delta_h)\left[H_{d,t-1}(p_{d,t} - q_{d,t}) + H_{f,t-1}(p_{f,t} - q_{f,t})\right] < 0.$$

The enforcement parameter, $\psi_{f,t}$, is governed by an AR(1) process with contemporaneous and one period ahead news shocks:

$$\log(\psi_{f,t}) = \rho_f \log \psi_{f,t-1} + \epsilon_{f,t} + \epsilon_{f,t-1}^1, \tag{1.14}$$

where equation (1.14) is written as a log deviation from the steady state value of $\bar{\psi}_f$ and where $0 \leq \rho_f \leq 1$, and $\epsilon_{f,t}$ and $\epsilon^1_{f,t-1}$ follow an *i.i.d* normal distribution with zero mean.

The idea of generating business cycles from variations in the severity of the borrowing constraint follows a similar use in Jermann and Quadrini (2012) in a closed economy context. We differ from that specification by adding news shocks. We can think of $\psi_{f,t}$ as a parameter that governs the ability of the lender to recover goods from the middleman in case the loan is not repaid. Lenders will limit the amount that the middleman can borrow in the absence of any commitment to repay the loan to a multiple of what can be recovered in default as is standard in this class of models. In this specific case, the lender can recover only a fraction of the match surplus, either because the rest can be hidden or because it is lost in the default process. If $\psi_{f,t}$ falls, lenders expect to recover a smaller fraction of middleman revenue in case of a default. As a result they make a smaller loan to the middleman, who in turn, are forced to send out fewer agents and reduce the number of matches with both domestic and foreign producers. The ensuing fall in customers, would cause production cutbacks and a fall in overall economic activity.[17] The mechanism described here is meant to capture the idea that tightening credit constraints may have influenced economic activity through cutbacks and closures in the (substantial) sectors of the economy that are involved in the distribution of goods. Note that the tighter credit constraints have a symmetric impact on domestic and foreign producers trying to build relationships with the domestic middleman. As we will see below, despite this symmetry, home producers will respond differently from foreign producers in terms of their marketing activity in the domestic market which will, in turn, cause a larger decline in foreign trade relative to domestic trade.

[17]Since we are not interested in exploring the origins of the financial crisis in this paper, we follow the literature and generate an economic downturn in our model by exogenously decreasing $\psi_{f,t}$.

1.2.4 Bargaining

Prices are determined by Nash bargaining. There are four producer prices, q_i, that need to be determined. The subscript i denotes which goods the middleman and producer are bargaining over, $i \in \{d, d^*, f, f^*\}$.[18] The producer's value function is the markup earned on selling a unit of the good plus the expected value of future sales taking into account the probability of the match breaking up.

$$W_{i,t} = \max\{0, q_{i,t} - v_{i,t}\} + (1 - \delta_H)E_t Q_{t+1} W_{i,t+1}. \tag{1.15}$$

Similarly, the middleman earns the difference between the customer price and the producer price, where the valuation equation takes into account that in the future the match may break and prices may change. The middleman's expected per unit surplus from matching with a domestic producer will be referred to as $J_{d,t}$, and matching with a foreign producer as $J_{f,t}$.

$$J_{i,t} = \max\{0, P_{i,t} - q_{i,t}\} + (1 - \delta_H)E_t Q_{t+1} J_{i,t+1}. \tag{1.16}$$

Overall, the expected surplus from each match is

$$J_t = \pi_{d,t} J_{d,t} + \pi_{f,t} J_{f,t}. \tag{1.17}$$

Based on these values, middleman and producers engage in Nash bargaining to determine the producer price, $q_{i,t}$, paid in exchange for one unit of good. The parties renegotiate every period while remaining matched, thus the prices change based on the state in each period. *As a result the following bargaining problem is static.*

[18] A producer price or value function with subscript d denotes bargaining between the home middleman and home producer, subscript d^* denote bargaining between foreign middleman and home producers, subscript f is between home middleman and foreign producers, and subscript f^* is between foreign middleman and foreign producer. And, note that $v_d = v_{d^*}$ and $v_f = v_{f^*}$ in a symmetric equilibrium.

$$q_{i,t} = \arg\max_q \{J_{it}^{\theta} W_{it}^{1-\theta}\} = \arg\max_q \{(P_{it} - q_{it})^{\theta}(q_{it} - v_{it})^{1-\theta}\},$$

The second equality follow from the fact that the bargaining occour every period. Therefore, the current choice of $q_{i,t}$ does not affect the continuation value, $J_{i,t}$ and $W_{i,t}$ so that

$$q_{i,t} = (1-\theta)P_{i,t} + \theta v_{i,t}, \tag{1.18}$$

where θ represents the bargaining power of the middleman. Equation (1.18) shows that the producer price, q_i, is a weighted average of the customer price, P_i, and the economy-wide marginal cost, v_i.

1.2.5 Equilibrium

An equilibrium in this economy is defined by the following contingent infinite sequences that solve the respective optimization problems of each agent: C_t, N_t, K_t, I_t, G_t, D_{t+1}, d_t and f_t for the household in home country, C_t^*, N_t^*, K_t^*, I_t^*, G_t^*, D_{t+1}^*, d_t^* and f_t^* for the household in foreign country, n_t, k_{t-1}, d_t, d_t^*, $a_{d,t}$, $a_{d^*,t}$, $H_{d,t+1}$, $H_{d^*,t+1}$ for the home firms, n_t^*, k_{t-1}^*, f_t, f_t^*, $a_{f,t}$, $a_{f^*,t}$, $H_{f,t+1}$, $H_{f^*,t+1}$, for the foreign firms, h_t for the home middleman, h_t^* for the foreign middleman, prices, Q_t, w_t, w_t^*, r_t, r_t^*, $P_{d,t}$, $P_{d,t}^*$, $P_{f,t}$, $P_{f,t}^*$, $q_{d,t}$, $q_{d,t}^*$, $q_{f,t}$, $q_{f,t}^*$ and real exchange rate, e_t that satisfy the following conditions.

The bond market clearing requires

$$D_t = D_t^*. \tag{1.19}$$

Intermediate goods market clearing requires that the output of each firm is fully used up in sales or marketing costs:

$$z_t n_t^{1-\alpha} k_{t-1}^{\alpha} = d_t + d_t^* + a_{d,t} + a_{d,t}^* \quad \text{and} \quad z_t^* n_t^{*1-\alpha} k_{t-1}^{*\alpha} = f_t + f_t^* + a_{f,t} + a_{f,t}^*. \tag{1.20}$$

Factor market clearing requires $N_t = \int_0^1 n_{i,t} di$ and $K_t = \int_0^1 k_{i,t} di$ where the integration is over the unit mass of producers and the middleman in the home country. A similar set of equations apply to the foreign country factor markets. Imposing symmetry on the two countries, the steady state prices are equal to

$$P_{d,t} = \Gamma P_{d,t}^* \quad \text{and} \quad P_{f,t}^* = \Gamma P_{f,t}, \tag{1.21}$$

where the Γ is the price differential solely introduced by the marketing cost differential. Similarly,

$$P_{d,t} = P_{f,t}^* \quad \text{and} \quad P_{d,t}^* = P_{f,t}. \tag{1.22}$$

The proportion of middleman's agents matched with producers from the Home country and from the Foreign country add up to one:

$$\pi_f + \pi_d = 1 \quad \text{and} \quad \pi_f^* + \pi_d^* = 1. \tag{1.23}$$

For future reference, we also define total trade, GDP and the trade - GDP ratio as calculated from the model as follows:

$$GDP = P_{d,t} d_t + P_{f,t} f_t + e_t q_{t,d^*} d_t^* - q_{f,t} f_t, \text{ and} \quad Trade = q_{f,t} f_t + e_t q_{d,t}^* d_t^*,$$

$$\frac{Trade}{GDP} = \frac{q_{f,t} f_t + e_t q_{d,t}^* d_t^*}{P_{d,t} d_t + P_{f,t} f_t + e_t q_{t,d^*} d_t^* - q_{f,t} f_t}. \tag{1.24}$$

1.3 Quantitative Results

In this section we present quantitative results based on a parameterized version of the model where some parameters are chosen to match key features of the US economy while other parameters are taken from the literature. Since, in the model, each period represents a quarter, data moments are calculated using quarterly data. We solve the model by linearizing the model equations around the stationary steady-state. Parameter values used in the simulation exercises are reported in Table 1.1.

1.3.1 Parameterization

The parameter values used in our paper can be found in Table 1.1. Here we describe the process determining these values. We begin with preference and technology parameters that are typical in the literature. The discount factor, β, is given a value of 0.99 which implies a 4 percent average annual risk-free real interest rate. We follow the literature and set the coefficient of relative risk aversion, σ, to 2. We also explore the sensitivity of changing this parameter on our results in section 1.3.3. We set $\gamma = 7.9$, the long run trade elasticity which is taken from Head and Ries (2001). None of the other parameters can be individually identified however we group them into two categories. The first set of parameters are common to many models and our targets and values are also commonplace. The technology and preference parameters are targeted with : (i) the investment to GDP ratio of 0.23; (ii) the percent of the time endowment worked equal to 30%; (iii) the share of labor income to GDP of 0.64; and (iv) the trade to GDP ratio of 0.26. We target these moments respectively with the capital depreciation rate, δ_k, the leisure preference parameter, ψ, the capital share parameter in the production technology, α, and the home-bias parameter, ω. We note, however, that these steady state ratios are also somewhat sensitive to the remaining parameters, in particular, the depreciation rate of relationship capital, δ_h. As a result the values assigned to the above parameters need to be chosen jointly with the targets and parameters discussed below. These cause only small changes from the values used in the literature. For example, compared to the values used in Drozd and Nosal (2012), our values differ only in the second or third decimal place.

Table 1.1: Parameter values

Parameter	Description	Value
β	Discount factor	0.99
σ	Household's utility	2.00
ψ	Household's utility	0.340
α	Production function	0.314
δ_k	Capital depreciation	0.035
γ	Long-run trade elasticity	7.90
$\bar{\psi}_f$	Financial enforcement	0.108
θ	Bargaining power	0.40
δ_h	Relationship capital depreciation	0.12
ζ_d	Home marketing cost	1
ζ_d^*	Foreign marketing cost	2.16
ω	Home bias	0.5353
ϕ_a	Marketing adjustment cost	0.0276
ρ_f	Persistence of financial shock	0.8330
ρ	Persistence of TFP	0.8701
σ	Variance of TFP shock	0.0045
$corr(\epsilon_z, \epsilon_z^*)$	Correlation of TFP shocks	0.425

Next, we discuss non standard parameters that relate to the relative weight of the middleman in the economy and to the size of marketing expenditure incurred by producers at home and abroad in steady state. Since the relative marketing cost difference between domestic and foreign markets is important for our work (as opposed to the absolute value), we normalize the cost of marketing to the home market, ζ, to unity while calibrating the foreign cost, ζ^*. By rearranging the optimality conditions of $a_{d,t}$,$a_{d,t}^*$,$H_{d,t}$, $H_{d,t}^*$, d_t, and d_t^* evaluated at the steady state, we obtain the following relationship:

$$\frac{\zeta^*}{\zeta} = \frac{q_d^* - v_d}{q_d - v_d}. \tag{1.25}$$

Equation (1.25) implies that the ratio of $\frac{\zeta^*}{\zeta}$ determines the relative markup of selling abroad and at home. Crucini and Yilmazkuday (2014) estimate that the long run average price differences across borders is about 10 percent after controlling for relative wages, distances, city dummy variables, etc. Since cross-border cost differences have already been accounted for in their estimation exercise, we can view the price difference as a markup difference between selling at home and abroad. Using the 10 percent result, we can back out the parameter ζ^*, to equal 2.16.

As discussed in the Introduction, we target middlemen related variables and parameters to the wholesale sector of the economy while the marketing parameters are tied down using sales and marketing occupation data. Our target ratios in steady state are: value-added in wholesale sector to GDP of 5.9%, and marketing expenditure to GDP of 3.7%. For the marketing expenditure to GDP ratio, we identify marketing/sales occupations from the Occupational Employment Statistics survey.[19] Then, we divide the wage bill of all these occupations by the wage bill of all occupations in the economy from 1999 to 2015.[20] Under the model assumption of constant returns to scale, the wage bill is proportional to output. As a result the ratio of the wage bill on marketing to the total wage bill should be similar to the share of marketing and sales output in GDP. For the wholesale value-added to GDP target which was obtained from the Bureau of Economic Analysis, we used data series in real terms between 1997 and 2015. In order to get a longer time-series, we also use the nominal data series which is available from 1947 to 2015, and obtain only a slightly higher ratio of 6.1%. As a result we stay with the previous value. In addition to these aforementioned targets, we also use a producer markup of 10 percent which is quite commonplace in the literature and is based on Basu and Fernald (1997)).

[19]These occupations are (i) Advertising and promotions managers, (ii) Marketing managers, (iii) Sales managers, (iv) Parts salespersons,(v) Advertising sales agents, (vi)Insurance sales agents, (vii)Sales representatives, wholesale and manufacturing, technical and scientific products, (viii) Sales representatives, wholesale and manufacturing, except technical and scientific products.

[20]In 1999, the Bureau of Labor Statistics changed the definition of occupations. Therefore, we cannot utilize the whole dataset.

To target these values, we set the relationship capital depreciation rate, δ_H, to 0.12; the steady state financial enforcement parameter, ψ_f, to 0.108; and the bargaining power parameter between a middleman and a producer, θ, to 0.4. Drozd and Nosal (2012) use a baseline value of .5 but find that the effect of bargaining power is mainly on pass-through. Since price movement plays only a small role in our work, this has a limited impact on our variables of interest. See section 1.3.3 for a confirmation. Since χ only appears as a ratio with ψ_f in equation (1.12), we set it to unity. The values of the other above-mentioned parameters are: the home bias parameter, ω, set equal to 0.537; the preference parameter on leisure, ψ, set to 0.34; the capital depreciation rate, δ_k, set equal to 0.035; and the parameter α in the production function, set to 0.314.

The adjustment cost parameter, ϕ, in the relationship capital accumulation equation is chosen to match the empirical value of the relative standard deviation of investment to the standard deviation of GDP which is equal to 2.66 in hp-filtered US data from 1947 to 2015. Since this is a long-run moment commonly targeted in studies without credit shocks, we use only the TFP shock processes for both countries to match the data. We proceed in a manner similar to Drozd and Nosal (2012): we pick the moments of the productivity process so that the model generates a correlation of 0.3 between the solow residual of the home and foreign country. The targeted volatility of the solow residual is 0.79%, and it displays a first order auto-correlation of 0.91. Since our model has several differences from Drozd and Nosal (2012), our parameter values needed to target the same data values are different. For example, the standard deviation of the TFP process in their work is 0.0083 while it is 0.0045 in ours while the autocorrelation coefficient is 0.79 versus 0.87 in our work.[21]

In order to uncover the parameters of the shock process on the financial enforcement parameter, we rearrange equation (1.12), recognizing that the total credit taken by the middleman is equal to the cost incurred. Moreover, since the value added by the wholesale

[21] The usual business cycle moment table associated with this exercise can be found in Table A2 in the Appendix along with a comparison to the data and related model moments.

sector (which is our proxy for the middleman) comes about from the margin made by buying and selling goods, we can rewrite (1.12) as $\psi_f = \frac{Credit}{\text{Value added of the Wholesale Sector}}$. To construct this series for ψ_f, we need a measure of the amount of credit used by the wholesale sector but this is unavailable so we proxy it with the issuance of non-financial commercial paper and divide by the value added of wholesale trade sector from 2005 to 2015. Then, we regress the detrended ψ_f series on its lag. This yields a value of ρ_f equal to 0.833 and a standard deviation of .088. Later we study the impact of varying this parameter.[22]

1.3.2 Trade, Marketing and the Impact of Credit Shocks

In this section, we ask if our model has the ability to quantitatively explain the large fall in the trade-GDP ratio in response to a financial shock. Since we do not have data on the amount of short term credit used by the wholesale sector, we cannot directly measure the size of the credit shock. Instead, we hit the model with a credit shock so that we can match the observed fall in employment in the wholesale sector. As shown in Figure 1.2, employment falls 3.62 percent below steady state (note that data is annual). To generate this fall in wholesale sector employment, we need a shock that reduces credit to 7.9% below steady state values. This is a pretty conservative shock relative to the data. By comparison, non financial commercial paper fell 37% below steady state levels. Given the global nature of the financial crisis, we hit both countries with identical shocks.

In response to the credit shock, the model generates a sizeable trade collapse and a fall in GDP so that the trade to GDP ratio falls 4.5% below steady state levels (see the impulse response plots in Figure 1.4). Before discussing in detail the mechanism by which the model generates the trade collapse, we briefly mention an alternative quantitative exercise where we ask how big must the fall in credit be in order to account for the entire fall in the trade-GDP

[22] Alternatively, we use the commercial and industrial loan as another proxy for credit, with a resulting value of ρ_f equal to 0.89 in the sensitivity sub-section 1.3.3 below.

ratio of 10%. This required credit to fall by 17.63% which is also substantially less than the actual fall in commercial paper.

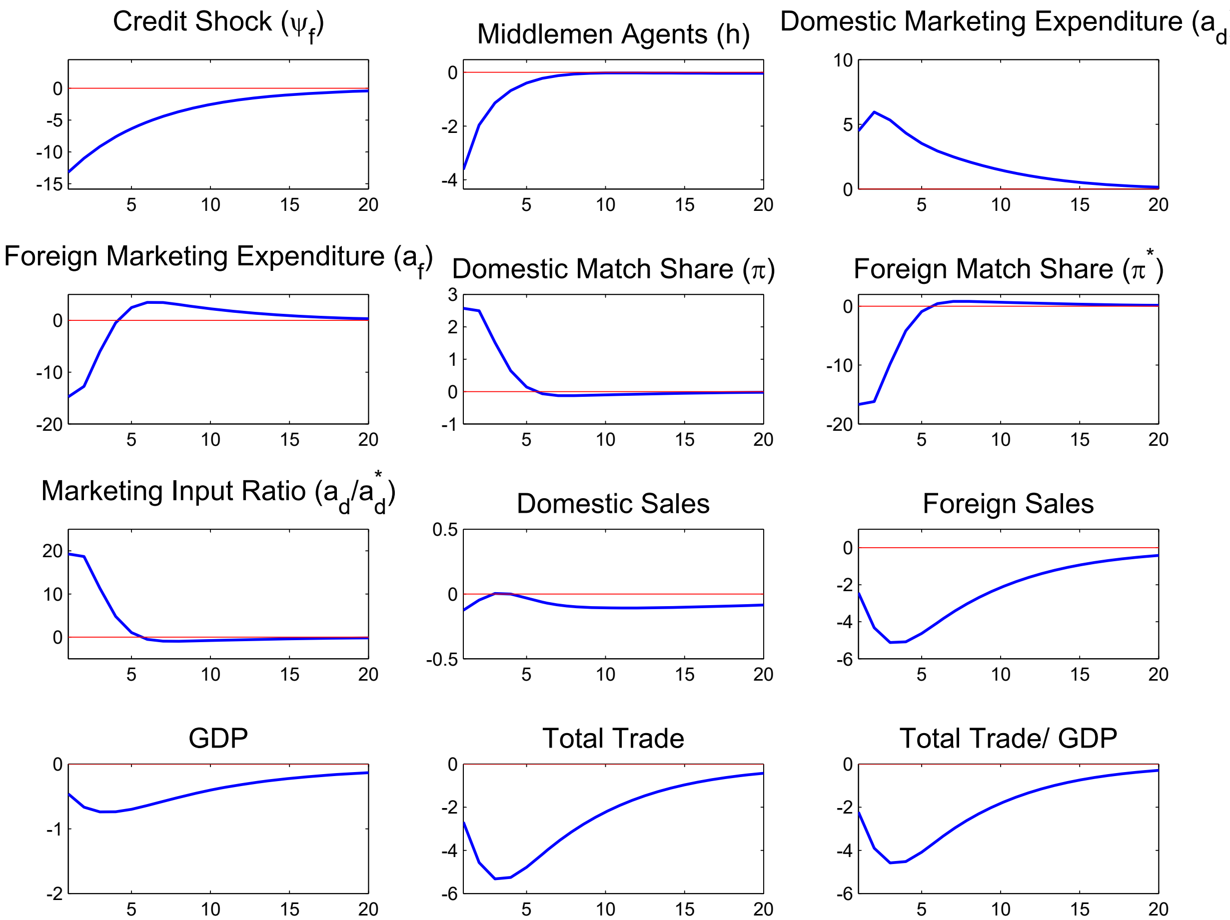

Figure 1.4: Impulse Responses to a Credit Shock

Note: All graph are in percent deviation from steady state.

In order to understand how the credit shock causes a trade collapse, we discuss the impulse response plots in turn. Our credit shock implies a tightening of the enforceability constraint through a reduction in ψ_{ft} in equation (1.12). Since the middleman must use this credit to pay for expenses in advance, the tighter constraint implies that the total number of agents sent into the matching market must be reduced in order to cut expenses in keeping with the fall in credit availability. The credit shock and the fall in agents, h_t, can be seen in the first two panels of the top row of Figure 1.4. The fall in agents equals the observed fall in wholesale employment as discussed above. The fall in middleman agents in the matching market has implications for the producers. Recall that producers must incur marketing expenses in both countries in order to add new relationships to their existing set of relationships, H_t. As shown in equation (1.8) acquiring new relationships requires inputs from both sides of the matching market. The fraction of marketing resources spent on the domestic market by the home country producer, relative to the resources spent by the foreign country producer determine the share of middleman agents that the home producer will match with. A similar calculus applies to the matches formed in the foreign country. On impact of the credit shock, in the face of a decline in agents, producers realize that they will add fewer new relationships to their lists, H_t, H_t^*, which will fall below their steady state levels if the amount of marketing expenditure remains unchanged. In fact, producers will find it optimal to reallocate marketing expenses between the two markets - reducing the amount spent on marketing in the foreign country while increasing the marketing in the home country. This can be seen in the third and fourth panel of Figure 1.4 as a rise in a_d and a fall in a_f. The rise in marketing expenditure in the home country increases the share of matches made by the domestic producer in the home market while the fall in a_f correspondingly reduces the share in the foreign market. This reallocation, therefore attenuates the fall in domestic relationship capital while exacerbating the fall in foreign country relationship capital caused by the fall in agents in the matching market. These changes in relationship capital translate into changes in the amount produced for domestic and foreign markets via the constraints shown in equation (1.10). As can be seen in the third row of Figure 1.4, by reallocating marketing expenses, the domestic producer manages to almost entirely protect his domestic market sales which drop less than 1% while accepting an almost 5% fall in sales in the foreign market. The reallocation of marketing expenses is driven by a desire to save resources in the more costly foreign market in order to spend it in the domestic market – in effect, it is cheaper to steal matches in the domestic market.

The importance of asymmetries in the cost of foreign marketing can be seen in Figure 1.7 where we remove the cost difference. Here, the producer responds to a fall in agents, h, by increasing marketing expenses in both countries by the same amount, leading to an equal but small reduction in domestic and foreign sales. As a result, trade falls by the same order of magnitude as GDP resulting in a very small fall in the trade-GDP ratio. Return to the present asymmetric cost case, the large fall in foreign marketing expenses causes an overall reduction in the marketing costs of the producer for one period but beyond that, the producer overall spends more resources on marketing to combat the persistent fall in agents in the matching markets of both countries. While the marketing expenses in the domestic market stay above steady state levels throughout, the foreign marketing expenses initially fall and then slowly rise back to steady state levels and then above.

To understand the overall result, by combining the relationship accumulation equation (1.8) and the sales constraint (1.10), we have[23]

$$d_t = (1 - \delta_h)d_{t-1} + \pi_d h_t. \tag{1.26}$$

The amount of goods sold this period is a function of the amount of goods sold last period, market share, π_d, and number of matching agents, h. The producer mitigates the impact of the fall in agents, h on domestic sales by engineering an increase in market share, π_d. So, the total sales of domestic goods barely falls. While there are some movements in prices in the economy in response to the credit shock, these are all less than one percent deviations from steady state values and play a very small role in the general equilibrium dynamics of the model. As a result, we do not discuss prices here but impulse responses are shown in the appendix.

[23] Since it is costly to accumulate extra relationships, a firm would never over-invest in a_d or a_d^*. As a result, in equilibrium, $H_t = d_t$. We check for this binding condition in our simulations.

Since both countries are hit with symmetric credit shocks, producers in both countries sell less in the other country's market so that both imports and exports decline a lot. This can be seen in Figure 1.4 as a roughly 6% fall in total trade. The large decline in both imports and exports coupled with a small decline in sales in the domestic market lead to a big fall in trade relative to GDP in the model. At this point, it is worth commenting on the mechanism in operation in the model which involves supply chain relationships in an economy's distribution networks. Essentially, the distribution network cutbacks force the ultimate user of goods to buy more domestic goods and fewer foreign goods. At first pass, one might think that these distribution networks change only very slowly, but this is not true in major recessions where a wholesale company engaged in buying and selling goods goes out of business, closes a regional office or downsizes salesmen who travel to different markets looking for firms with new products. While the ultimate buyer may still be aware of the existence of the products they used to buy, these products may no longer be distributed in a market so a switch to a different product takes place. Similarly producers may decide not to operate sales offices in certain countries and concentrate marketing efforts where profit margins are higher. Once again, certain products may disappear from some markets but not from others.

News About Credit Shocks

As discussed earlier, trade begins to fall one quarter before our measures of credit in US data. In this section, we study the model response to a one period ahead news shock to the enforceability constraint of the middleman. Since the responses will be the same as in the previous section after the shock is realized in period 2, here we only discuss the response of the model on arrival of the news in period 1 (see Figure 1.5). Not surprisingly, the peak response of the credit shock moves from period 1 to 2 as far as credit use by the middleman is concerned. Most of the fall in middleman agents occurs in period 2 as well, though there is a small fall on impact of the news. Producers respond immediately to the news that credit

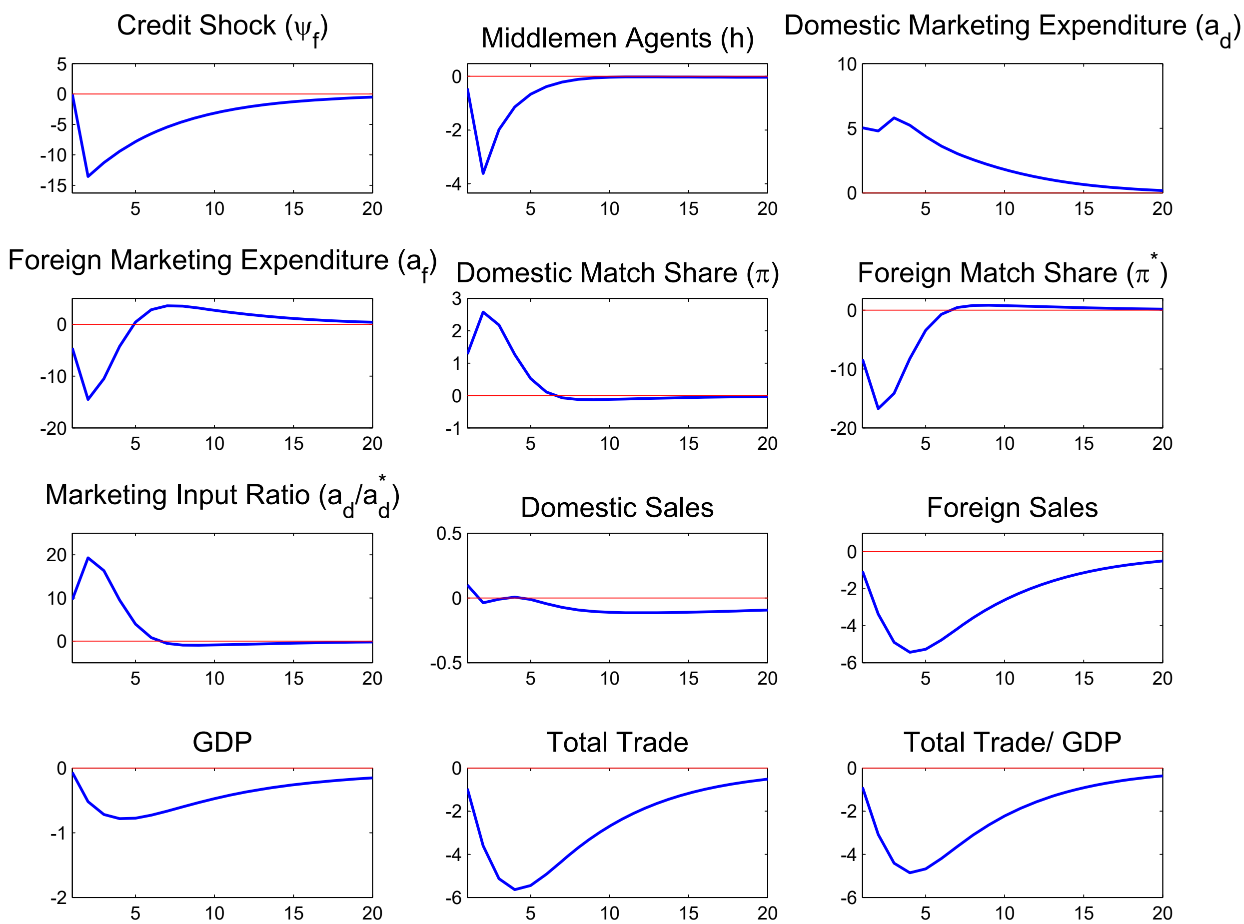

Figure 1.5: Impulse Responses to a Credit News Shock

Note: All graph are in percent deviation from steady state.

will be tighter for the middleman next period. Anticipating the large fall in agents next period, they immediately begin the reallocation of marketing resources towards the domestic market. In order to understand why producers respond immediately to an anticipated future fall in agents, we focus on the relationship capital accumulation equation (1.8) where we have substituted in the sales constraint as before and recursively substituted backwards by one period to obtain

$$d_2 = (1-\delta_h)^2 d_0 + (1-\delta_h)\pi_{d1}h_1 + \pi_{d2}h_2. \tag{1.27}$$

Consider now a situation where producers receive news in period 1 that h will fall in period

2. Given h in period 1, producers can try to protect their sales in period 2 by increasing market share π_d in period 1 which is in fact what occurs in the impulse responses shown in Figure 1.5. An increase in market share requires producers to spend more on marketing, a_d, which rises about 5% above steady state levels on arrival of the news which in turn causes a 1% rise in domestic market share of the home producer. This translates into a small increase in domestic sales. This rise in marketing expenses is driven by an increase in the shadow value of relationship capital which rises about 4% above steady state (see Figure A3 in the Appendix). As before, the presence of higher marketing costs in the foreign market lead to a reallocation effect where the producer lowers the amount spent on marketing in the foreign country to about 5% below steady state levels. The loss of market share in the foreign country causes an immediate 1% decline in sales to that market. The fall in foreign sales combined with a small increase in domestic sales translates into a bigger fall in trade relative to GDP so that the trade-GDP ratio falls in period 1 by 1%. Once the credit shock actually hits in period 2, this initial decline is amplified resulting in a pattern similar to the data where the decline in credit occurs after the decline in trade begins.

To show that the effects of news on producer actions are driven by the enduring nature of relationship capital (and to understand the influence of adjustment costs and δ_h on our results), we consider two additional special cases of the model. In the first case, we turn off the adjustment costs and set the depreciation rate of relationships capital, $\delta_h = 1$. Now, on impact of news, the (the dashed blue line) impulse responses in Figure 1.6 indicate that there is almost no rise in the value of relationship capital (about 0.1% vs. 4%) and in turn, no increase in market share (about one hundredth of one percent). Since market share does not move, d also does not move significantly from steady state levels in period 1 (nor does f) as can be seen from the equation above. The combined equations after imposing the sales constraint in our simpler model without adjustment costs and $\delta_h = 1$, as before, we have:

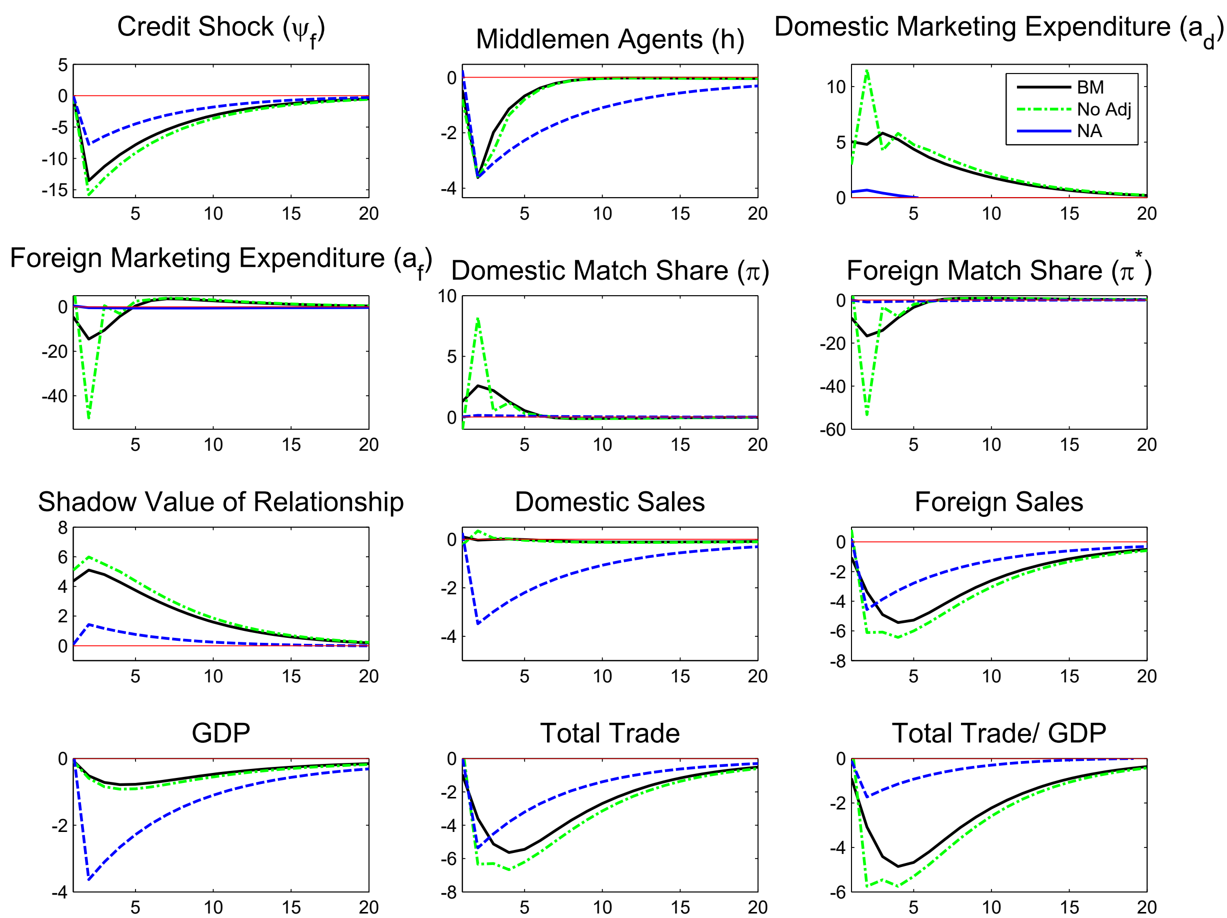

Figure 1.6: Impulse Responses to a Credit News Shock: Two Specifications Without Adjustment Costs

Note: All graph are in percent deviation from steady state. BM: Benchmark; No Adj: No adjustment cost, benchmark δ_h; NA: No adjustment cost, $\delta_h = 1$

$$d_t = \frac{a_{d,t}}{\bar{a}} h_t. \tag{1.28}$$

Sales of domestic goods at home is now only a function of current marketing inputs and the number of agents of the middleman. Since firms have no accumulated relationships available to sell their products, they must expend marketing resources each period in order to sell any product. This implies that the reallocation effect in response to a fall in agents is muted as can be seen in the impulse response graphs where the rise in domestic marketing and the fall in foreign marketing are less than 1% from steady state levels. Once again, the lack of movement in market share implies that the path of h dominates the behavior of d and f which both fall (3% and 4%) below steady state levels. As expected, trade falls only a little more than GDP leading to a small drop in the trade-GDP ratio of less than 2% as compared to 4.5% in the baseline case. The transitional dynamics of trade and GDP follow the path of credit back to steady state with no visible hump in the dynamics. Clearly the accumulation of relationships plays an important role in propagation of the credit shock through the economy and especially for the dynamics of the trade-GDP ratio.

In the next case (dot-dashed green line), we revert to the baseline depreciation rate of relationship capital but we leave adjustment costs turned off. Now the producer is free to adjust marketing expenses in both countries without the penalty imposed for large movements in the period that news arrives. Anticipating the future fall in agents, h, in both markets, producers immediately increase spending on marketing in both countries.[24] The key impact of adjustment costs can be seen in the behavior of marketing in the foreign country where the initial rise in period 1 is followed by a sharp fall in period 2. Since these large changes are penalized in the presence of adjustment costs in the baseline model, there the producer prefers to slowly lower marketing expenses in period 1 followed by a further fall in period two when the credit actually tightens.

1.3.3 Special Cases, Extensions and Robustness Checks

In the next few subsections, we discuss various versions of our model in order to understand the contributions of key economic mechanisms. We begin with removing the marketing cost differential, then we remove the ability of producers to change market share thus bringing out

[24] The key element driving the rise in the shadow value of relationship capital is the depreciation rate and not the presence of adjustment costs as can be confirmed by allowing adjustment costs with depreciation set to unity.

their importance in generating a large trade collapse. Then, we discuss the sensitivity of the results to some key parameters and finally present responses to TFP shocks.

No Marketing Cost Differential

One important element that drives the trade collapse in our model is that the marketing expense ratio, a_d/a_d^*, rises in response to the drop in agents sent out by the middleman. This rise is the result of the marketing cost differential, $\zeta^* > \zeta$. To show the impact of removing this cost differential, we produce impulse responses to the news shock case when $\frac{\zeta^*}{\zeta} = 1$, in Figure 1.7. The shock to the enforcement constraint causes the middleman to lower the number of agents and in response the producer increases marketing expense in both countries in order to protect market share, however, since marketing expenditure is increased symmetrically in all countries, the marketing expense ratio does not change. As a result, the matching market share remains unchanged so the fall in h causes a symmetric fall in d and in f. As a result, the quantity of trade falls only slightly more than GDP, leading to a very small drop in the trade-GDP ratio as can be seen in Figure 1.7.[25]

[25] The small drop in the trade-GDP ratio is coming from the small fall in the prices.

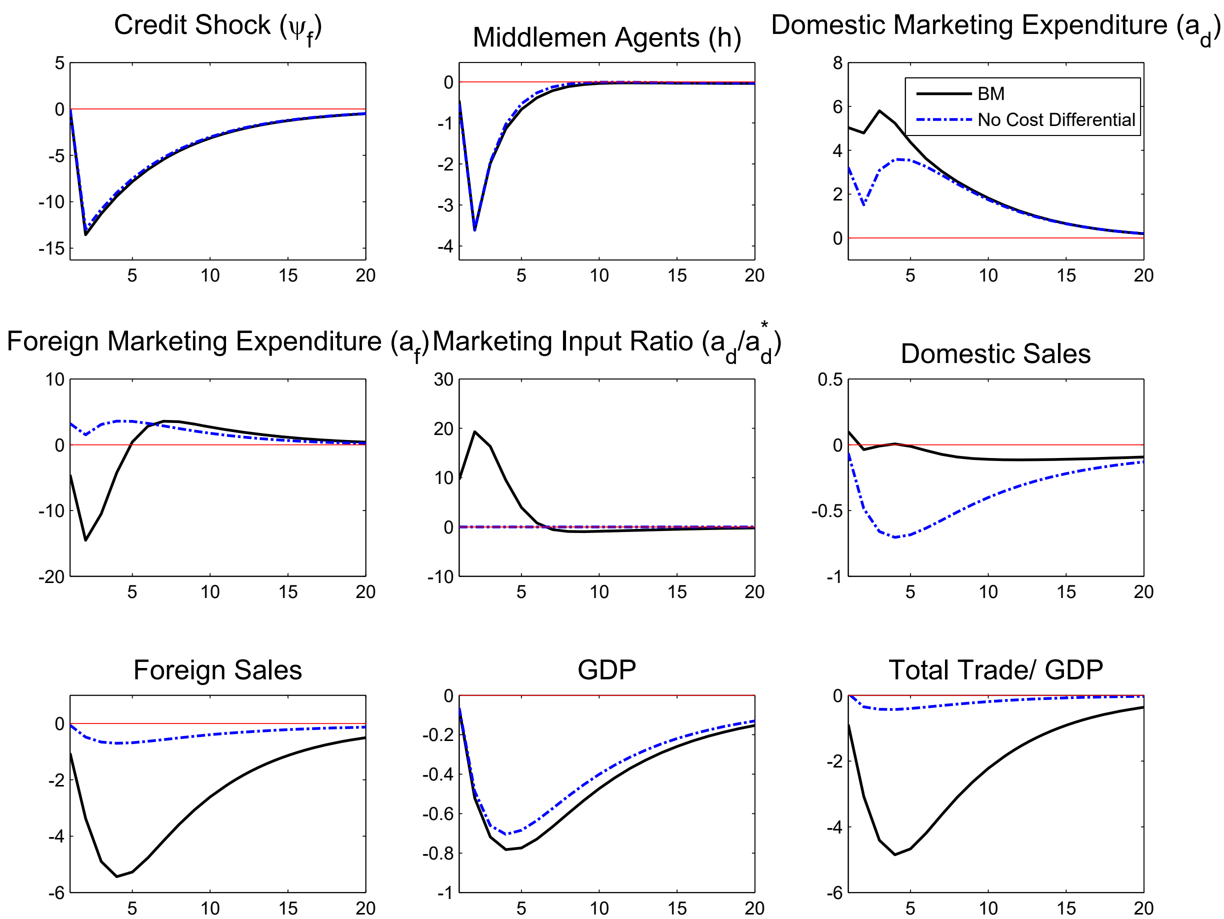

Figure 1.7: Impulse Responses to a News Shock: No Marketing Cost Differential

Note: All graph are in percent deviation from steady state.

Static Market Share

In our earlier discussions of the impulse responses, we have highlighted the role played by the desire of the producer to control market share in driving the dynamics of the trade collapse. In order to understand the importance of this choice, we study the case where a firm's marketing expense is predetermined and static. This implies that the accumulation of new relationship capital is driven only by the number of agents of the middleman. Specifically, we replace π_d and π_d^* in equation (1.8) and (1.9) with constants that give the steady state trade-GDP ratio of 26 percent in both the home and foreign market. Replacing H_t, the list of relationships with the quantity of goods sold, d_t, the relationship capital accumulation equation can be written as:

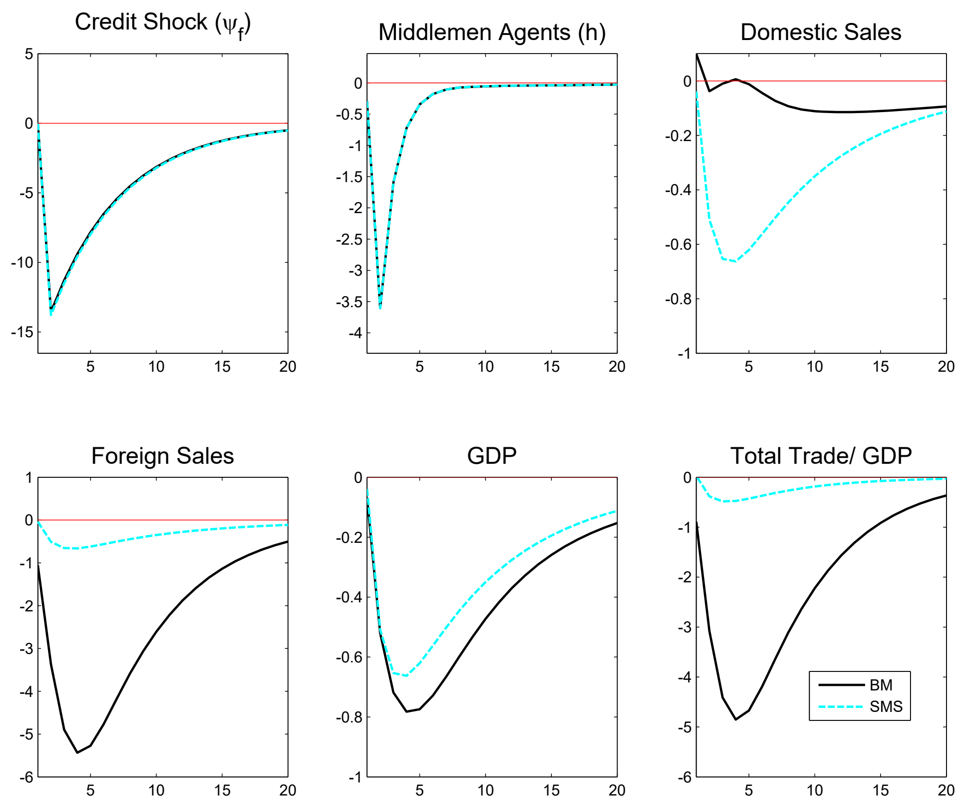

Figure 1.8: Impulse Responses to a News Shock: Specifications with Static Market Share (SMS)

Notes: BM: Benchmark; SMS: Static market share. Parameters are calibrated to steady state targets for each cases. Shocks are adjusted to match a fall in wholesale labor of 3.62%. All graph are in percent deviation from steady state.

$$d_t = (1 - \delta_H)d_{t-1} + \bar{\pi}_H h_t, \tag{1.29}$$

where $\bar{\pi}_H$ is a static market share. We parameterize this model using the same steady state targets as the benchmark model with the natural exception of the target for marketing expenditure which is removed since the marketing input variables are constant terms here. As shown in Figure 1.8, when the model is hit with tighter credit conditions as before, the fall in the trade-GDP ratio is much smaller than our benchmark model despite a similar fall in the number of agents looking for matches with producers. The initial story remains the same in response to the financial shock: the middleman lowers h and given the static market shares, slows down new relationship acquisition and, this implies lower sales. Since no reallocation of marketing expenses is possible, both foreign and domestic production is equally hit. As a result the fall in trade is much closer in magnitude to the fall in GDP in contrast to the data.

Sensitivity to Key Parameters

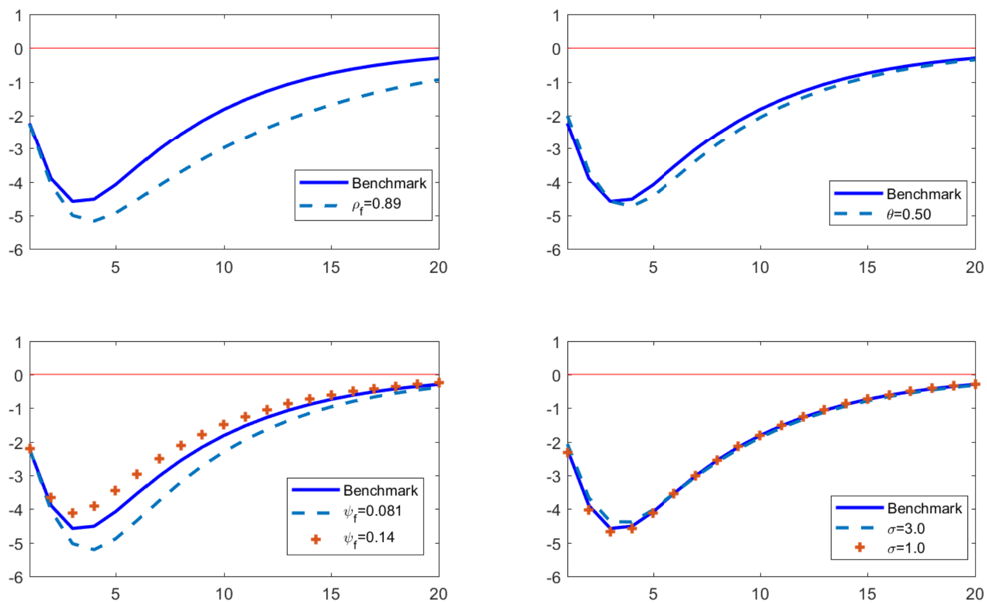

Figure 1.9: Trade/GDP Responses: Sensitivity to Parameter Changes

Note: All graph are in percent deviation from steady state.

To test the robustness of our mechanism, we look into the sensitivity of key parameters in generating the trade collapse holding all other parameters constant. Figure 1.9 plots the impulse response of trade-GDP ratio for each sensitivity test on the following four parameters: $\theta, \bar{\psi}_f, \sigma$, and ρ_f. The sensitivity tests involve increasing $\theta = 0.5$ which implies equal bargaining power, considering values of ψ_f that are 25% above and below our benchmark calibrated value, increasing $\sigma = 3$ and decreasing $\sigma = 1$ from the benchmark value of 2 and increasing the persistence of the shock process to .89 which is the estimated value using commercial and industrial loans instead of non-financial commercial paper as in our benchmark calibration. The responses are largely insensitive to the change in parameters except for ρ_f. Increasing the persistence of the credit shock leads to a bigger and longer trade collapse as one would expect.

TFP Shock

Our model contains one other stochastic processes, a shock to producer's total factor productivity z_t. The impulse responses are in Figure 1.10 (see also Figure 1.15, 1.16a and 1.16b in the appendix). We will discuss them here with the main goal being to point out that this shock cannot easily explain the fall in the trade-GDP ratio.

The main impact of a 1% fall in TFP in both countries is to cause marginal costs to rise in the economy. This has an impact on all firms: producers produce less output and spend less on marketing while middlemen send fewer agents into the matching market. This can be seen in Figure 1.10 which shows that marginal costs rise roughly 1% above steady state levels and then slowly return to steady state over the next two years. In response producers cut domestic marketing expenses by about 9% symmetrically in both countries (note this is the no cost differential case – see Figure 1.16a) and immediately reduce production by 0.5% for both markets. Similarly the middleman reduces agents by 5%. As relationship capital declines, the fall in production increases to a trough of roughly 1%. Since GDP falls slightly more than total trade the trade-GDP ratio rises ever so slightly. The presence of a cost differential makes the case for TFP shocks worse since trade rises while GDP falls leading to an overall rise in the trade-GDP ratio. The rise in trade is driven by an increase in sales in the foreign market while the fall in GDP is driven by a decrease in sales in the home market. Ignoring adjustment costs for a minute and replacing the sales constraints into the relationship capital accumulation equations in both markets, we notice that since the

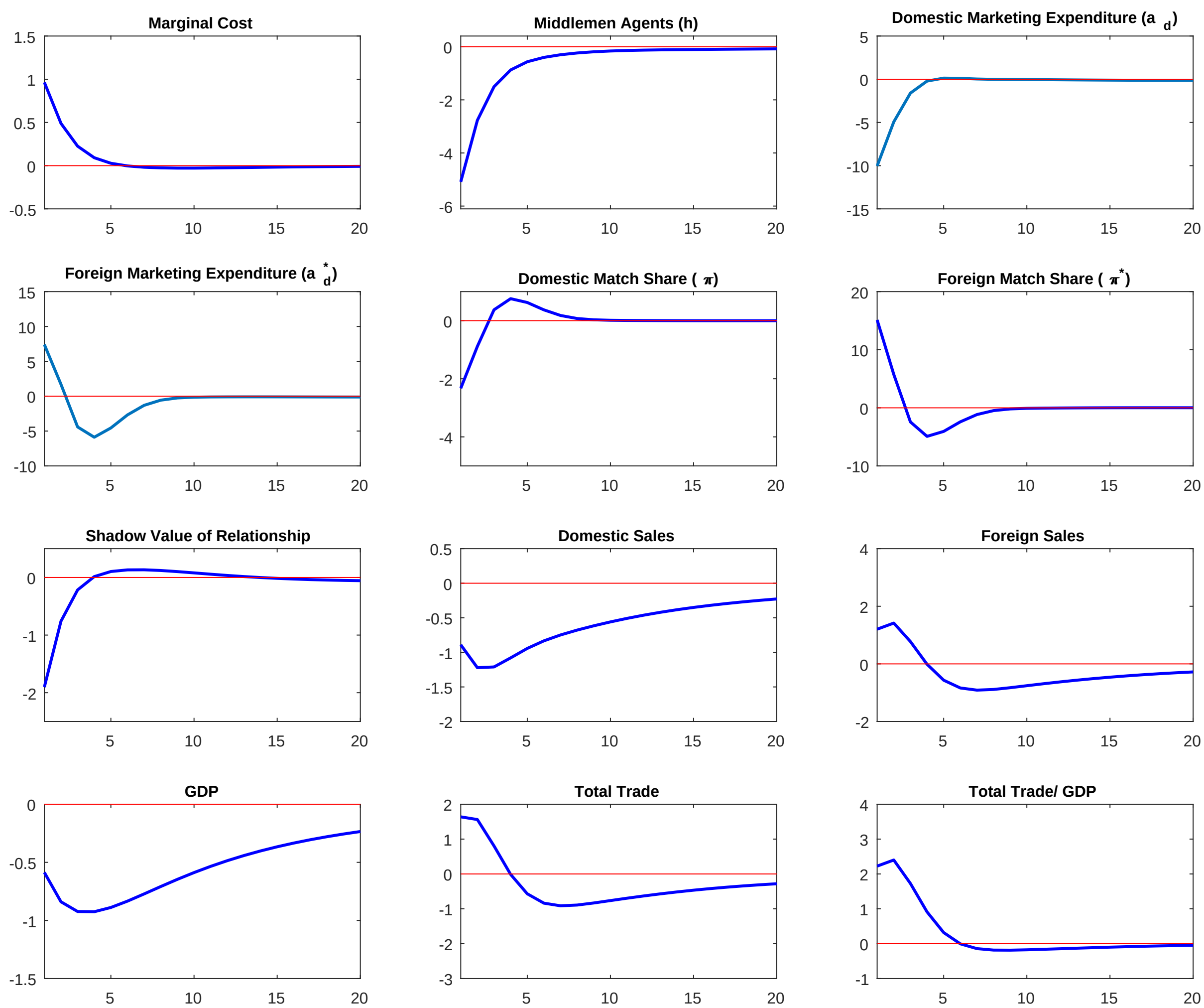

Figure 1.10: Impulse Responses to a TFP Shock

Note: Impulse response to a 1% TFP shock. All graph are in percent deviation from steady state.

number of middleman agents fall in both markets, the differential response of sales must come from differences in the behavior of π_d and π_d^* which, in turn, depends on differences in the behavior of marketing expenditure by the producer in the home and foreign country. This is confirmed in Figure 1.10 where we see that a_d falls while a_d^* rises on impact. The desire to reduce marketing expenses can be seen in the fall in the shadow value of relationships in both markets. This desire is temporarily overturned by the opportunity created by the cut in home marketing which increases the ability of producers to gain market share in the foreign market for one period before reverting to below steady state marketing levels in both countries. The extra relationships created by this temporary burst in marketing leads to increased foreign sales for three periods due to the persistence of relationships. The net result is a rise in the trade-GDP ratio during a recession. The presence of adjustment costs lengthen out and mitigate the burst of foreign marketing so that trade rises while GDP falls for several periods longer than in the absence of adjustment costs.

1.4 Conclusion

What explains the unusual collapse in trade during the Great Recession? The behaviour of trade during this recession was unusual not only in its severity relative to past episodes but is also puzzling relative to the predictions of international business cycle models where it is hard to generate movements in trade that are significantly larger than in GDP. We contribute to the existing literature by using a real two-country business cycle model with relationship capital and credit shocks to generate a size-able collapse in trade that explains roughly 44 percent of the fall in the trade-GDP ratio seen in the data. Key features of the model that contribute to trade moving more than GDP are a cost differential between marketing expenses to acquire supply-chain relationships in the home market relative to abroad and the presence of long-term enduring relationships. The basic mechanism driving the drop in economic activity is as follows: tighter credit constraints create a drop in demand for the product of firms which respond by switching scarce marketing resources from the foreign country to the home country. As a result, cross-border trade drops more than domestic trade, leading to a large movement in the trade-GDP ratio.

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1.6 Appendix

1.6.1 Data Sources

Table 1.2: Data Sources

Panel A: Series were retrieved from FRED, Federal Reserve Bank of St. Louis		
Code name from source	Series name	Unit
GDPC1	Real Gross Domestic Product	Billions of Chained 2009 Dollars, Quarterly, Seasonally Adjusted Annual Rate
EXPGSC1	Real Exports of Goods and Services	Billions of Chained 2009 Dollars, Quarterly, Seasonally Adjusted Annual Rate
IMPGSC1	Real Imports of Goods & Services	Billions of Chained 2009 Dollars, Quarterly, Seasonally Adjusted Annual Rate
NFINCP	Commercial Paper of Non-financial Companies	Billions of Dollars, Monthly, Seasonally Adjusted
DTBSPCKM	Commercial Paper Outstanding	Billions of Dollars, Monthly, Seasonally Adjusted
PCEC96	Personal Consumption Expenditures	Billions of Chained 2009 Dollars, Quarterly, Seasonally Adjusted Annual Rate
GPDIC1	Real Gross Private Domestic Investment	Billions of Chained 2009 Dollars, Quarterly, Seasonally Adjusted Annual Rate
HOANBS	Nonfarm Business Sector: Hours of All Persons	Index 2009=100, Quarterly, Seasonally Adjusted
LABSHPUSA156NRUG	Share of Labour Compensation in GDP	Current National Prices for United States, Annual, Annual Rate

Panel B: Others
Bureau of Labor Statistics, U.S. Department of Labor, Occupational Employment Statistics, [date accessed: March 01,2017] [www.bls.gov/oes/].
U.S. Bureau of Economic Analysis, Gross-Domestic-Product-(GDP)-by-Industry Data, [date accessed: March 01,2017], [https://www.bea.gov/industry/gdpbyind_data.htm].

1.6.2 Figures

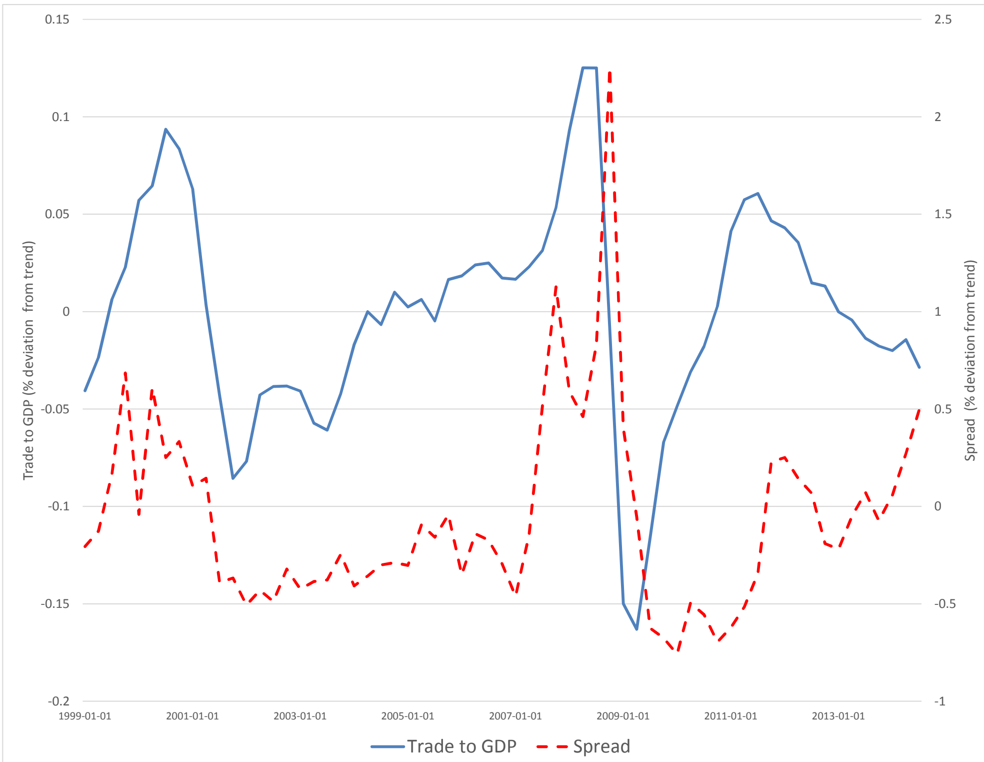


Figure 1.11: % Deviation from Trend: Spread and Trade/GDP

Note: Spread refers to the difference between the Libor rate and US T–bill rate. The trend is calculated using HP-filter with smoothing parameter of 1600.

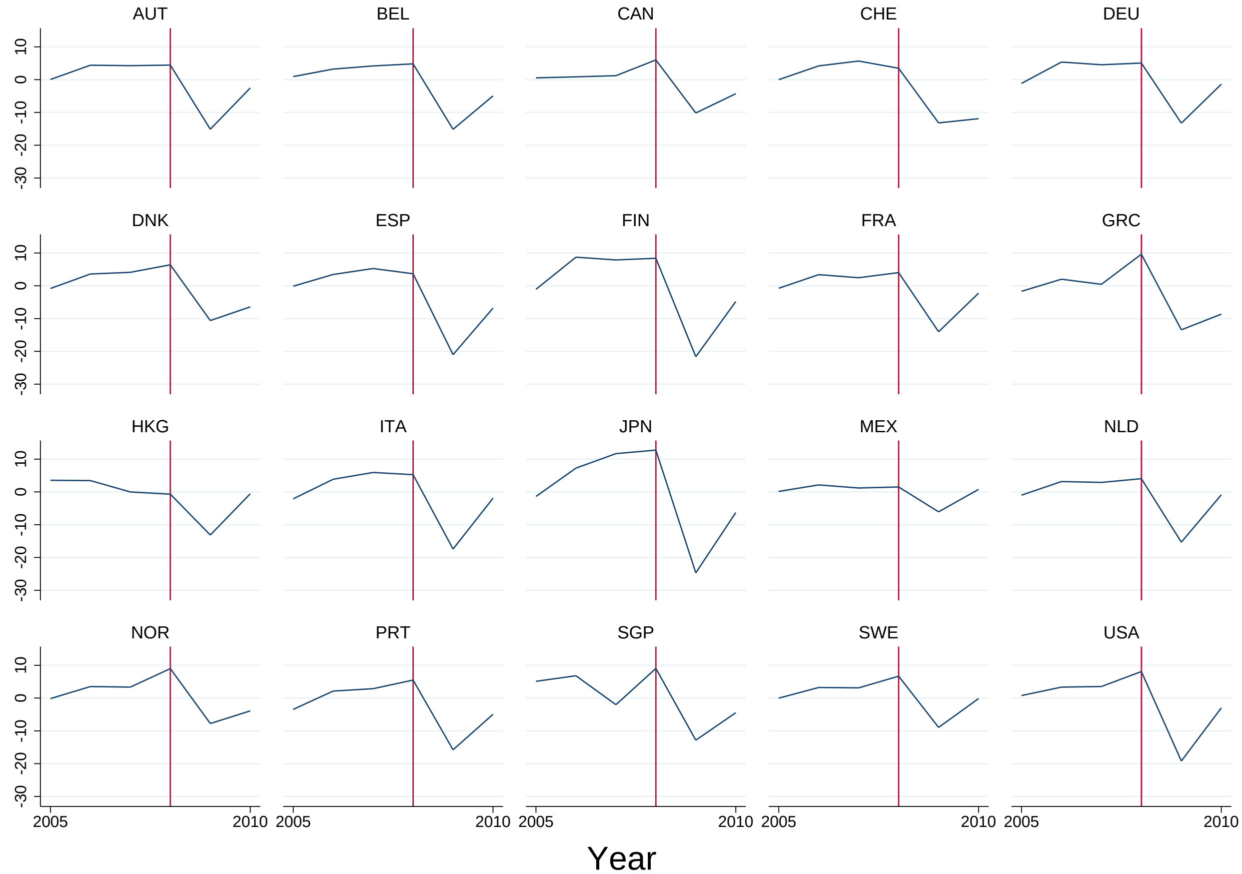


Figure 1.12: % Deviation from Trend: Trade/GDP

Note: Red lines reference the year 2008. The trade data is from World Integrated Trade Solution. The GDP is from the World Bank. Both series are annual series in nominal value. The trend is calculated using HP-filter with smoothing parameter of 16.

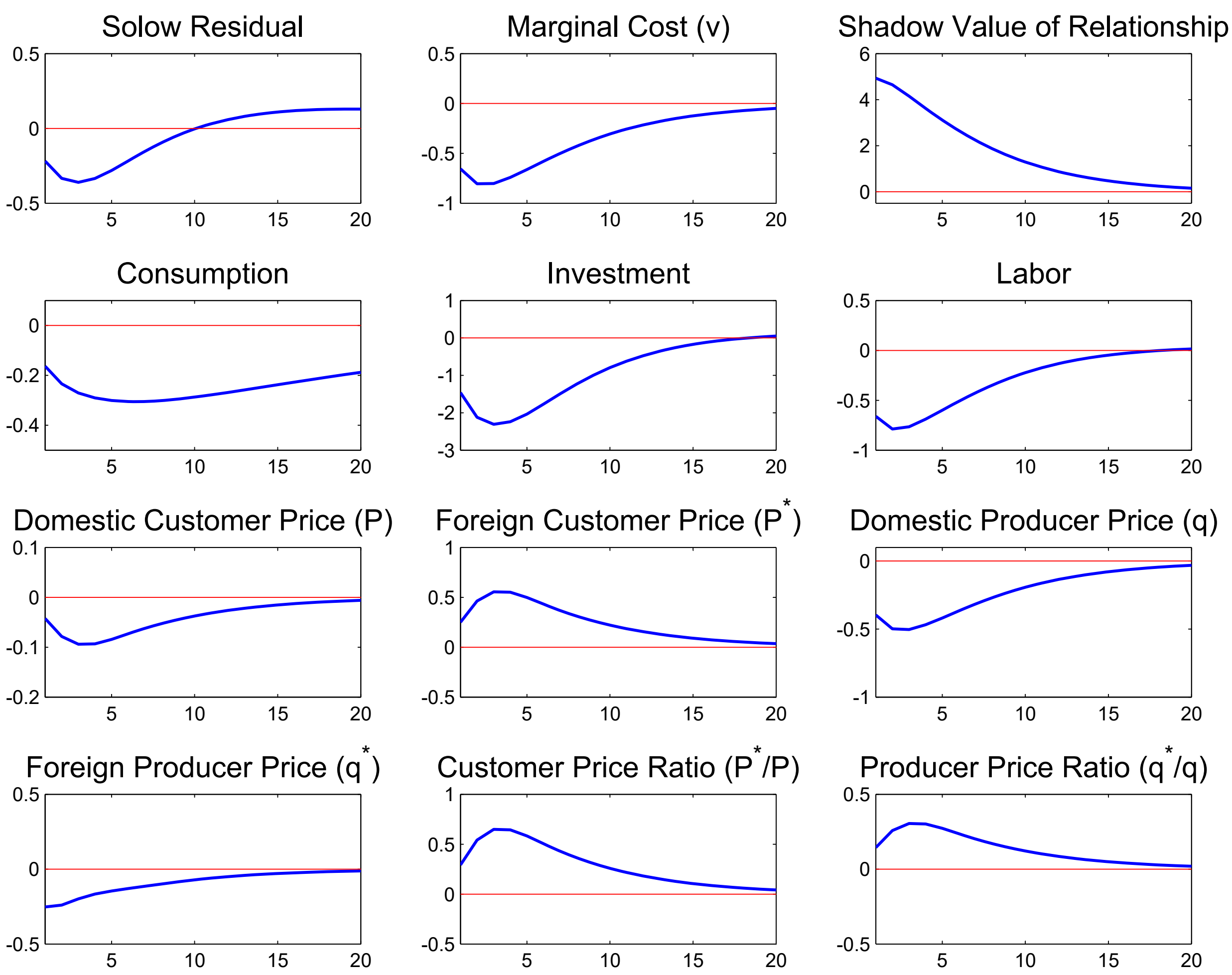


Figure 1.13: Impulse Response to a Credit Shocks Additional Variables

Note: Impulse response to a Credit Shock. All graph are in percent deviation from steady state.

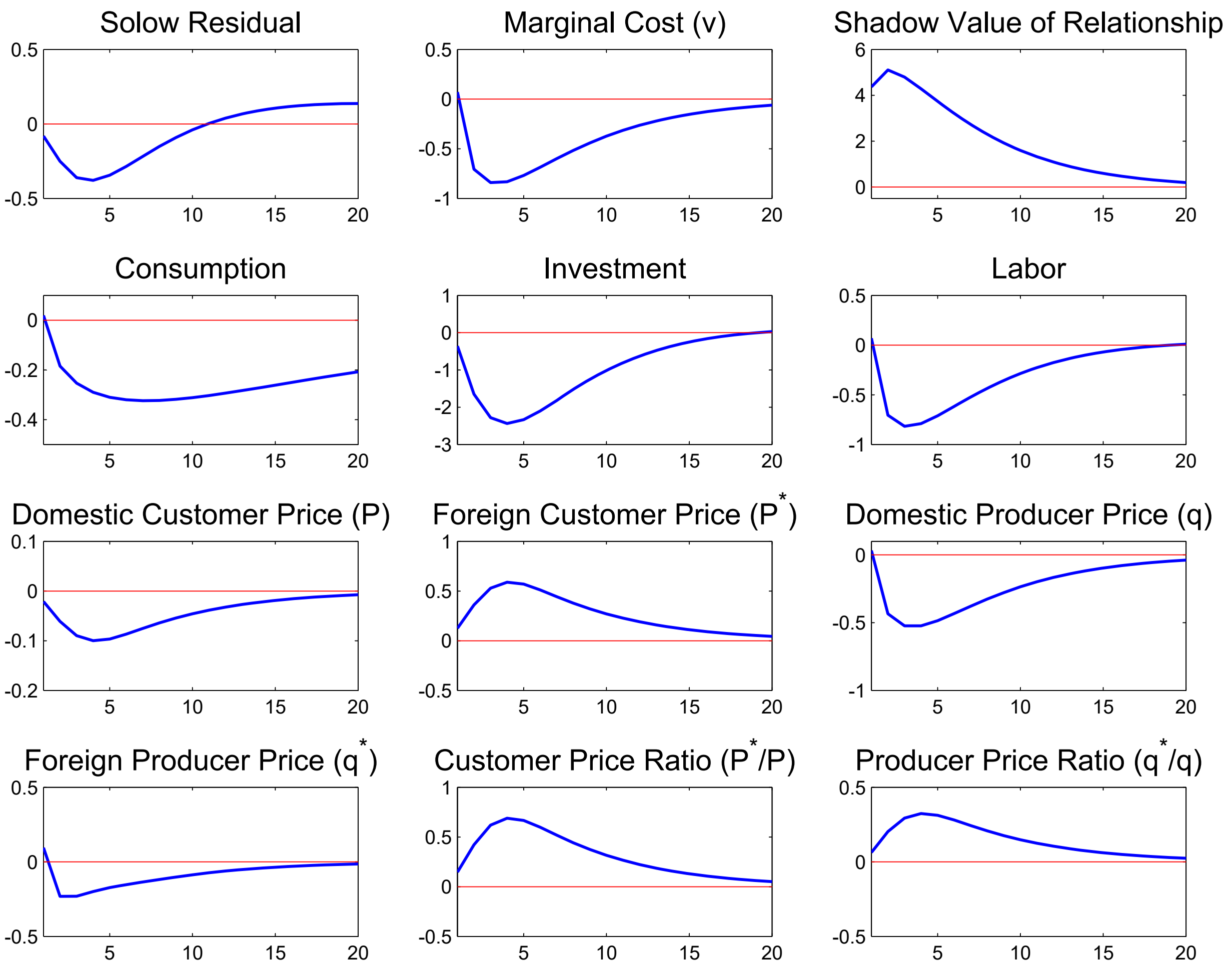


Figure 1.14: Impulse Response to a Credit News Shock Additional Variables

Note: Impulse response to a Credit News Shock. All graph are in percent deviation from steady state.

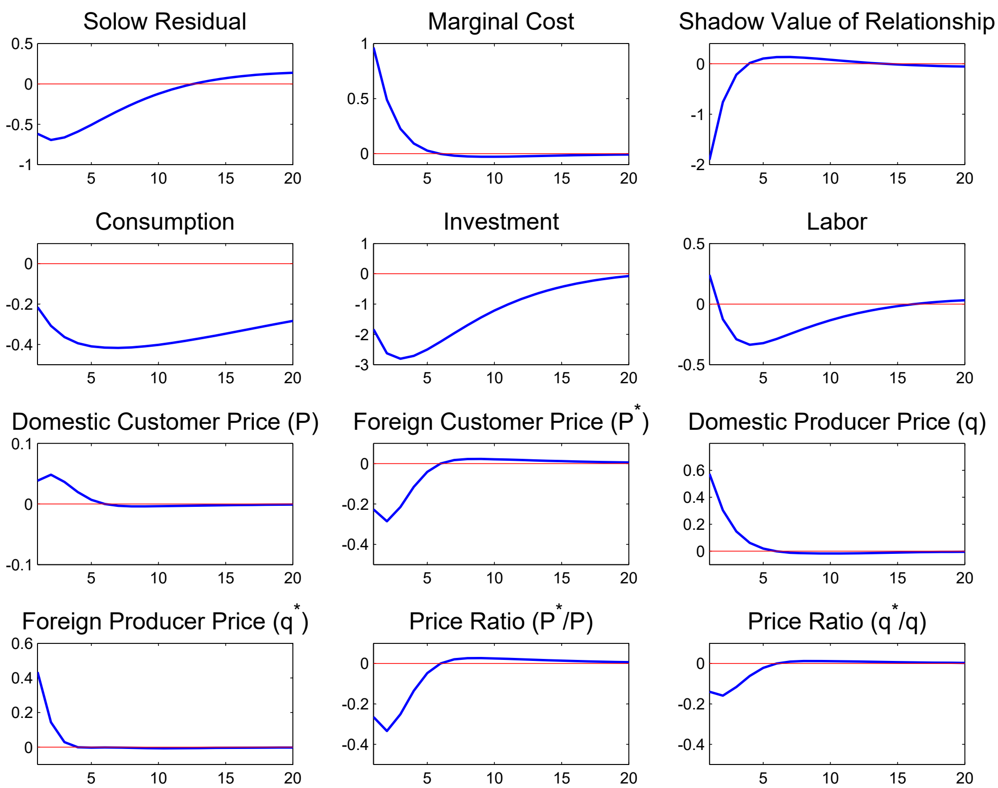


Figure 1.15: Impulse Response to a TFP Shock Additional Variables

Note: Impulse response to a 1% TFP shock.

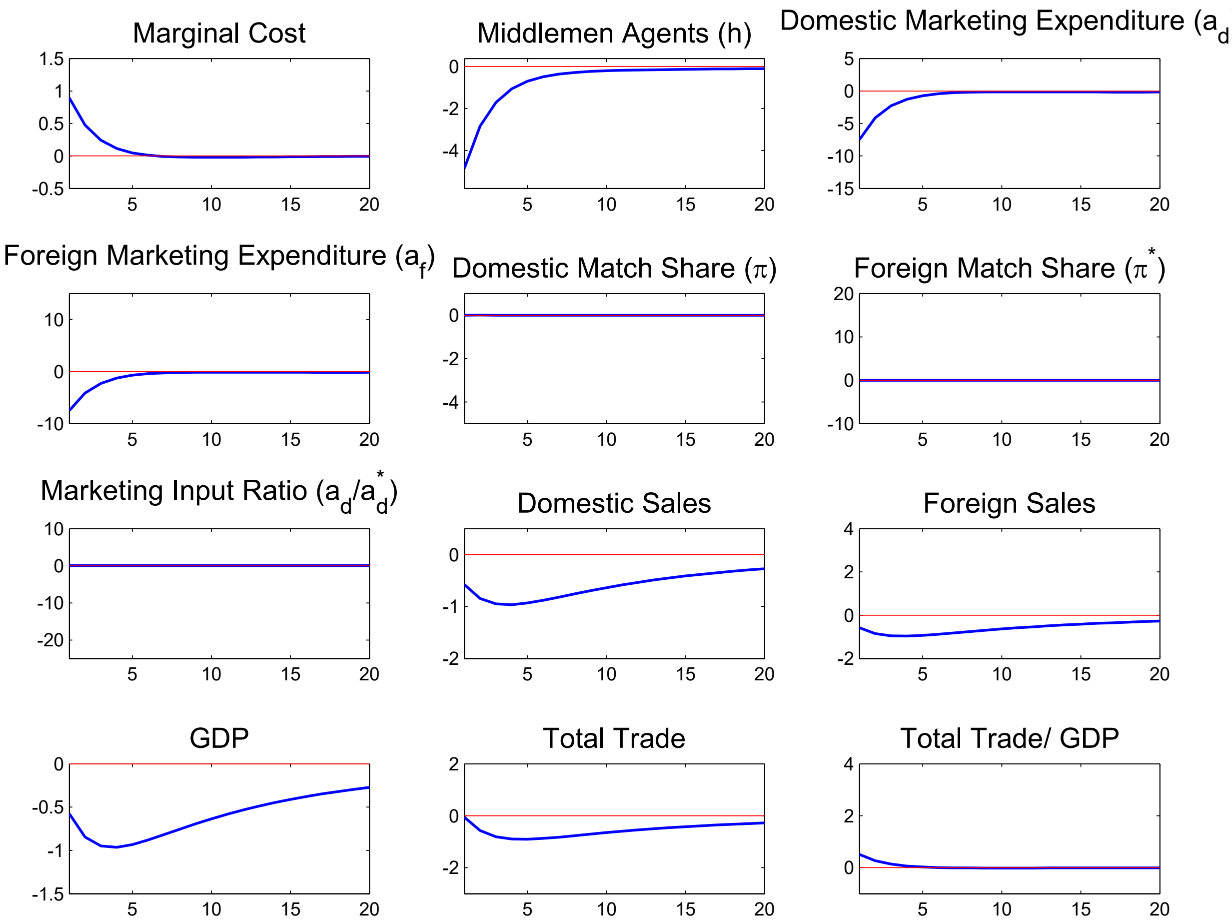


Figure 1.16a: Impulse Response of a TFP shock without cost differential

Note: Impulse response to a 1% TFP shock.

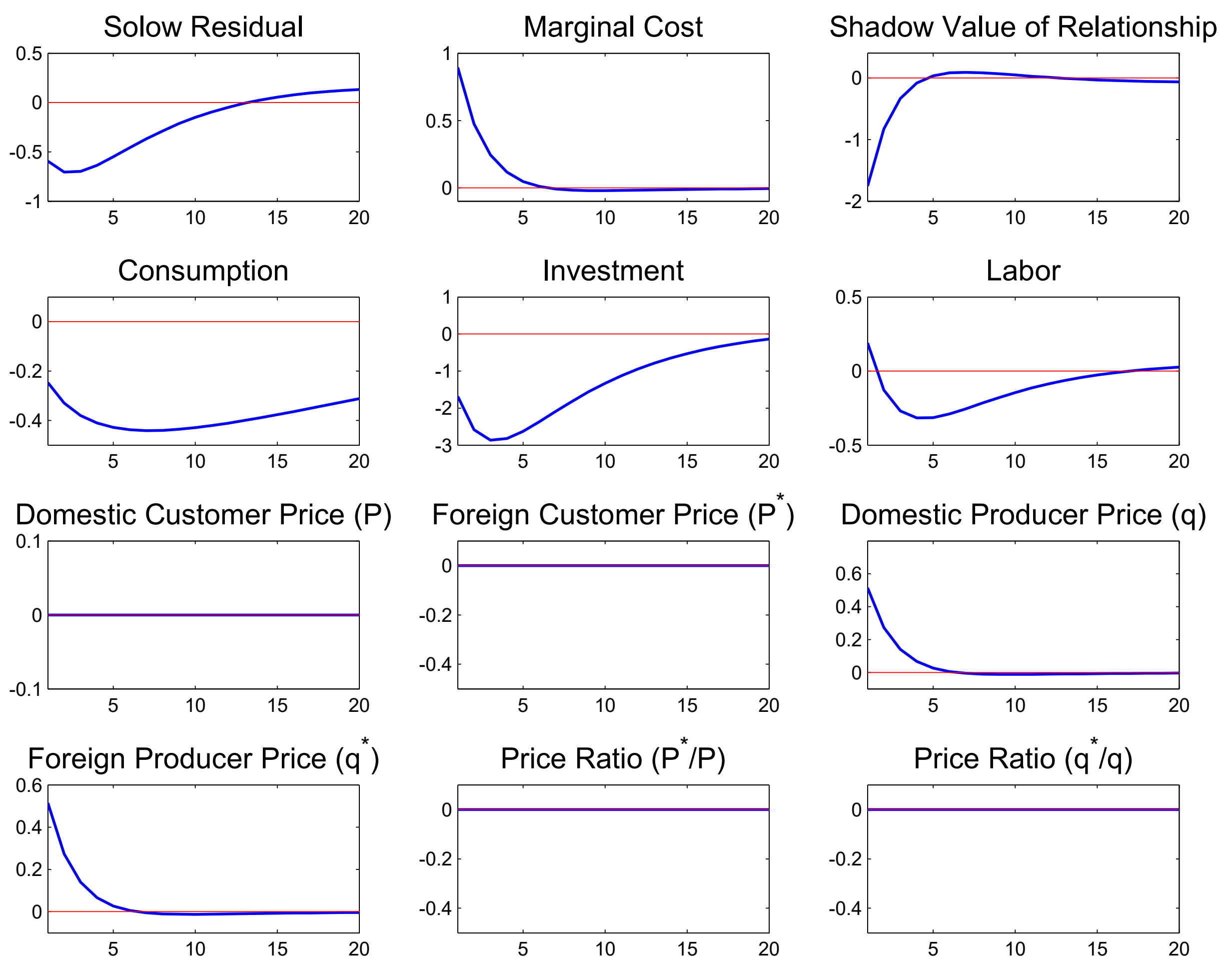


Figure 1.16b: Impulse Response of a TFP shock without cost differential

Note: Impulse response to a 1% TFP shock.

Table 1.3: Moments: Data v.s. Model

Moments	Data	Model	D&N	BKK
Volatility relative to GDP				
Investment	2.76	2.76*	3.67	3.45
Total Trade	2.47	1.78	0.80	0.96
Consumption	0.74	0.31	0.31	0.34
Employment	0.81	0.51	0.60	0.48
Correlation				
GDP with				
Consumption	0.83	0.78	0.94	0.94
Employment	0.85	0.77	0.86	0.99
Investment	0.93	0.94	0.98	0.98
Autocorrelation				
GDP	0.85	0.85	0.81	0.70
Consumption	0.82	0.89	0.71	0.76
Employment(hour)	0.91	0.74	0.58	0.70
Investment	0.80	0.87	0.83	0.70
Trade	0.69	0.74	0.81	0.74

Notes: D&N: Drozd and Nosal (2012) and BKK: Backus(1992). All Statistics based on logged and HP filtered time series. * calibrated.
Source: Investment: Real Gross Private Domestic Investment; GDP: Real Gross Domestic Product; Employment: Nonfarm Business Sector: Hours of All Persons; Trade: Real Import + Real Export.

Chapter 2

Productivity, Political Economy, and Intellectual Property Rights

2.1 Introduction

Production as measured by output per capita varies significantly across countries;. Much of this is due to differences in total factor productivity (TFP).[1] Why do some countries have high TFP while others do not? Since TFP is an aggregate result of firms' technology choice, it is crucial to understand firms' behavior and their incentive to adopt or not adopt the frontier technology. Besides production inputs, market competitiveness, and other factors, intellectual property rights (IPR) can play an important role in determining firms' profit from adopting frontier technology, and thus their choice of production technology. A large body of literature shows that strict IPR enforcement can lead to higher productivity under some conditions (e.g., a competitive market).[2] However, we do not observe that all developing countries try

[1] The literature shows that TFP accounts for most economic growth across countries. Meanwhile, labor and capital account for only 30% of GDP per capita (Caselli, 2005; Jones, 2015).

[2] In particular, the Schumpeterian growth model examines productivity and growth through the channel of creative destruction, catching-up, and so forth. Aghion et al. (2014) provide a comprehensive survey

to strengthen their IPR policy to encourage growth, even if they are capable of doing so. Here, I suggest that this occur due to political risk, in particular, firms disadvantaged by IPR protection would influence policymakers, leading to sub-optimal outcomes.

As discussed in Prescott (1998), an important source of the large international differences in income per capita and productivity seen in the data may occur due to differences in technology adoption.[3] Studying the interplay between the market and political economy is important in explaining policy making, and thus the difference in economic performance across countries.[4] This study aims to provide such a theory and contributes to the literature by incorporating a rent-seeking policymaker into a model in which each firm possessing differing technology adoption abilities chooses a production technology, by either adopting the frontier technology or imitating older technology. I argue that these are important features that generate multiple equilibria that resemble the high international variability in productivity.

To explain the productivity differential across countries, I analyze a model featuring firms with an endogenous choice of production technology and a rent-seeking policymaker. Given access to the same frontier technology, firms choose a production technology that provides the highest return depending on their ability to adopt it.[5] Firms with low adoption ability would copy older and less efficient technologies, but are subject to state enforcement, and are thus less competitive in the market. Non-frontier firms are subject to IPR enforcement, and the government may confiscate non-frontier firms revenue as these firms appropriate technology. As the government changes IPR enforcement, the market environment changes, some firms would find beneficial to change their technology adoption decision.

of the literature and some recent work. For recent related work using the Schumpeterian framework, see Acemoglu and Cao (2015) and Davis and Şener (2012). It would be an interesting extension to incorporate Schumpeterian features in this model.

[3]See also Lucas (1988).

[4]See North (1990) for a detailed discussion and various historical evidence. Nunn (2009) provides an overview of the evidence of how the initial institutions interact with the economy and determine growth, which is path-dependent.

[5]An extensive body of literature discusses technology diffusion (e.g., Eaton and Kortum (1999), Matsuyama et al. (2014), etc.), but I focus on the adoption of frontier technology available within a country. This is a particularly valid assumption for developing countries, which is common in the literature.

Collectively, these non-frontier firms can influence policymakers' turn-over risk to have IPR enforcement set in their favor. The political economy has a simple form, and is similar to that in Acemoglu (2006) and Besley and Persson (2011). Policymakers earn political rent in proportion to the total output and face the risk of losing power.[6] Under strict enforcement, non-frontier firms oppose policymakers by supporting the non-incumbents, which increases the policymaker's turnover risk. In a non-cooperative environment, as in Cooper and John (1988), I show that the possibility of losing power can lead to a sub-optimal policy. Turnover risk is a function of the proportion of non-frontier firms, their contribution to the opposition, and the strength of the institutions. When the institution is strong, non-frontier firms have little influence on the policymaker. This results in a unique equilibrium where the policymaker selects a level of enforcement that maximizes total output (and thus policymakers' rent). However, if the institution is weak, non-frontier firms have profound political influence. In this case, there are two equilibria when we consider a non-cooperative equilibrium as in Cooper and John (1988): one featuring IPR enforcement that maximizes non-frontier firms' profit and a second where the policymaker's benefit from total output growth exceeds the loss from rising political risk. A country without strong institutions may stay in either a low or high productivity equilibrium depending on the previous path.

The technology adoption decision changes as the gains from production change in different market environments. The model predicts that a relatively stronger institution is required for the existence of a high IPR enforcement state.[7] I also show that a country is likely to be in a lower economic state when firms produce highly substitutable goods. As Easterlin (1981) and Becker et al. (2011) show, countries with higher education (technology adaptability in

[6] Acemoglu and Robinson (2012) provides many historical events in which political consolidations have a negative effect on technology adoption, one of which is quite explicit: Queen Elisabeth I rejected a patent application from William Lee for his knitting machine invention. The Queen stated her concern that the knitting machine could cause unemployment.

[7] Acemoglu et al. (2016) emphasize that the institutional environment has a substantial impact on technological progress by showing that post offices—an extended arm of the patent office at the county level—predicted future patenting in the 19th century.

the model) are likely to have a higher technology adoption rate. This model yields similar implications. When countries are bound at a certain level of IPR enforcement (either as an exogenous shock or as an initial state), countries with a higher ability to adopt technology are more likely to converge to the high state equilibrium.

Gradstein (2007) examines how the initial income distribution determines the level of property rights enforcement by mean of democratization. The elite class, the group holding political power in the initial period, makes a trade-off between economic growth and gains from appropriation. In this paper, the trade-off is between the size of total output and the chance that the policymaker stays in power. Gradstein (2007) does not consider technology adoption as the main mechanism for productivity. Gonzalez (2005) investigate the incentive to adopt frontier technology in the presence of exogenously given insecure property rights.[8] Eicher and García-Peñalosa (2008) endogenize the private investment in IPR protection in a growth model, while this paper examines the political economy of public IPR protection in a heterogeneous agents model. Akcigit et al. (2016) shows that an efficient patent market can affect growth.Krusell and Ríos-Rull (1996) extend the vintage human capital model of Chari and Hopenhayn (1991) with political economy to study the growth and stagnation of technology adoption. Generational conflict prevents the economy from adopting superior technology. The resistance comes mainly from the older generation, who invested in the older technology. This paper considers different sources of conflict, where the resistance comes from firms with low adoption ability. Acemoglu et al. (2006) model an economy that chooses between innovation and technology adoption with a simple political economy; however, the author focus on the government's investment subsidy in their paper. The policymaker's trade-off decision is similar of that in Bai and Lagunoff (2011), "if the current ruler chooses

[8]In Gradstein (2007) and Gonzalez (2005), firms appropriate from a common pool or a similar mechanism to allocate each firm's gains. In this paper, firms complete in a monopolistic competitive market. The change in IPR policy triggers some firms to adopt (or not adopt) frontier technology and affect the other firms through the change in total demand and relative prices. See also Gonzalez (2007) for an application to growth and welfare.

his preferred policy, he then sacrifices future political power; yet if he wants to preserve his future power, he must sacrifice his present policy objective". A set of literature analysis the effect of strengthening IPR, for example, Kiedaisch (2015) and Tanaka and Iwaisako (2014).

This paper provides insight on some extensive international IPR enforcement treaties. In 1994, the World Trade Organization (WTO) set a minimum standard of IPR regulation for its member countries, the Trade-Related Aspects of Intellectual Property Rights (TRIPS). For some existing members, especially developing economies, it is a large exogenous shock to IPR enforcement. The model provides a framework to analyze the effect of such exogenous shocks. It hints that countries with low substitutability between goods and high education (or talent to adopt) would move to the high IPR state. Additionally, the model provides a rationale for the series of negotiations between the WTO and members with developing economies.[9] The policymaker may not observe the possibility of high IPR state, or that the high IPR state does not even exist based the country's characteristics. Consequently, the policymaker resists implementing the WTO's requirement on IPR regulation.

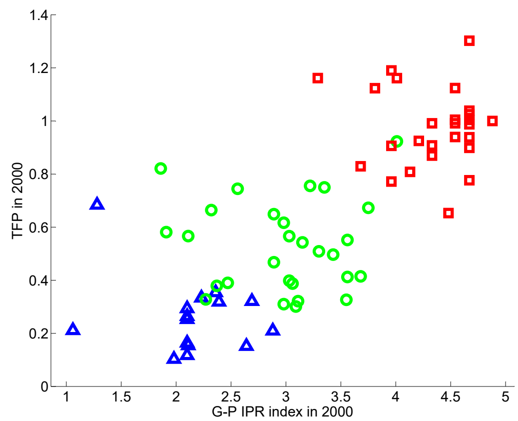
In section 2, using country level data and a firm-level survey, I show that countries with stricter IPR protection are associated with higher TFP. Firms in countries with stricter IPR protection are more likely to adopt technology actively. Section 3 discusses a market environment with an exogenous policy, and Section 4 discusses the IPR policy determination through political economy and its effect on the market. Section 5 concludes.

2.2 Motivation

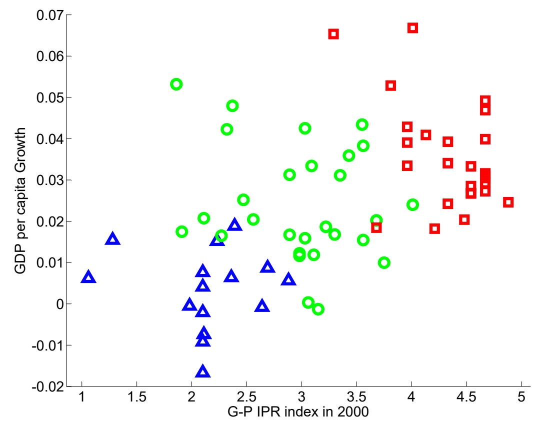
To shed light on the correlation between TFP, IPR and political environment, this section presents some empirical regularities using country-level data from the Penn World Table

[9]See the Agreement on Trade-Related Aspects of Intellectual Property Rights and the Doha Declaration. See also Scotchmer (2004), he analyzes the political economy of intellectual property treaties and provides an overview of the historical time line.

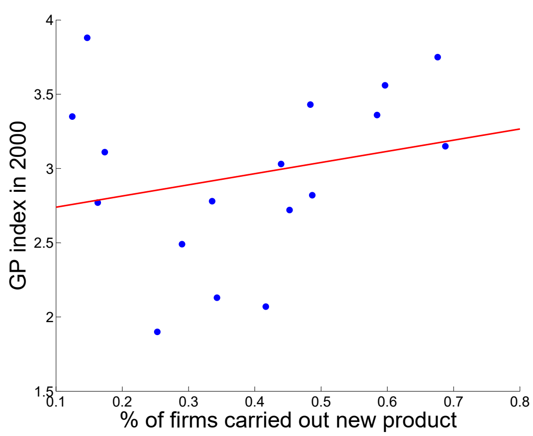
(version 8.1), a firm-level survey from the World Bank's Enterprise Surveys and the Database of Political Institutions.



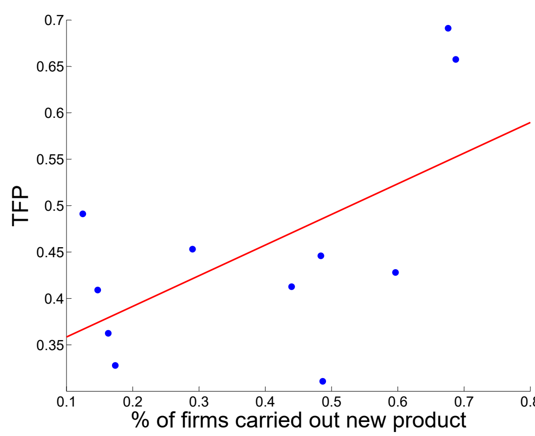
(a) TFP vs. GP index



(b) GDP growth vs. GP index



(c) Percent of firms with new product vs. GP index



(d) TFP v.s. Percent of firms with new product

Figure 2.1: TFP, GDP growth, Innovativeness, and Patent Rights Index

Notes: Clusters in figures a) and b) are assigned using a K-mean algorithm with 100,000 initial points. GDP per capita growth calculated between 1960 and 2000.

Sources: Penn World Table 8.1, Park (2008), and Enterprise Survey from World Bank.

Except for the IPR proxy, I obtain all country level data from the Penn World Table. I use a patent index constructed by Ginarte and Park (1997) as a proxy for IPR protection (hereafter, the GP index).[10] I drop countries with small population sizes of less than 100,000

[10]This index is based on five main components: (i) membership in an international patent agreement, (ii)

people. After merging the dataset, only 69 countries remain in the sample. Figures 2.1a and 2.1b plot the level of TFP and GDP per capita growth from 1960 to 2000 against the GP index. The shape of the data points represents three clusters (low income – triangle, middle income – circle, and high income – square). Both TFP and GDP growth have a positive relationship with the GP index.[11]

To investigate the relationship between frontier technology adoption and IPR enforcement, I use the firm-level survey initiated by the World Bank Group. The Enterprise Survey collects information about firms' experience of the business environment and their characteristics across countries. The survey was conducted between 2002 and 2006 and covers 71,789 firms in 63 countries. Unfortunately, the subsequent surveys do not ask the same set of questions and drop some of the important variables in this study. Although the interviewer asked the managers questions face-to-face based on the same questionnaire, not all firms answer all questions listed on the questionnaire.[12] After merging with the GP index, removing the state/government-owned firms, and keeping the firms that answered the question related to the main dependent variable, the sample decreased to 10,609 firms in 21 countries.[13] All countries are considered developing countries with Gross National Income (GNI) per capita ranging from \$ 100 to \$ 2,850 USD. To measure innovation activity, similar to Gorodnichenko and Schnitzer (2013), the variable *new product* takes a value of one if the firm developed a new product (including those that involve a significant change in the production process) in the last three years.[14] Since the sample is in developing countries, most of the firms are

provisions for loss of protection, (iii) enforcement mechanisms, (iv) duration of protection, and (v) extent of coverage, calculated quinquennially. I use the updated index in Park (2008).

[11]Since IPR is likely correlated with human capital, the TFP measurement here accounts for the quality of labor and capital. The result is similar when TFP is not input-quality adjusted.

[12]For administrative reasons, some questions were dropped completely in some specific countries.

[13]The sample covers Algeria, Brazil, China, Ecuador, El Salvador, Ethiopia, Guatemala, Honduras, Indonesia, Mali, Morocco, Nicaragua, Peru, the Philippines, Senegal, South Africa, Sri Lanka, Syria, Thailand, the United Republic of Tanzania: Mainland, and Zambia.

[14]Alternatively, the variables *develop new product*, *update product*, and *R&D* take a value of one if the firm undertook initiatives to develop a major new product line, update an existing product line, or if the firm spent more than \$1,000 on research and development, respectively. These variables follow the recommendation of the Oslo Manual; see Mairesse and Mohnen (2010) for a discussion of these measurements of innovation. Although

expected to adopt frontier technology rather than develop its own new technologies/products, which fit the description of the model below.[15]

Conditional on the variable *new product* equal to one (zero), the mean of the GP index is 3.30 (3.01). Of the sample, 4,595 firms developed a new product and 6,014 did not. Based on the t-test, the two mean estimates are significantly different. Figure 2.1c shows that the proportion of firms that develop a new product in each country is positively correlated with the GP index.[16] Figure 2.1d shows that TFP is positively correlated with the proportion of firms developing a new product in a country.

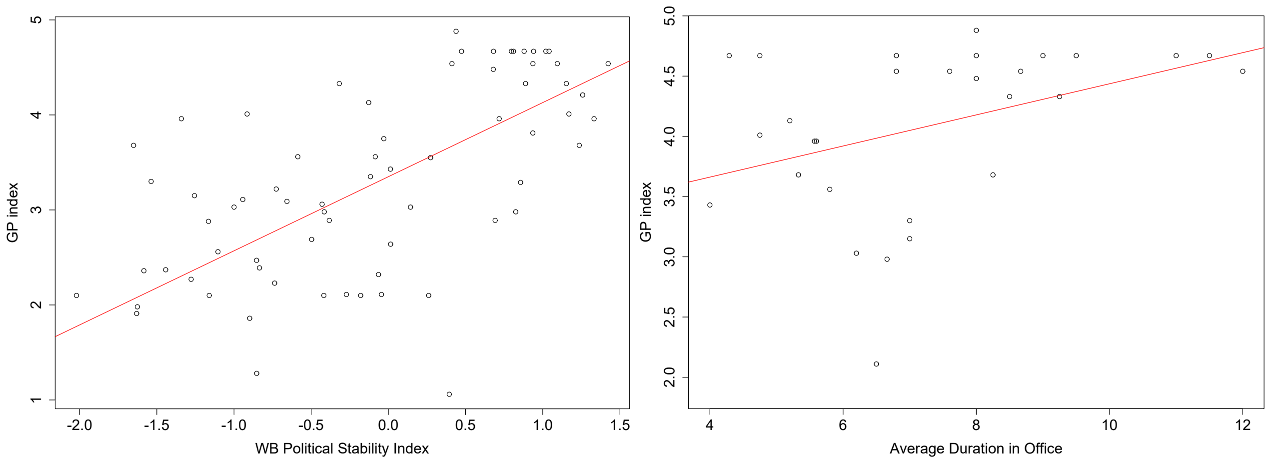
Turning to the relationship between political competition and the IPR, I show that policymakers might choose a suboptimal, low degree of IPR enforcement due to political considerations by showing that countries with low government stability are more likely to have weak IPR enforcement. Figure 2.2a shows a positive correlation between political stability and the IPR. I obtain the political stability index from the World Bank, which measures "perceptions of the likelihood of political instability and/or politically-motivated violence." Figure 2.2b illustrates a positive relationship between the GP index and the average duration of office tenure. The average length of office tenure is calculated using the Database of Political Institutions 2015 (Beck et al. (2001)), a dataset that begins in 1975. For each country, I record the length of each party in office (in years), and then calculate its average. However, not all countries are suitable to calculate the average length of tenure. To make a systematic adjustment, I drop the following observations: (i) the first party and the last party observations in the dataset, (ii) countries with one or less than one turnover; (iii) countries independent after 1991. Also, I count coalition parties as the successor or predecessor if they

these are self-reported, subjective measures, as Mairesse and Mohnen (2010) and Gorodnichenko and Schnitzer (2013) discuss, we are less likely to observe objective measures such as patents and R&D expenditures in developing economies. Additionally, these measures provide us information from the producer's point of view, which are unobservable in the common objective measure.

[15] Santacreu (2015) studies technology adoption by importing goods from a country leading in the technology, and finds that technology adoption contributes a large proportion of growth in developing countries.

[16] Three countries have a GP index greater than 3, but have a low percentage of firms that developed a new product: El Salvador, the Philippines, and Sri Lanka.

are the major party in the coalition. The coefficients of the fitted line (linear model) in both figures are statistically significant at the 5% level. The empirical results here suggest only correlation. However, to establish causality, we need to find an exogenous shock to the IPR regime (e.g., Aghion et al. (2015), Eicher and Newiak (2013)). In the appendix I provide some similar result using the firm as the sample unit.



(a) GP index vs. WB PSI (b) GP index vs. Average Tenure Duration

Figure 2.2: TFP, GDP growth, Innovativeness, and Patent Rights Index
Notes: The beta coefficient of WB Political Stability Index is 0.584 (std. error: 0.090) and the beta coefficient of WB Political Stability Index is 0.129 (std. error: 0.058).
Sources: Database of Political Institutions 2015, Worldwide Governance Indicators from World Bank, and Park (2008).

2.3 Model Economy

The model economy contains a continuum of agents and politicians who live for infinite periods. Each agent operates a firm in a monopolistically competitive market. In each period, only one of many politicians determines the level of IPR enforcement (hereafter, the policymaker). To focus on describing the characteristics of the market and the firms, I use the following process with an exogenous IPR enforcement parameter and defer the discussion of policymakers and the political economy of IPR until section 2.4. I also focus on the case where a higher IPR increases (decreases) the profit that the frontier (non-frontier) firm receives. This can be relaxed by changing the fixed cost structure that firms have to pay more for frontier technology as the IPR enforcement increases.

2.3.1 Agents and Firms

A continuum of agents indexed by $i \in [0,1]$ operate firms and consume production surplus every period. Each agent differs in term of ability or efficiency in adopting technology. The difference can be driven by the mix of employees' education or experience with the technology within each firm. Agent i's talent ω_i is a non-negative random draw from distribution $F(\omega)$. Each agent produces and represents the industry of a differentiable good i associated with an exogenous frontier technology, with productivity equal to $\bar{A}_i$.[17] For simplicity, the following assumes that the productivity of frontier goods is numerically the same (i.e., $\bar{A}_i = \bar{A}_j = A_f,\ \forall i,j$).[18] Before production, agents choose either to adopt frontier technology and become a frontier firm, or to imitate some embodied technology and become a non-frontier firm. Compared to frontier firms' goods, non-frontier firms' goods are less productive but is cheaper to produce. However, the technology is protected, and thus firms using non-frontier technology in production are subject to IPR enforcement. In the follwing, firms' variables do not carry the time subscript since they do not make any dynamic decisions, Also, the subscript f on frontier firms' variables represents the frontier and the subscript a on non-frontier firms represents appropriation.

To be at the technology frontier, agents must pay a fixed cost depending on their ability:

$$C(\omega_i) = c\left(\frac{A_f}{\omega_i}\right)^{\frac{1}{\mu}}, \quad 0 < \mu < 1, \tag{2.1}$$

where c is the unit cost measured in final good. The cost is lower when the agent is more

[17] This sets the upper bound of aggregate production, but does not determine solely how successful the economy is. Rather, the interaction of the political and market economy determines aggregate productivity, which is the main focus of this study.

[18] Relaxing assumption $A_i = A_j = A_f,\ \forall i,j$ would be interesting; however, it would not change the main results of this study except for extreme cases.

efficient in adopting technology (i.e., higher talent ω_i).[19] Adopting frontier technology costs more as technology advances (i.e., higher A_f), which captures the idea that it costs more to adopt a complex technology, for example, automated versus manual manufacturing technology. The parameter μ determines the shape of the fixed cost function. For a given A_f and c, a lower μ leads to a higher dispersion of fixed costs among agents.[20]

Agents' ability determines the choice to become a frontier or non-frontier firm since it affects the profit of the two options. Assume a unique threshold $\bar{\omega}$ that splits the population into two groups (see Section 2.3.3 for a proof). If agent i has talent $\omega_i > \bar{\omega}$, the agent pays a fixed cost $C(\omega_i)$ and adopts technology at the frontier, then chooses the amount of output y_f to maximize profit:[21]

$$\pi_{f,i} = \max_{y_f} p_f y_f - c y_f - C(\omega_i), \tag{2.2}$$

where p_f is the price frontier the firm receives.

If an agent's ability is below the threshold (i.e., $\omega_i \leq \bar{\omega}$), the agent operates a non-frontier firm that appropriates technology in industry i by investing ci_a and producing goods with quality A_a, restricted to be less than that of A_f. Imitators can narrow the gap between A_a and A_f by investing more in imitation. The quality of the imitation technology for a given imitating investment i_a is:

$$A_a = A_f i_a^{\mu}. \tag{2.3}$$

[19] Foster and Rosenzweig (1995) shows that "imperfect knowledge about the management of the new seeds was a significant barrier to adoption"(p.1176).

[20] Boldrin and Levine (2013) discusses how strict property rights may actually increase the barriers to reach the technology frontier. It can be built into this model by modifying the fixed cost function as a function of the IPR enforcement parameter. This amendment would not affect the main result as long as, for some agents, the profit from adopting frontier technology become higher than that from imitating the technology when the IPR enforcement becomes stricter. For example, the fixed cost function can be written as: $C(\omega_i) = c\left(\frac{A_f}{\omega_i}\right)^{\frac{1}{\mu_1}} \kappa^{\mu_2}$.

[21] Since every firm of the same type produces the same amount of goods and receives the same price, I omit subscript i when this is clear.

For simplicity, I assume that agents' ability does not affect the quality of the non-frontier good. In other words, there is no difference in ability to imitate, so everyone will choose the same level. While using non-frontier technology has a lower fixed cost, there is a probability κ that the government discovers these non-frontier firms and confiscates their revenue. Non-frontier firms maximize profit by choosing y_a and i_a:

$$\pi_a = \max_{y_a, i_a} (1-\kappa) p_a y_a - c y_a - c i_a. \tag{2.4}$$

Alternatively, we can model the IPR as a protection of frontier firms' revenue. In this alternative environment, the non-frontier firms can steal frontier firms' ideas and therefore reduce the frontier firms' profit. The IPR can reduce the chance of such theft.[22] In addition, we can interpret the fixed cost as a fee for protecting frontier firm's revenue, in which stronger IPR implies a cheaper fixed cost.[23] The firms have only two choices of production technology: (i) adopt the frontier technology and produce without violating other firms' IPR or (ii) produce using non-frontier technology and violate the IPR, in which case the government may confiscate the revenue with probability κ. A natural extension of this paper would include a third possibility where firms produce inefficiently, with some very primitive technology, but do not violate any IPR. The least efficient firm would opts for this third option. However, for simplicity, I do not model this case.

After production, agents sell their good in a monopolistic competition market. A final

[22]Specifically, equation (2.2) becomes

$$\pi_{f,i} = \max_{y_f} \kappa p_f y_f - c y_f - C(\omega_i)$$

Thus, a higher κ leads to a higher expected revenue. The implication is largely unchanged; see the Appendix 2.7.5.

[23]The fixed cost is then $C(\omega_i) = c\left(\frac{A_f}{\omega_i}\right)^{\frac{1}{\mu}}(1-\kappa)^{\frac{1}{\mu_2}}$. See the Appendix 2.7.4 for more detail.

goods firm represents this market and aggregates goods, maximizing the following profit:

$$\pi_G = \max_{y_i} Y - \int_0^1 p_i y_i di \quad \text{s.t.} \quad Y = \left(\int_0^1 (A_i y_i)^\alpha di \right)^{\frac{1}{\alpha}}, \tag{2.5}$$

where $0 < \alpha < 1$.

The final goods firm uses a constant elasticity of substitution (CES) aggregation technology to produce total output Y. Since there are only two levels of quality produced in the market, the final goods firm has two inverted demand functions for intermediate goods: one for non-frontier firms and one for frontier firms:

$$p_j^* = Y^{1-\alpha} A_j^\alpha y_j^{\alpha-1} \quad , \quad j \in \{a, f\}, \tag{2.6}$$

Given the downward sloping demand curves (2.6), it follows that frontier firms sell more of their output. Agents choose a production technology by comparing the optimal profit of the two options. First, consider the frontier firm's optimal profit:

$$\pi_{f,i}^* = Y \left(\frac{A_f}{c} \right)^{\frac{\alpha}{1-\alpha}} \left[\frac{1}{\alpha} - 1 \right] \alpha^{\frac{1}{1-\alpha}} - c \left[\frac{A_f}{\omega_i} \right]^{\frac{1}{\mu}}. \tag{2.7}$$

Optimal profit increases with talent ω_i, total output Y, and decreases with unit cost c. Frontier technology A_f and substitutability α have an ambiguous effect on a frontier firm's profit.

Next, consider the optimal profit when agents choose to imitate technology. The main difference between the two problems is that non-frontier firms also choose the amount of investment in the imitation, which is governed by the parameter μ.[24] The profit-maximizing level of investment in imitation is a μ percentage of the good's sales (i.e., $i_a = \mu y_a$). The

[24]The parameter μ can be interpreted as the learning elasticity that is common to the population. Differing μ for learning the two types of production technology would not alter the main result, except for some extreme cases.

optimal profit for imitating frontier technology is then

$$\pi_a^* = Y^{\frac{1-\alpha}{\phi}}(1-\kappa)^{\frac{1}{\phi}} A_f^{\frac{\alpha}{\phi}} \mu^{\frac{\mu\alpha}{\phi}} c^{-\frac{\mu\alpha+\alpha}{\phi}} \left[\alpha^{\frac{\mu\alpha+\alpha}{\phi}} - (1+\mu)\alpha^{\frac{1}{\phi}}\right], \tag{2.8}$$

where $\phi = 1 - \mu\alpha - \alpha$.

Given a constant total output Y, the profit decreases with κ. If we allow for equilibrium effect, with varying Y, the effect is ambiguous. I discuss this in later sections. Going forward, I will restrict the parameters to $\frac{1}{1+\mu} \geq \alpha$ to satisfy the necessary condition that both types of firms exist in the economy (see Appendix 2.7.1).

2.3.2 Firms and Market

Firms trade in a monopolistic competitive market. Their profit depends on the actions of the other firms. First, to demonstrate how the total output varies as the composition of technology changes, given that $y_f A_f$ and $y_a A_a$ are the same within the frontier firms group and non-frontier firms group, I rewrite the CES technology as

$$Y = \left(\int_0^{\bar{\omega}} (A_a y_a)^\alpha dF(\omega) + \int_{\bar{\omega}}^{\infty} (A_f y_f)^\alpha dF(\omega)\right)^{\frac{1}{\alpha}} = \left(A_a^\alpha y_a^\alpha F(\bar{\omega}) + A_f^\alpha y_f^\alpha (1 - F(\bar{\omega}))\right)^{\frac{1}{\alpha}}, \tag{2.9}$$

Equation (2.9) shows the proportion of frontier firm $(1 - F(\bar{\omega}))$ and of non-frontier firm $F(\bar{\omega})$ affects total output. An increase in the proportion of frontier firms leads to higher aggregate productivity, and thus the total output Y increases.[25,26]

Dividing the inverted demand function (2.6) for non-frontier firms by that for frontier firms and combining with the optimal supply equations gives:

$$y_f = \left[\frac{Y^\alpha y_a^{1-\alpha\mu-\alpha}}{(1-\kappa)\mu^{\alpha\mu}}\right]^{1-\alpha}. \tag{2.10}$$

[25] This holds when the unit cost c is not too high nor too low, see Lemma 2.7.2 in Section 2.3.3.

[26] The aggregate productivity is defined as the weighted average of A_a and A_f.

Frontier firms produce more when the non-frontier firms produce more. Additionally, as the level of IPR enforcement increases, frontier firm produces more.

I wish to point out two properties related to the output and profit at this point. First, an increase in y_f does not imply a proportional increase in y_a (i.e., $\frac{y_a}{y_f}$ is not a constant) because non-frontier firms can invest more in imitation activities to advance their technology A_a. This implies that the two types of firms would not grow at the same rate. Second, non-frontier firms' profit is nonlinear in κ. From equation (2.9), the growing proportion of frontier firms leads to an increase in total output Y, and, as I show below, the total output Y can be written as a function of IPR enforcement κ and have a positive effect on non-frontier firms' profit (see equation (2.8)). Adding the direct negative effect on non-frontier firm's profit from a change in the level of IPR enforcement κ, the profit function is non-linear in κ. In other words, an increase in total output has a spillover effect on firms, while non-frontier firms are penalized for copying technology. This implies that the optimal level of enforcement for non-frontier firms is between zero and one. Meanwhile, frontier firms have a monotonically increasing profit function with respect to κ because it is not subject to government enforcement while the profit is positive with respect to $(1 - F(\bar{\omega}))$ and y_f. Thus, frontier and non-frontier firms prefer different levels of IPR enforcement, and it is source of the political conflict.

Figure 2.3 shows firms' profit by level of enforcement κ. The left panel shows the profit for a non-frontier firm with an optimal point between zero and one. The right panel shows agents' profit at three levels of ability ω_i when they produce with frontier technology. The solid line is the profit for a low-ability agent. Since these agents face a high fixed cost, they cannot earn a positive profit at any level of enforcement. That is, these firms would not enter as a frontier firm, even if operating non-frontier production technology earns zero profit. The next line up shows the profit for mid-level talent agents. Under low enforcement, these agents make a negative profit, but earn more profits as enforcement becomes stricter due to spillover from the increase in total output Y. Agents in this region are an interesting case because they would switch to frontier technology from non-frontier technology when the policymaker changes the IPR enforcement. The top line is the profit for agents with high ability. These agents earn a positive profit regardless of the level of IPR enforcement. All three profit curves have a positive relationship with the level of enforcement.

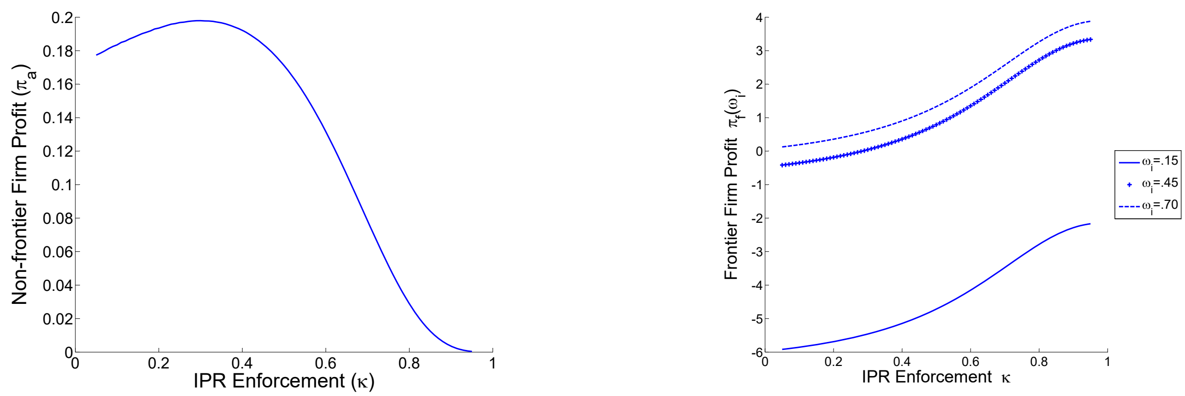


Figure 2.3: Profit by Property Rights

Notes: Other parameters: $A_f = 0.85$, $\alpha = 0.5$, $c = 0.3$, and $\mu = 0.30$

2.3.3 Agents' Choice of Production Technology

This subsection analyzes properties and the existence of a threshold that determines agents' choice of production technology. The following assumes that both types of firms make a non-negative profit and coexist in the economy (see section 2.7.1 in the appendix).

Agents adopt frontier technology only if the profit is greater than the expected profit from using non-frontier technology (i.e., $\pi_f^*(\omega_i) \geq \pi_a^*$). The threshold $\bar{\omega}$ is the point at which agents are indifferent between the two options (i.e., $\pi_f^*(\bar{\omega}) = \pi_a^*$):

$$\bar{\omega} = A_f \left[Y A_f^{\frac{\alpha}{1-\alpha}} \left(\frac{\alpha}{c}\right)^{\frac{1}{1-\alpha}} \left(\frac{1}{\alpha} - 1\right) - Y^{\frac{1-\alpha}{1-\mu\alpha-\alpha}} A_f^{\frac{\alpha}{1-\mu\alpha-\alpha}} \mu^{\frac{\mu\alpha}{1-\mu\alpha-\alpha}} \left((1-\kappa)\frac{\alpha}{c}\right)^{\frac{1}{1-\alpha\mu-\alpha}} \left(\frac{1}{\alpha} - (1+\mu)\right)\right]^{-\mu}. \tag{2.11}$$

In the following, I discuss the impact of a change in these parameters. For a given Y, an increase in the level of frontier technology A_f can have ambiguous effect on the threshold, while an increase in IPR enforcement κ reduces the threshold. An increase in frontier technology has three effects: (i) higher fixed cost, (ii) better imitation technology, and (iii) higher profit for being frontier firm. The expensive adoption cost reduces agents' incentive to adopt the frontier technology. Furthermore, technological advancement increases the value of outside options; non-frontier firms can produce goods of a higher productivity for the same amount of investment in imitation. However, the higher A_f would also increase the profitability for adopting frontier technology. Together, these effects lead to an ambiguous effect on the threshold.[27]

The government confiscates non-frontier firms' revenue for appropriating technology with probability κ. When a policymaker implements stricter enforcement, more agents, who would otherwise be a non-frontier firm, become a frontier firm. However, this relationship is not obvious when we allow the total output Y to vary with $\bar{\omega}$ (i.e., more or less frontier firms). As discussed above, non-frontier firms' profit can grow with strengthening enforcement when the initial IPR enforcement is very weak as the total output Y increases. Nonetheless, the analysis above holds for the region in which non-frontier firms' profits start to fall with increasing levels of enforcement.

Uniqueness of the Threshold

I begin by establishing the conditions under which a unique solution exists. For simplicity and to keep the notation clean, the talent distribution $F(\omega)$ follows a uniform distribution

[27]The condition for $\frac{\partial \bar{\omega}}{\partial A_f} > 0$ is

$$A^{\frac{-\alpha\mu}{1-\alpha\mu-\alpha}} > \frac{\Omega_x - \mu\Omega_x \frac{\alpha\mu}{1-\alpha\mu-\alpha}}{\Omega_y - \mu\Omega_y \frac{1}{1-\alpha}},$$

where $\Omega_x = Y^{\frac{1-\alpha}{1-\mu\alpha-\alpha}} \mu^{\frac{\mu\alpha}{1-\mu\alpha-\alpha}} \left((1-\kappa)\frac{\alpha}{c}\right)^{\frac{1}{1-\alpha\mu-\alpha}} \left(\frac{1}{\alpha} - (1+\mu)\right)$ and $\Omega_y = Y\left(\frac{\alpha}{c}\right)^{\frac{1}{1-\alpha}}\left(\frac{1}{\alpha} - 1\right)$.

with $\omega \in [0,1]$, and I rewrite equation (2.9).[28]

$$Y = (\bar{\omega}(A_a y_a)^\alpha + (1-\bar{\omega})(A_f y_f)^\alpha)^{1/\alpha}. \tag{2.12}$$

Since $A_f y_f$ is higher than $A_a y_a$, total output increases when more agents adopt the frontier technology (i.e., $\bar{\omega}$ decreases). Using the optimal condition from the two types of firms and expressing total output as a function of $\bar{\omega}$,

$$Y = \left[\frac{1-(1-\bar{\omega})(A_f\Omega_f)^\alpha}{\bar{\omega}(A_f\mu^\mu\Omega_a^{\mu+1})^\alpha}\right]^{\frac{1-\alpha-\alpha\mu}{\alpha\mu}} = Y(\bar{\omega}), \tag{2.13}$$

where $\Omega_f = \left[\frac{\alpha A_f^\alpha}{c}\right]^{\frac{1}{1-\alpha}}$, and $\Omega_a = \left[\frac{\alpha(1-\kappa)A_f^\alpha\mu^{\mu\alpha}}{c}\right]^{\frac{1}{1-\alpha-\mu\alpha}}$.

I assume that $1-(1-\bar{\omega})(A_f\Omega_f)^\alpha > 0,\ \forall\, \bar{\omega} \in [0,1]$, to guarantee that Y is positive. To guarantee $Y(\bar{\omega})$ is a monotonically decreasing function with $\bar{\omega}$,

Lemma 1 $Y(\bar{\omega}) \in [Y(1) = \frac{1}{(A_f\mu^\mu\Omega_a^{\mu+1})^\alpha}\ ,\ Y(0) \to \infty)$ *is monotonically decreasing if the following condition holds:*

$$\alpha A_f > c > \alpha A_f(1-\tilde{\omega})^{\frac{1-\alpha}{\alpha}}, \tag{2.14}$$

where $\tilde{\omega}$ is the highest possible $\bar{\omega}$.

Proof 1 *See Appendix.*

Output is increasing in $\bar{\omega}$ only when the unit cost is not too high or too low. This condition is satisfied as long as the A_f is not too much greater than c. Rearranging equation (2.11) and rewriting it as a function of Y,

$$\bar{\omega}^{\frac{-1}{\mu}} = \Omega_1 Y(\bar{\omega}) - \Omega_2 Y(\bar{\omega})^\zeta = G_1(Y), \tag{2.15}$$

[28]The Uniform distribution assumption is not a necessary condition, though it allows for an isolation from the effect of the shape parameter of the other distribution (e.g., Pareto Distribution). In addition, the parameter μ allows a fixed cost distribution similar to a power function.

where $\Omega_1 = A_f^{\frac{\alpha}{1-\alpha}-\frac{1}{\mu}}\left(\frac{\alpha}{c}\right)^{\frac{1}{1-\alpha}}\left[\frac{1}{\alpha}-1\right]$ and $\Omega_2 = A_f^{\frac{\alpha}{1-\mu\alpha-\alpha}-\frac{1}{\mu}}(1-\kappa)^{\frac{\alpha}{1-\mu\alpha-\alpha}}\mu^{\frac{\mu\alpha}{1-\mu\alpha-\alpha}}\left(\frac{\alpha}{c}\right)^{\frac{1}{1-\alpha\mu-\alpha}}\left[\frac{1}{\alpha}-(1+\mu)\right]$. Using equation (2.15), we have the following relationship,

Lemma 2 $\frac{\partial G_1(Y)}{\partial Y} < 0 \quad \forall \omega \in [0,1]$ *if* $A_f^{\frac{\alpha(-\alpha\mu)}{1-\alpha}}\left(\frac{\alpha}{c}\right)^{\frac{-1}{1-\alpha}}(1-\kappa)^{\frac{-1}{\alpha\mu}}\mu^{-1} < Y(1)$

Proof 2 *See Appendix.*

When the above conditions hold, there is a unique threshold dividing agents into two types of firms.

Proposition 1 *There is a unique solution for equation (2.11) if the following conditions hold: (i)* $A_f^{\frac{\alpha(-\alpha\mu)}{1-\alpha}}\left(\frac{\alpha}{c}\right)^{\frac{-1}{1-\alpha}}(1-\kappa)^{\frac{-1}{\alpha\mu}}\mu^{-1} < Y(1)$, *(ii)* $G_1(1) \leq 1$, *and (iii)* $\alpha A_f > c > \alpha A_f(1-\bar{\omega})^{\frac{1-\alpha}{\alpha}}$.

Proof 3 *See Appendix.*

The following provide a sketch of the proof. As the threshold, $\bar{\omega}$, increases, the function $G_1(Y)$ increases (i.e., $\frac{\partial G_1}{\partial Y}\frac{\partial Y}{\partial \bar{\omega}} > 0$). Meanwhile, the left hand side of equation (2.15) is a deceasing function of $\bar{\omega}$. Therefore, there can only be one crossing and it provide the uniqueness of the threshold.

To summarize, Figure 2.4 illustrates firms' profit based on agents' ability ω_i under different levels of IPR enforcement. The threshold is the point at which profit starts increasing with ability. As the level of enforcement increases, the threshold moves to the left. In addition, for a given talent level, a frontier firm earns more when the economy has stricter property rights because the total output increases - spillover effect. The right panel of Figure 2.4 shows how the threshold changes at different levels of IPR enforcement. Note that the rate of change is decreasing as κ increases, since the margin gain in expected profit decreases for an additional frontier firm in the market.

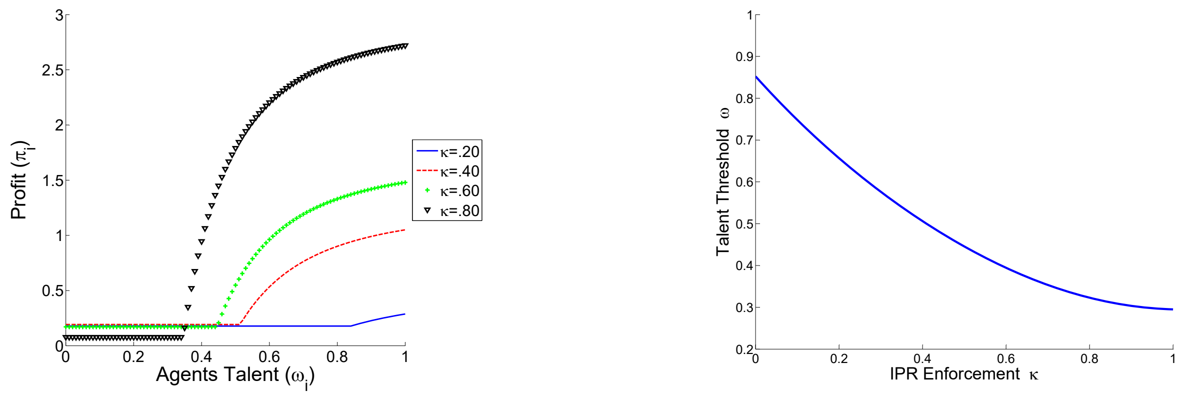


Figure 2.4: Profit by Talent, Talent Threshold, and Property Rights Enforcement

Notes: Other parameter values: $A_f = 0.85$, $\alpha = 0.5$, $c = 0.3$, and $\mu = 0.30$

2.4 Political Economy

In this section, instead of using an exogenous IPR policy, the level of IPR enforcement is the consequence of a policymaker's trade-off between political rent and turn-over risk. There is a continuum of politicians in the model economy, but only one of them is in the role of the policymaker. Non-incumbents are those politicians not in power. After losing power, another politician will replace a policymaker. For simplicity, I assume that such politicians cannot return to power.[29] Non-incumbents receive support from non-frontier firms to oppose the policymaker when the policy is not optimal for non-frontier firms. Thus, the chance of policymaker staying in power becomes lower. In the following, I first describe the policymaker's problem, interaction with the market, and behavior under different market conditions, and then provide a welfare analysis.

Each period, a policymaker earns rent equal to a γ percent of the total output through rent-seeking activity (e.g., lobbying, expropriation, corruption, etc.) and the revenue confiscated from non-frontier firms. Hence, one of the policymaker's objectives is to maximize total

[29] Acemoglu (2006) and Ales et al. (2014) use a similar assumption.

output. However, the policymaker has less chance of staying in power when choosing a policy that reduces non-frontier firms' profit; in response to strengthening IPR enforcement, non-frontier firms increase their support of non-incumbents. Similar to Acemoglu (2006), I use a reduced form specification to represent the political economy.[30] In Acemoglu (2006), the policymaker worries that a subgroup in the economy may take over the power. As this subgroup becomes economically powerful, the chance of turnover is higher. To reduce the chance of being overthrown, the policymaker chooses a sub-optimal policy in order to weaken oppositions' economic power. In this paper, the policymaker chooses a suboptimal policy, to reduce the resistance from non-frontier firms. In particular, the policymaker has a survival function with the form of one minus a power function with a positive parameter ψ. The parameter ψ captures the influence of non-frontier firms and is determined by the political institution and the society. A higher parameter value implies that non-frontier firms have less influence on policymaker's turnover risk. The probability that a policymaker remains in power follows the survival function:

$$h(\kappa) = 1 - (TC)^{\psi} = 1 - \left(|\kappa - \hat{\kappa}| F(\bar{\omega}(\kappa))\Theta\right)^{\psi}, \qquad (2.16)$$

where $\Theta = \frac{1}{F(\bar{\omega}(\hat{\kappa}))}$ is a scalar that normalizes the function $F(\bar{\omega}(\kappa))$ to one when $\kappa = \hat{\kappa}$, TC is the total contribution from opposition and $\psi > 0$.[31] The survival function has two components. First, $|\kappa - \hat{\kappa}|$ is the per-firm support of non-incumbents. Support increases when the IPR enforcement level moves further away from the optimal level $\hat{\kappa}$ that maximizes non-frontier firms' profit. This linear form is for simplicity. Second, $F(\bar{\omega}(\kappa))$ is the mass of non-frontier firms. A larger proportion of non-frontier firms makes more resources available to oppose the policymaker. Thus, the chance the policymaker stays in power increases as the proportion of non-frontier firms in the economy shrink. The turnover risk is $(1 - h(\kappa))$. As an alternative, I

[30] The main result holds if we use a median voter as the political mechanism, which results in a discrete rent function for the policymaker over different levels of IPR enforcement.

[31] This normalization is required for a comparison across different parameter spaces.

include frontier firms' support for the non-incumbent in equation (2.16). The main result holds and depends on the relative influence on the turnover risk.

The risk of losing power induces the policymaker to stay in an inefficient equilibrium: the policymaker does not choose an enforcement level that optimizes total output or agents' welfare (see section 2.4.4). To summarize, the policymaker has two choices: earning higher rent but expecting to remain in power for a shorter period, or earning lower rent but expecting to stay in power for a longer period. The policymaker maximizes lifetime rent:

$$R = \max_{\kappa} \gamma Y(\kappa) + \gamma_d \kappa d(\kappa) + h(\kappa)\beta R', \tag{2.17}$$

where R is the value of being in power in this period, R' is the value of being in power in the next period, $d(\kappa) = p_a(\kappa)y_a(\kappa)F(\bar{\omega}(\kappa))$ is the total revenue of non-frontier firms, γ_d is the remaining proportion after the administrative cost of catching appropriation activity, and β is the discount rate. The discount rate can be thought of as the combination of a natural discount rate and the probability of losing power without any interference from agents. Since the policymaker's choice in this period does not change the value in the next period, the optimal choice is the same across time. Every period, the policymaker retains information about how the market responds to the last period's choice of κ. Since the choice is the same for all periods, we can focus on the stationary equilibrium,

$$R^{ss} = \frac{\gamma Y(\kappa) + \gamma_d \kappa d(\kappa)}{1 - \beta h(\kappa)}. \tag{2.18}$$

Before discussing the interaction between the firms and the policymaker, it is useful to discuss the equilibrium concept here. Rewrite the policymaker's payoff function as $R(e_p, e_f)$, where e_p is the policymaker's strategy and e_f is a vector of strategies chosen by all firms. More importantly, only firms with the middling talent matter, as they would switch their technology choice depending on the degree of IPR enforcement. Then, I rewrite the payoff function for the firm as $\pi_i(e_i, e_p)$. Firms can choose to adopt the frontier technology or imitate non-frontier technology as a strategy, while the policymaker chooses the degree of IPR enforcement.

Let $e_p^*(e_f)$ be the policymaker's optimal response when the firms pick e_f, and the policymaker maximizes $R(e_p^*, e_i)$. Then, $e_f^*(e_p)$ denotes firms' optimal response to maximize $\pi_i(e_i^*, e_p)$ when the policymaker picks e_p, subject to the inverse demand function. In the Nash equilibrium, the optimal responses are $e_p^*(e_f^*)$ and $e_f^*(e_p^*)$. The notation is similar to that of Cooper and John (1988). Below, I will show that there is two maximal in policymaker's objective function, as a result, multiple equilibria arise.

The policymaker earns higher rent when the economy is more productive. The policymaker can benefit from stricter IPR enforcement since it encourages agents to switch to frontier technology, thus increasing total output. The other component of the rent comes from confiscating non-frontier firms' revenue. The gain from confiscation shrinks as the level of enforcement increases (i.e., $\frac{\partial d(\kappa)}{\partial \kappa}$).[32] In the following, γ_d is chosen such that the rent increase from output can eventually dominate the change in confiscated revenue. Therefore, per-period rent is an increasing function of κ (i.e., $\gamma \frac{\partial Y(\kappa)}{\partial \kappa} > 0$). The curve depends on the market parameters and non-linearity determines the equilibria.

The policymaker has a lower chance of staying in power when the enforcement level diverges from non-frontier firms' optimal $\hat{\kappa}$, which differs from that of frontier firms. Below, I first describe the case with two equilibria, and then describe the case featuring only one equilibrium. First, consider the range left of the optimal level (i.e., $\kappa \in [0, \hat{\kappa})$): increasing the IPR enforcement κ increases non-frontier firms' profit. Thus, each non-frontier firm reduces their support for non-incumbents (i.e., $|\kappa - \hat{\kappa}|$ decreases). As both the rent and the survival rate are increasing in κ, the policymaker increases the level of IPR enforcement until the enforcement level pass non-frontier firms' optimal $\hat{\kappa}$, the lifetime rent may start to fall and yields a (local) maximum of the policymaker's rent function.

[32] The $d(\kappa)$ is required to eliminate the existence of dominant strategy that policymaker choose low enforcement regardless as $R(e_p = low, e_f = frontier) > R(e_p = high, e_f = frontier)$.

Another maximum exists to the right of the optimal level for non-frontier firms (i.e., $\kappa \in (\hat{\kappa}, 1])$. When the policymaker enforces stricter IPR protection, non-frontier firms raise their support for non-incumbents, which increase the policymaker's turn-over risk and lower the policymaker's lifetime value. Meanwhile, total output Y continues to grow as more agents adopt the frontier technology (i.e., $\frac{\partial Y}{\partial \kappa} > 0$). Additionally, the proportion of non-frontier firms shrinks as agents move to the frontier, weakening non-frontier firms' collective political power (i.e., $\frac{\partial F(\bar{\omega}(\kappa))}{\partial \kappa}$). The lifetime value starts increasing when the marginal gain in rent from output growth outweighs the increase in turnover risk. Thus, it yields the second equilibrium. This second maximum is not guaranteed to be higher than that of the optimal property policy $\hat{\kappa}$ for the non-frontier firm; it depends particularly on the survival elasticity of opposition support ψ. Then, the condition for multiple equilibria is, formally:[33]

Proposition 2 *The necessary conditions for the two equilibria to exist are: (i)*$\frac{\partial Y(\kappa)}{\partial \kappa} > 0$*, (ii)* $\frac{\partial |\kappa - \hat{\kappa}|}{\partial \kappa} > 0$*, and (iii)* $\frac{\partial F(\bar{\omega}(\kappa))}{\partial \kappa} < 0$*, when* $\kappa \in (\hat{\kappa}, 1)$.

Proof 4 *See Appendix.*

When the policymaker cannot cooperate with the firms, multiple equilibria occur.[34] In this case, the policymaker may hesitate to make a significant policy change because the outcome is uncertain. In the following, I discuss the interplay between policymaker and firms that would switch production technology between the two equilibria, and focus on a non-cooperative equilibrium.[35] On the one hand, if firms do not react to the policy change, the policymaker would not receive a higher rent nor would the proportion of non-frontier firms decline. However, there would be an increase in support for non-incumbents. Consequently, the policymaker

[33]Conditions (ii) and (iii) can be substituted by generic function. For example, $f(\kappa) = |\kappa - \hat{\kappa}|$ and $g(\kappa) = F(\bar{\omega}(\kappa))$.

[34]If we consider a cooperative equilibrium, the policymaker can set the IPR policy to a level that maximize their rent.

[35]In general, if we consider a Nash Equilibrium where the firms and the policymaker do not cooperate and the model features strategic complementarity, a coordination failure occurs (see Cooper and John (1988)).

loses out when they change the enforcement level, κ, due to the higher turnover risk. On the other hand, non-frontier firms earn a negative profit if they adopt frontier technology when the policymaker does not change the level of IPR enforcement. In other words, there is no dominant strategy for the policymaker and firms with middling talent. Although the policymaker gains from higher total output, holding κ constant, the policymaker would lose because the gain from confiscating profit from non-frontier firms, $\gamma_d \kappa d(\kappa)$, falls as there are fewer imitating firms. Yet there is gain if both choose the high IPR equilibrium.

Market parameters (e.g., α, c, μ, etc.) determine the proportion of non-frontier firms and non-frontier firms' optimal level of enforcement $\hat{\kappa}$, which together affects the policymaker's lifetime value. In other words, the interaction between the market and political economy determine the existence and locations of the equilibria.

2.4.1 Institution State

The discussion above shows that multiple equilibria exist under some conditions. However, a case with a unique equilibrium also exists when the policymaker's gain from increasing IPR enforcement is always higher than or less than the loss from the increasing risk of losing power. This unique equilibrium can exist with either a high or low IPR enforcement. When parameter ψ is lower (higher), non-frontier firms have greater (less) influence on the policymaker's survival function.[36] The low enforcement equilibrium occurs due to the adverse effect on the policymaker's chance of survival after increasing the enforcement level. Thus, if non-frontier firms have weak influence on the turnover risk, the policymaker can choose the higher level of enforcement without putting too much weight on the turnover risk.

Figure 2.5 plots the policymaker's lifetime rent on the enforcement level κ with different levels of elasticity of turnover risk to the change in κ. When non-frontier firms' influence is

[36] Since $h(\kappa) \in [0, 1]$, a smaller value for the power term yields a lower survival probability for a given argument.

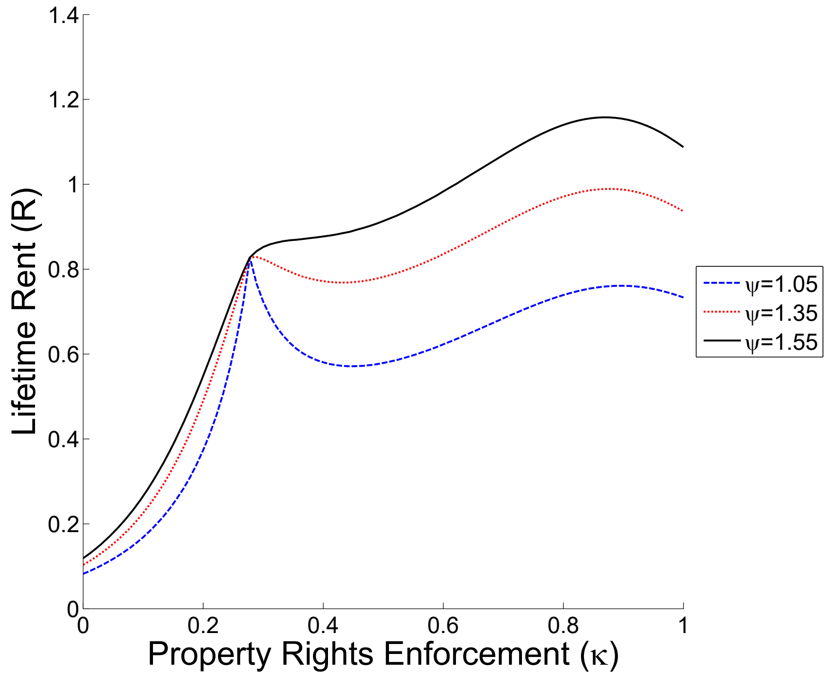


Figure 2.5: Government Rent for different value of ϕ

Notes: Other parameter values: $A_f = 0.85$, $\alpha = 0.5$, $c = 0.3$, and $\mu = 0.30$

high ($\psi = 1.05$), the strong enforcement equilibrium yields a lower lifetime rent than that with a low enforcement equilibrium, and is also lower than the strong enforcement equilibrium in the other two scenarios. This implies that even in a cooperative equilibrium, the policymaker would still choose weak IPR enforcement.[37] As the influence of non-frontier firms decreases ($\psi = 1.35$), the adverse effect from turnover risk is weaker than in the last case, and the lifetime rent is higher in the strong enforcement equilibrium than in the low enforcement equilibrium. When non-frontier firms' influence is at the weakest level among the three ($\psi = 1.55$), the slope does not become negative, although the lifetime rent first increases at a slower rate after $\hat{\kappa}$. In this case, there is only one equilibrium, as $\frac{\partial R(e_p,e)}{\partial e_p} > 0$ anywhere left of the optimal level. In summary, an institution independent of non-frontier firms can align the private interest

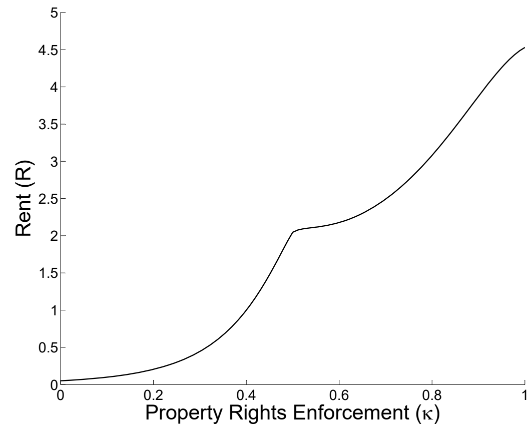
[37]Note that in a cooperative equilibrium, the policymaker can choose the κ that gives a global maximum with respect to his rent.

(the policymaker's rent) and social interest (aggregate productivity).

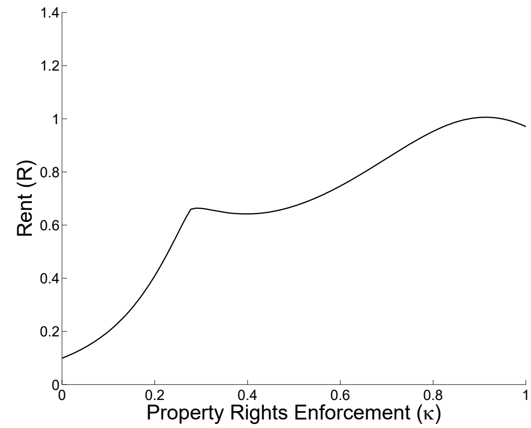
2.4.2 Goods' Substitutability

This subsection shows that the equilibrium also depends on the substitutability between goods. There is only one equilibrium when the goods in the market are highly or weakly substitutable. When more agents choose the frontier technology, the total output grows, though it grows more slowly when the goods have high substitutability. An additional frontier good does not increase total output as much compared to a market with weaker substitutability between goods. Therefore, non-frontier firms' benefits from switching to frontier technology are low, and thus, the total output grows slowly. This implies that the policymaker's rent increases slowly as well.

Figure 2.6 shows the policymaker's rent function at different levels of α. When α is low, goods are less substitutable, so there is only a corner solution of $\kappa = 1$, as in Figure 2.6a. Figures 2.6b and 2.6c show similar graphs to that in Figure 2.5 and illustrates the evolution as the goods becomes more substitutable to each other at the same institution state. As the α increases to 0.65, there is only one solution at $\kappa = 0$ because output and the number of frontier firms grows very slowly at a high α level.



(a) $\alpha = 0.45$



(b) $\alpha = 0.50$

(c) $\alpha = 0.55$

(d) $\alpha = 0.65$

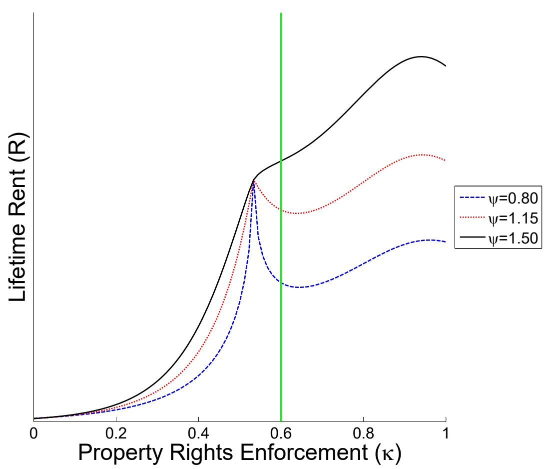
Figure 2.6: Policymaker's Rent at Different values of α
Notes: Other parameter values: $A_f = 0.85$, $c = 0.3$, $\mu = 0.30$, and $\psi = 1.30$

2.4.3 Firms' Ability

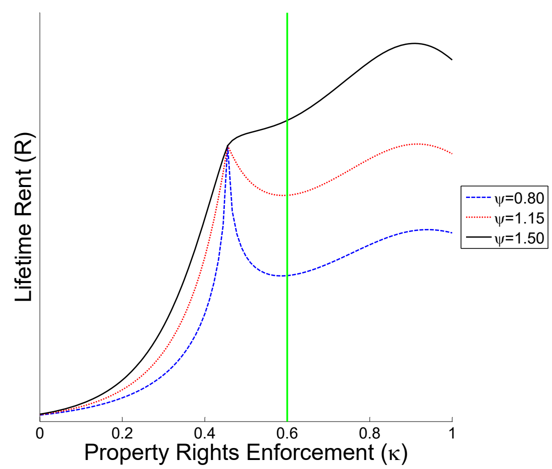
The literature shows that education is an important determinant of technology adoption. If we interpret higher ability to adopt technology due to better education; then, for a given IPR enforcement level κ, a country with higher ability is more likely to converge to the higher state. In the following, I compare two economies: one with $\omega \in [0, 1]$ and one with $\omega \in [0, 1.2]$.[38]

[38] The mean ability for the first (second) economy is 0.5 (0.6).

In Figure 2.7a and 2.7b, I show a similar graph as in Figure 2.5 with a vertical line at $\kappa = 0.6$. The vertical line can be interpreted as an exogenous binding constraint (e.g., the TRIPS) or as an initial level of IPR enforcement. Given a low enough ψ, Figure 2.7a shows that a country starting with $\kappa = 0.6$ would converge back to the low IPR enforcement state or stay at $\kappa = 0.6$, since $\frac{\partial R}{\partial \kappa} < 0$. The country with higher ability would converge to the high IPR enforcement state as $\frac{\partial R}{\partial \kappa} > 0$ at $\kappa = 0.6$, shown in Figure 2.7b. This result is intuitive. For a given κ, there are more non-frontier firms in the economy with lower average ability. Their collective political power is higher compared to the economy with higher average ability. Therefore, the policymaker has more risk of losing power when implementing stricter IPR enforcement.



(a) $\omega \in [0, 1.0]$



(b) $\omega \in [0, 1.2]$

Figure 2.7: Policymaker's Rent for Different values of ω_{max}
Notes: Other parameter values: $A_f = 0.85$, $c = 0.3$, and $\mu = 0.30$

2.4.4 Welfare Analysis

Although stricter IPR enforcement increases total output, it can impose a loss on non-frontier firms. This implies that moving to the high enforcement and high output equilibrium is not a

Pareto improvement. To address whether it is possible for the economy to benefit in aggregate with some transfer arrangement, I analyze the aggregate welfare, defined as:

$$\begin{aligned} W = W_a + W_f = \bar{\omega} Y^{\frac{1-\alpha}{\phi}} (1-\kappa)^{\frac{1}{\phi}} A_f^{\frac{\alpha}{\phi}} \mu^{\frac{\mu\alpha}{\phi}} c^{-\frac{\mu\alpha+\alpha}{\phi}} \left[\left(\frac{1}{\alpha}\right)^{-\frac{\mu\alpha}{\phi}} - (1+\mu) \left(\frac{1}{\alpha}\right)^{-\frac{1}{\phi}} \right] \\ + (1-\bar{\omega}) Y \left(\frac{A_f}{c}\right)^{\frac{\alpha}{1-\alpha}} \left[\frac{1}{\alpha} - 1\right] \alpha^{\frac{1}{1-\alpha}} - c A_f^{\frac{1}{\mu}} \left(\frac{\mu}{\mu-1}\right) \left[1 - \bar{\omega}^{\frac{\mu-1}{\mu}}\right], \end{aligned} \tag{2.19}$$

where $W_a = \int_0^{\bar{\omega}} \pi_{i,a} di = \bar{\omega} Y^{\frac{1-\alpha}{\phi}} (1-\kappa)^{\frac{1}{\phi}} A_f^{\frac{\alpha}{\phi}} \mu^{\frac{\mu\alpha}{\phi}} c^{-\frac{\mu\alpha+\alpha}{\phi}} \left[\left(\frac{1}{\alpha}\right)^{-\frac{\mu\alpha}{\phi}} - (1+\mu) \left(\frac{1}{\alpha}\right)^{-\frac{1}{\phi}} \right]$ and $W_f = \int_{\bar{\omega}}^1 \pi_{i,f} di = (1-\bar{\omega}) Y \left(\frac{A_f}{c}\right)^{\frac{\alpha}{1-\alpha}} \left[\frac{1}{\alpha} - 1\right] \alpha^{\frac{1}{1-\alpha}} - c A_f^{\frac{1}{\mu}} \left(\frac{\mu}{\mu-1}\right) \left[1 - \bar{\omega}^{\frac{\mu-1}{\mu}}\right]$.

In the region where non-frontier firms' profits diminish (i.e., the region after κ^*) as IPR enforcement becomes stricter, holding everything constant, an increase in enforcement has a negative impact on W_a. As the threshold $\bar{\omega}$ decreases, it has two effects on W. First, there is less weight on the shrinking non-frontier firms' profit. However, the cost for frontier firms increases (i.e., the last term in equation (2.19)) as more low-ability agents with a high fixed cost adopt the frontier technology. As discussed above, the total output also increases, which increases the revenue for both types of firms. Together, there are four forces, two negative and two positive, determining aggregate welfare. To summarize

Proposition 3 *An increase in IPR enforcement is welfare improving only if*

$$\begin{aligned} \frac{\partial \omega(\kappa)}{\partial \kappa} \left[Y(\kappa)^{\frac{1-\alpha}{\phi}} (1-\kappa) \Omega_{W1} - Y(\kappa) \Omega_{W2} + \Omega_{W3} \frac{\mu-1}{\mu} \omega(\kappa)^{\frac{-1}{\mu}} \right] \\ + \frac{\partial Y(\kappa)}{\partial \kappa} \left[\omega(\kappa) \frac{1-\alpha}{\phi} Y(\kappa)^{\frac{1-\alpha}{\phi}-1} (1-\kappa) \Omega_{W1} + (1-\omega(\kappa)) \Omega_{W2} \right] > \omega(\kappa) Y(\kappa)^{\frac{1-\alpha}{\phi}} \Omega_{W1} \end{aligned} \tag{2.20}$$

where $\Omega_{W1} = A_f^{\frac{\alpha}{\phi}} \mu^{\frac{\mu\alpha}{\phi}} c^{-\frac{\mu\alpha+\alpha}{\phi}} \left[\left(\frac{1}{\alpha}\right)^{-\frac{\mu\alpha}{\phi}} - (1+\mu) \left(\frac{1}{\alpha}\right)^{-\frac{1}{\phi}} \right]$, $\Omega_{W2} = Y \left(\frac{A_f}{c}\right)^{\frac{\alpha}{1-\alpha}} \left[\frac{1}{\alpha} - 1\right] \alpha^{\frac{1}{1-\alpha}}$, *and* $\Omega_{W3} = c A_f^{\frac{1}{\mu}} \left(\frac{\mu}{\mu-1}\right)$.

This proposition shows the condition in which there is room for the frontier firm transfer income to the non-frontier firm and reduces inefficiencies arising from the political economy, in isolation from any potential incentive problem. For example, transfer payment may induce firms to be non-frontier firms, even if the economy is better off as a whole if these firms become a frontier firm. Although it is interesting, it stretches beyond the extent of this paper.

2.5 Conclusion

Many explanations of the divergent growth paths among low-income countries point to differences in productivity. Since firms differ in their adoption ability, they find it in their interest to choose a production technology according to their ability to adopt the technology. Shift in the intellectual property rights structure induce changes in firms' behavior. Some would switch their production technologies while others would not. As a collective unit, the non-frontier group can oppose stricter protection by supporting the opponent. To stay in power, the policymaker may choose a sub-optimal IPR policy in terms of aggregate productivity.

I demonstrate a model in which the market and policymaker interact. There is heterogeneity in agents' ability to adopt frontier technology, with low-ability agent imitating frontier technology and vice versa. Since non-frontier goods are not as competitive in the market, these non-frontier firms protect their profit by supporting the policymaker's political opposition when the policy is not in their favor. The policymaker, as a rent-seeker, wants to maximize lifetime rent and may choose a low-productivity state that allows the policymaker to stay in power for a longer period. Such interaction determines the path of economic performance through the choice of IPR enforcement. The model features multiple equilibria and can be interpreted as path-dependent. That is, if an economy starts in a high state, it is likely to stay there, and vice versa. The model shows that the strength of institutions and market fundamentals matter, such as the substitutability of goods, and that countries with a greater ability to adopt a technology are more likely to converge to the high state. Last, the model provides some insight on the TRIPS.

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2.7 Appendix: Proof

2.7.1 Existence of Firms in the Economy

I now establish the parameter space in which firms will choose to produce. As we will see, the parameter space in which both types of firms operate in the market is more restricted than in one where only one type of firm operates does so. Since the political economy requires that non-frontier firms compete with frontier firms and vice versa, the co-existence of the two types of firms is important. First, frontier firms enter the market only if their optimal profit is non-negative, $\pi^*_{f,i} \geq 0$.

Proposition 4 *Frontier firms would enter the market if the following condition holds:*

$$\widetilde{\omega} \geq A_f^{\frac{1-\alpha-\mu\alpha}{1-\alpha}} Y^{-\mu} c^{\frac{\mu}{1-\alpha}} \left(\frac{1}{\alpha} - 1\right)^{-\mu} \alpha^{\frac{-\mu}{1-\alpha}}. \tag{2.21}$$

Proof 5 *Set* $\pi^*_{f,i} \geq 0$

$$\begin{aligned} \left(Y A_f^{\frac{\alpha}{1-\alpha}} c^{\frac{\alpha}{\alpha-1}-1} \left[\frac{1}{\alpha} - 1\right] \alpha^{\frac{1}{1-\alpha}}\right)^{\mu} &\geq \frac{A_f}{\omega_i} \\ \omega_i &\geq A_f^{\frac{1-\alpha-\mu\alpha}{1-\alpha}} \left[Y c^{\frac{1}{\alpha-1}} \left(\frac{1}{\alpha} - 1\right) \alpha^{\frac{1}{1-\alpha}}\right]^{-\mu} \end{aligned} \tag{2.22}$$

This gives a lower bound of the threshold $\widetilde{\omega}$ such that a frontier firm makes a non-negative profit—a necessary condition to enter the market. Since ability ω is bounded by zero, all frontier firms make a positive profit when the lower bound is zero, $\widetilde{\omega} = 0$.

Proposition 5 *All agents adopt frontier technology and make a positive profit only if* $\alpha \leq 0$ *or* $\alpha \geq 1$.

Proof 6 *From equation (2.21), we set $\widetilde{\omega} = 0$. Since A_f, Y, c, and α are positive, we have*

$$0 \geq \left(\frac{1}{\alpha} - 1\right) \quad or \quad \alpha \leq 0 \tag{2.23}$$

Since I restrict $\alpha \in (0, 1)$, only a fraction of agents would adopt the frontier technology.[39] Intuitively, as ω tends to zero, fixed costs become so high that agents cannot break even in any situation. In other words, some agents would produce with non-frontier technology as long as their profit is positive. As a necessary condition, non-frontier firms enter the market when they can make a non-negative profit, $\pi_a^* \geq 0$.

Proposition 6 *If $\frac{1}{1+\mu} \geq \alpha$ holds, some agents produce with imitated technology.*

Proof 7 *Set $\pi_a \geq 0$ and recall that Y, $(1-\kappa)$, A_f, μ, and c are positive. From equation (2.8),*

$$\begin{aligned} \left(\frac{1}{\alpha}\right)^{\frac{\mu\alpha+\alpha}{\mu\alpha+\alpha-1}} - (1+\mu)\left(\frac{1}{\alpha}\right)^{\frac{1}{\mu\alpha+\alpha-1}} &\geq 0 \\ \frac{1}{\alpha} &\geq 1+\mu \end{aligned} \tag{2.24}$$

Proposition 6 implies that for non-frontier firms to make a profit, goods in the market are not highly substitutable as μ increases.

By the threshold definition, frontier firms earn a profit at least equal to that of non-frontier firms. Thus, if the condition (2.21) holds, satisfying the necessary condition that non-frontier firms make a positive profit implies the necessary condition for the frontier firms to make a positive profit.

[39]The necessary condition $\alpha < 0$ implies complementarity between goods. A meaningful solution does not exist unless there is an exogenous limit on resources. This is not a case of interest.

2.7.2 Proof: Uniqueness of the Threshold

Lemma 1 $Y(\omega) \in [Y(1) = \frac{1}{(A_f \mu^\mu \Omega_a^{\mu+1})^\alpha}\ ,\ Y(0) \to \infty)$ is monotonically decreasing if the following condition holds:

$$\alpha A_f > c > \alpha A_f (1-\bar{\omega})^{\frac{1-\alpha}{\alpha}}, \tag{2.25}$$

where $\tilde{\omega}$ is the highest possible ω.

Proof By definition,

$$\frac{\partial Y(\bar{\omega})}{\partial \bar{\omega}} = \left[\frac{1-\alpha-\alpha\mu}{\alpha\mu}\left(\frac{1-(1-\bar{\omega})(A_f\Omega_f)^\alpha}{\bar{\omega}(A_f\mu^\mu\Omega_a^{\mu+1})^\alpha}\right)^{\frac{1-\alpha-2\alpha\mu}{\alpha\mu}}\right]\left[\frac{(A_f\Omega_f)^\alpha}{\bar{\omega}(A_f\mu^\mu\Omega_a^{\mu+1})^\alpha} - \frac{1-(1-\bar{\omega})(A_f\Omega_f)^\alpha}{\bar{\omega}^2(A_f\mu^\mu\Omega_a^{\mu+1})^\alpha}\right] \leq 0 \tag{2.26}$$

Either term will be negative, while the other is positive. Rearranging the first term:

$$\begin{aligned} \frac{1-\alpha-\alpha\mu}{\alpha\mu}\left(\frac{1-(1-\bar{\omega})(A_f\Omega_f)^\alpha}{\bar{\omega}(A_f\mu^\mu\Omega_a^{\mu+1})^\alpha}\right)^{\frac{1-\alpha-2\alpha\mu}{\alpha\mu}} &\leq 0 \\ 1 &\leq (1-\bar{\omega})(A_f\Omega_f)^\alpha \\ c &\leq (1-\bar{\omega})^{\frac{1-\alpha}{\alpha}}\alpha A_f \end{aligned} \tag{2.27}$$

Then, rearrange second term:

$$\begin{aligned} \frac{(A_f\Omega_f)^\alpha}{\bar{\omega}(A_f\mu^\mu\Omega_a^{\mu+1})^\alpha} - \frac{1-(1-\bar{\omega})(A_f\Omega_f)^\alpha}{\bar{\omega}^2(A_f\mu^\mu\Omega_a^{\mu+1})^\alpha} &\leq 0 \\ A_f\Omega_f &\leq 1 \\ A_f\alpha &\leq c \end{aligned} \tag{2.28}$$

So, we need either (i) $\alpha A_f \leq c \leq (1-\bar{\omega})^{\frac{1-\alpha}{\alpha}}\alpha A_f$ or (ii)$\alpha A_f \geq c \geq (1-\bar{\omega})^{\frac{1-\alpha}{\alpha}}\alpha A_f$, but (i) implies $\bar{\omega} \leq 0$. Thus, the only condition is case (ii). The highest possible ω gives the tightest constraint. Therefore we can substitute $\bar{\omega}$ with $\tilde{\omega}$.

Lemma 2 If $A_f^{\frac{\alpha(-\alpha\mu)}{(1-\alpha)(1-\mu\alpha-\alpha)}}\left(\frac{\alpha}{c}\right)^{\frac{-\alpha\mu}{(1-\alpha)(1-\mu\alpha-\alpha)}}(1-\kappa)^{\frac{-\alpha}{1-\mu\alpha-\alpha}}\mu^{\frac{-\mu\alpha}{1-\mu\alpha-\alpha}} < Y(1)^{\zeta-1}$, then $\frac{\partial G_1(Y)}{\partial Y} <$

$0 \forall \omega \in [0,1]$

Proof Rewrite and define equation (2.11) as $G_1(Y)$,

$$\bar{\omega}^{\frac{-1}{\mu}} = \Omega_1 Y(\bar{\omega}) - \Omega_2 Y(\bar{\omega})^{\zeta} = G_1(Y) \tag{2.29}$$

where $\zeta = \frac{1-\alpha}{1-\alpha-\mu\alpha}$, $\Omega_1 = A_f^{\frac{\alpha}{1-\alpha}-\frac{1}{\mu}} \left(\frac{\alpha}{c}\right)^{\frac{1}{1-\alpha}} \left[\frac{1}{\alpha} - 1\right]$ and
$\Omega_2 = A_f^{\frac{\alpha}{1-\mu\alpha-\alpha}-\frac{1}{\mu}} (1-\kappa)^{\frac{\alpha}{1-\mu\alpha-\alpha}} \mu^{\frac{\mu\alpha}{1-\mu\alpha-\alpha}} \left(\frac{\alpha}{c}\right)^{\frac{1}{1-\alpha\mu-\alpha}} \left[\frac{1}{\alpha} - (1+\mu)\right]$.

To show $\frac{\partial G_1(Y)}{\partial Y} < 0$, we need only show that the function is negative at the smallest possible $Y(1)$.

$$\begin{aligned} \frac{\partial G_1(Y)}{\partial Y} = \Omega_1 - \zeta \Omega_2 Y(1)^{\zeta-1} < 0 \\ \frac{\Omega_1}{\Omega_2} < \zeta Y(1)^{\zeta-1} \end{aligned} \tag{2.30}$$

Rearrange the left hand side:

$$\begin{aligned} \frac{\Omega_1}{\Omega_2} &= \frac{A_f^{\frac{\alpha}{1-\alpha}-\frac{1}{\mu}} \left(\frac{\alpha}{c}\right)^{\frac{1}{1-\alpha}} \left(\frac{1}{\alpha} - 1\right)}{(1-\kappa)^{\frac{1}{\phi}} A_f^{\frac{\alpha}{\phi}-\frac{1}{\mu}} \mu^{\frac{\mu\alpha}{\phi}} \left(\frac{\alpha}{c}\right)^{\frac{1}{\phi}} \left(\frac{1}{\alpha} - (1+\mu)\right)} \\ &= \frac{1-\alpha}{1-\alpha(1+\mu)} A^{\frac{\alpha(-\alpha\mu)}{(1-\alpha)(1-\mu\alpha-\alpha)}} \left(\frac{\alpha}{c}\right)^{\frac{-\alpha\mu}{(1-\alpha)(1-\mu\alpha-\alpha)}} (1-\kappa)^{\frac{-1}{1-\mu\alpha-\alpha}} \mu^{\frac{-\mu\alpha}{1-\mu\alpha-\alpha}} \end{aligned} \tag{2.31}$$

Plug it back to the inequality constraint (2.30)

$$\frac{1-\alpha}{1-\alpha(1+\mu)} A_f^{\frac{\alpha(-\alpha\mu)}{(1-\alpha)(1-\mu\alpha-\alpha)}} \left(\frac{\alpha}{c}\right)^{\frac{-\alpha\mu}{(1-\alpha)(1-\mu\alpha-\alpha)}} (1-\kappa)^{-\frac{1}{1-\mu\alpha-\alpha}} \mu^{\frac{-\mu\alpha}{1-\mu\alpha-\alpha}} < \zeta Y(1)^{\zeta-1}$$

$$A_f^{\frac{\alpha(-\alpha\mu)}{1-\alpha}} \left(\frac{\alpha}{c}\right)^{\frac{-1}{1-\alpha}} (1-\kappa)^{\frac{-1}{\alpha\mu}} \mu^{-1} < Y(1) \tag{2.32}$$

Proposition 1 Given $Y \to \infty$ as $\omega \to 0$, there is a unique solution for equation (2.11) if the following conditions hold: (i) $A_f^{\frac{\alpha(-\alpha\mu)}{1-\alpha}} \left(\frac{\alpha}{c}\right)^{\frac{-1}{1-\alpha}} (1-\kappa)^{\frac{-1}{\alpha\mu}} \mu^{-1} < Y(1)$, and (ii) $G_1(1) \leq 1$.

Proof Recall that $\frac{\partial Y(\omega)}{\partial \omega} < 0$; we thus have

$$\begin{aligned}(G_1 \circ Y)'(\omega) &= (G_1' \circ Y)Y' \\ &= \begin{cases} > 0 & \text{if } G_1' < 0 \\ < 0 & \text{if } G_1' > 0 \end{cases}\end{aligned}$$

From Lemma 2.7.2, if the condition satisfies, $G_1' < 0$. Therefore, $(G_1 \circ Y)'(\omega) > 0$. Additionally, since

$$(\omega)^{\frac{-1}{\mu}} = (G_1 \circ Y)'(\omega)$$

The left-hand side is a decreasing function of $\bar{\omega}$ and the right-hand side is an increasing function of $\bar{\omega}$. Therefore, there is at most one solution. Given $G_1(1) \leq 1$, there is at least one solution.

2.7.3 Policymaker

They maximize their life-time rent by choosing κ:

$$R = \gamma Y(\kappa) + \gamma_d p_a y_a F(\bar{\omega})\kappa + f(\kappa)g(\kappa)\beta R' \tag{2.33}$$

As the long run performance is the main focus of this paper, we focus on the stationary equilibrium.

$$R^{ss} = \frac{\gamma Y(\kappa) + \gamma_d p_a y_a F(\bar{\omega})\kappa}{1 - \beta f(\kappa)g(\kappa)} \tag{2.34}$$

Take the first order with respect to κ:

$$\begin{aligned}\frac{\partial R}{\partial \kappa} &= \frac{\gamma}{1-\beta f(\kappa)g(\kappa)}\frac{\partial Y(\kappa)}{\partial \kappa} - \frac{\gamma Y(\kappa)}{[1-\beta f(\kappa)g(\kappa)]^2}\left[-\beta g(\kappa)\frac{\partial f(\kappa)}{\kappa} - \beta f(\kappa)\frac{\partial g(\kappa)}{\kappa}\right] \\ &= \frac{\gamma}{1-\beta f(\kappa)g(\kappa)}\left(\frac{\partial Y(\kappa)}{\partial \kappa} + \frac{\beta Y(\kappa)}{1-\beta f(\kappa)g(\kappa)}\left[g(\kappa)\frac{\partial f(\kappa)}{\kappa} + f(\kappa)\frac{\partial g(\kappa)}{\kappa}\right]\right) = 0\end{aligned} \tag{2.35}$$

Then, we know the condition when we would have multiple equilibrium is when output and resistance is increasing in κ while the portion of resistance firm is decreasing. Formally,

Proposition 2 There are at least two equilibrium when (i)$\frac{\partial Y(\kappa)}{\partial \kappa} > 0$, (ii) $\frac{\partial f(\kappa)}{\partial \kappa} > 0$, and (iii) $\frac{\partial g(\kappa)}{\partial \kappa} < 0$ for all $\kappa \in (0,1)$, and (2.35) crosses zero twice.

2.7.4 Property Rights on Fixed Cost

This sub-section describes the alternative specification of the property rights enforcement. In particular, the property rights enforcement is part of the fixed cost function. Higher enforcement gives to lower fixed cost.

We rewrite the frontier firm's problem and non-frontier firm's problem as follow:

$$\pi_{f,i} = \max_{y_f} p_f y_f - c y_f - C(\omega_i) \quad \text{s.t.} \quad C(\omega_i) = c \left(\frac{A_f}{\omega_i}\right)^{\frac{1}{\mu_1}} (1-\kappa)^{\frac{1}{\mu_2}} \ , \quad 0 < \mu_i < 1 \tag{2.36}$$

$$\pi_a = p_a y_a - c y_a - c i_a \quad \text{s.t.} \quad A_a = A_f i_a^{\mu} \tag{2.37}$$

Since the fixed cost do not alter the marginal cost or marginal benefit, the optimal output using frontier technology is the same as in the main text. The optimal output using non-frontier technology is

$$y_a^* = \left[\frac{c}{\alpha Y^{1-\alpha} A_f^{\alpha} \mu^{\mu\alpha}}\right]^{\frac{1}{\mu\alpha+\alpha-1}} \tag{2.38}$$

The optimal profit for frontier firm and non-frontier is then,

$$\pi_{f,i} = Y A_f^{\frac{\alpha}{1-\alpha}} c^{\frac{\alpha}{\alpha-1}} \left[\frac{1}{\alpha} - 1\right] \alpha^{\frac{1}{1-\alpha}} - c \left[\frac{A_f}{\omega_i}\right]^{\frac{1}{\mu_1}} (1-\kappa)^{\frac{1}{\mu_2}} \tag{2.39}$$

$$\pi_a = Y^{\frac{1-\alpha}{1-\alpha\mu-\alpha}} A_f^{\frac{\alpha}{1-\alpha\mu-\alpha}} \mu^{\frac{\alpha\mu}{1-\alpha\mu-\alpha}} c^{\frac{\alpha\mu+\alpha}{\alpha\mu+\alpha-1}} \left[\left(\frac{1}{\alpha}\right)^{\frac{\alpha\mu+\alpha}{\alpha\mu+\alpha-1}} - (1+\mu)\left(\frac{1}{\alpha}\right)^{\frac{1}{\alpha\mu+\alpha-1}}\right] \tag{2.40}$$

Find the threshold, $\bar{\omega}$, by equating equation (2.40) and (2.39),

$$Y A_f^{\frac{\alpha}{1-\alpha}} c^{\frac{\alpha}{\alpha-1}} \left[\frac{1}{\alpha} - 1\right] \alpha^{\frac{1}{1-\alpha}} - c \left[\frac{A_f}{\omega_i}\right]^{\frac{1}{\mu_1}} (1-\kappa)^{\frac{1}{\mu_2}} = Y^{\frac{1-\alpha}{1-\alpha\mu-\alpha}} A_f^{\frac{\alpha}{1-\alpha\mu-\alpha}} \mu^{\frac{\alpha\mu}{1-\alpha\mu-\alpha}} c^{\frac{\alpha\mu+\alpha}{\alpha\mu+\alpha-1}} \left[\left(\frac{1}{\alpha}\right)^{\frac{\alpha\mu+\alpha}{\alpha\mu+\alpha-1}} - (1+\mu)\left(\frac{1}{\alpha}\right) \tag{2.41}$$

$$\bar{\omega} = A(1-\kappa)^{\frac{\mu_1}{\mu_2}} \left[Y A_f^{\frac{\alpha}{1-\alpha}} \left(\frac{\alpha}{c}\right)^{\frac{1}{1-\alpha}} \left(\frac{1}{\alpha} - 1\right) - Y^{\frac{1-\alpha}{\phi}} A_f^{\frac{\alpha}{1-\mu\alpha-\alpha}} \mu^{\frac{\mu\alpha}{\phi}} \left(\frac{\alpha}{c}\right)^{\frac{1}{\phi}} \left(\frac{1}{\alpha} - (1+\mu)\right)\right]^{-\mu} \tag{2.42}$$

Note that the parameter space for proposition in the baseline model is different. However, it would not affect the main effect in the paper.

2.7.5 Property Rights on Frontier firm's revenue protection

This subsection describe a problem where the property rights enforcement is to protect frontier firm's revenue.

Rewrite frontier firm's problem as

$$\pi_{f,i} = \max_{y_f} \kappa p_f y_f - c y_f - C(\omega_i) \quad \text{s.t.} \quad C(\omega_i) = c\left(\frac{A_f}{\omega_i}\right)^{\frac{1}{\mu_1}} (1-\kappa)^{\frac{1}{\mu_2}}, \quad 0 < \mu_i < 1 \tag{2.43}$$

The non-frontier firm's problem is

$$\pi_a = p_a y_a - c y_a - c i_a + \frac{\gamma_a (1-\kappa) \int_{\bar{\omega}}^{1} p_f y_f dF(\omega)}{\int_0^{\bar{\omega}} dF(\omega)} \tag{2.44}$$

where $0 < \gamma_a < 1$ is the gain for non-frontier from frontier firm after some cost.

The optimal output for frontier firm is

$$y_f^* = \left[\frac{\alpha\kappa Y^{1-\alpha} A^{\alpha}}{c}\right]^{\frac{1}{1-\alpha}} \tag{2.45}$$

$$\pi_{f,i}^* = \kappa^{\frac{1}{1-\alpha}} Y A_f^{\frac{\alpha}{1-\alpha}} c^{\frac{\alpha}{\alpha-1}} \left[\frac{1}{\alpha} - 1\right] \alpha^{\frac{1}{1-\alpha}} - c\left[\frac{A_f}{\omega_i}\right]^{\frac{1}{\mu_1}} \tag{2.46}$$

The non-frontier firm's optimal profit is

$$\pi_a^* = Y^{\frac{1-\alpha}{1-\alpha\mu-\alpha}} A_f^{\frac{\alpha}{1-\alpha\mu-\alpha}} \mu^{\frac{\alpha\mu}{1-\alpha\mu-\alpha}} c^{\frac{\alpha\mu+\alpha}{\alpha\mu+\alpha-1}} \left[\left(\frac{1}{\alpha}\right)^{\frac{\alpha\mu+\alpha}{\alpha\mu+\alpha-1}} - (1+\mu)\left(\frac{1}{\alpha}\right)^{\frac{1}{\alpha\mu+\alpha-1}} \right] + \gamma_a(1-\kappa)\frac{1-\bar{\omega}}{\omega} p_f y_f \tag{2.47}$$

To find $\bar{\omega}$, set $\pi_f^* = \pi_a$,

$$\begin{aligned} \eta_1 - c\left[\frac{A_f}{\omega_i}\right]^{\frac{1}{\mu_1}} &= \eta_2 + \gamma_a(1-\kappa)\frac{1-\bar{\omega}}{\omega} p_f y_f \\ \eta_1 - \eta_2 &= c\left[\frac{A_f}{\omega_i}\right]^{\frac{1}{\mu_1}} + \frac{\gamma_a \kappa p_f y_f}{\omega} - \gamma_a(1-\kappa) p_f y_f \\ \eta_1 - \eta_2 + \gamma_a(1-\kappa) p_f y_f &= c\left[\frac{A_f}{\bar{\omega}}\right]^{\frac{1}{\mu_1}} + \frac{\gamma_a(1-\kappa) p_f y_f}{\bar{\omega}} \end{aligned} \tag{2.48}$$

where $\eta_1 = \kappa^{\frac{1}{1-\alpha}} Y A_f^{\frac{\alpha}{1-\alpha}} c^{\frac{\alpha}{\alpha-1}} \left[\frac{1}{\alpha} - 1\right] \alpha^{\frac{1}{1-\alpha}}$
and $\eta_2 = Y^{\frac{1-\alpha}{1-\alpha\mu-\alpha}} A_f^{\frac{\alpha}{1-\alpha\mu-\alpha}} \mu^{\frac{\alpha\mu}{1-\alpha\mu-\alpha}} c^{\frac{\alpha\mu+\alpha}{\alpha\mu+\alpha-1}} \left[\left(\frac{1}{\alpha}\right)^{\frac{\alpha\mu+\alpha}{\alpha\mu+\alpha-1}} - (1+\mu)\left(\frac{1}{\alpha}\right)^{\frac{1}{\alpha\mu+\alpha-1}} \right]$.

Then, we can solve this equation numerically. For special case where $\mu = 1$ or $\mu = 2$, we can find an analytical solution.

However, note that this specification has some important difference from the baseline case. The profit of frontier firm is not positive and is not higher than the profit of non-frontier firm for all κ. For instance, when $\kappa = 0$, frontier firm's profit is negative as they do not gain any revenue. Meanwhile, with the baseline assumption, non-frontier would earn a positive profit for all κ. So, for some κ, the profit of non-frontier firm is higher than one of frontier firm.

Chapter 3

Baby Bonus, Anyone? Examining Heterogeneous Responses to a Pro-Natalist Policy

3.1 Introduction

With declining birth rates in most of the developed world, nations are concerned with the burden placed on the working population to support a growing fraction of the retired population. Understanding the potential problems of below-replacement fertility rates raises a number of questions about pro-natalist policies: do they work, who is taking advantage of the incentives provided, and how costly are the programs? Past research finds that tax exemptions on children, child tax credits, and family allowances all increase fertility; however large increases in the benefits would be needed to reach replacement fertility levels (Zhang et al., 1994). Evidently, the policies are very expensive and if we can observe heterogeneous responses to the incentives then governments could tailor pro-natalist policies to encourage births from certain groups at lower cost.

The Canadian province of Quebec implemented a universal in-cash transfer, namely, the Allowance for Newborn Children (ANC), for all babies born from May 1988 to September 1997 to all residents of Quebec. Hereafter, we refer to this transfer as a baby bonus. This quasi-natural experiment has many qualities that allow us to estimate the impact of financial incentives on fertility.[1] First, the structure and payment plan of the pro-natalist policy was announced suddenly in the newspapers, allowing it to be treated as an unanticipated exogenous shock to the people of Quebec (Montreal Gazette, 1988a,b; La Presse, 1988).[2] The front page of the Montreal Gazette read “Have more babies, Liberals say”. Second, the baby bonus reached as high as C$8,000 for families having a third child or higher. This is a sizeable benefit and not tied to any other benefits or clawed back at higher income brackets. Parent and Wang (2007) stress the importance of fiscal incentives being large enough to induce an increase in household births. Also, our control group, the province of Ontario did not introduce new child benefit legislation until 1997, allowing for a clean comparison (Battle and Mendelson, 1997). Finally, and most importantly, the ANC is a universal pro-natalist policy implemented specifically in response to low fertility rates. Many pro-natalist policies are implemented for specific subgroups of the population, usually low-income individuals, to promote horizontal equity. For example, the Canada Child Tax Benefit payment, an in-cash transfer for anyone with a child, is reduced once adjusted family net income is over a threshold income (Milligan and Stabile, 2011). Since the ANC is universal we are able to examine the heterogeneous response of different subgroups of the population to this pro-natalist policy, and, thus, shed light on which women are being induced to have more children.

Assuming pro-natalist policies do impact fertility, it is important to know whether or

[1] There are many papers studying the impact of fiscal incentives on fertility; examples include Ang (2015), Baughman and Dickert-Conlin (2009), Brewer et al. (2012) , Cohen et al. (2013), González (2013), LaLumia et al. (2015), and Raute (2017).

[2] Unfortunately, the cancellation of the policy is announced well in advance, and replaced by universal childcare; this creates a less credible experimental environment at the end of the policy period.

not the effect is permanent or transitory. If the effect is transitory this implies that women only choose to adjust the timing of their births, while this could impart a shift on the age distribution, if the government is trying to increase family size then resources are being wasted on a purely transitory effect. If the effect is permanent this implies that women did choose to have more babies, and, hence, increases completed fertility. Past papers are unable to answer whether this baby bonus had a permanent effect because enough time needs to pass to examine the entire child-bearing period of each cohort. Using the confidential birth vital statistics and census data, we are able to calculate completed fertility rates for a number of cohorts that were impacted by the ANC, thereby providing the first analysis on whether or not the ANC had a permanent or transitory effect on fertility.

The ANC has been previously studied by Duclos et al. (2001), Milligan (2005), and Kim (2012, 2014). The latter studies build on Duclos et al. (2001) by using an additional data set, which contains demographic information about the mother and the family. All papers find a positive average effect of the ANC on fertility, Duclos et al. (2001) using vital statistics, while Milligan (2005) and Kim (2012, 2014) are using the public-use census file to control for individual household characteristics. Unfortunately, the public-use census files contain a small sample and indicate only if a child under the age of six is present on the census day, not the actual age. With access to de-identified individual census records we know the exact date of birth. Moreover, unlike past papers, a larger sample size allows us to examine the heterogeneous response to the ANC by income, education, parity (birth order), and immigrant status and to estimate meaningful marginal effects. Ang (2015) addresses the effect of the ANC on birth order, but does not delve into the spacing of births, changes in completed fertility, or sex preference as we do and does not delve into the heterogenous effect on different groups except for birth parity. Since we know the sex of older siblings in the household, we ask whether the sex of the two older children influences the decision to have a third, something suggested by the large literature on parental preference. There is a primary preference for one-of-each-sex with a secondary preference for a son in North America and other developed countries as opposed to a strong primary preference for sons in developing countries (e.g., Andersson et al. (2006); Angrist and Evans (1998); Freedman et al. (1960); Williamson (1983)).

As argued in the seminal paper, Becker and Lewis (1973), parents trade off the number of children they have with the quality of those children. If families trade-off quality for quantity (Mogstad and Wiswall (2016), and Pop-Eleches (2006)) and low-income families are sensitive to these pro-natalist policies (Pop-Eleches, 2010) then these baby bonuses may worsen intergeneration inequality. That is, if low-income parents are induced to have more children through pro-natalist policies then the quantity-quality trade-off suggests that these parents invest less in their children. Building on the quantity-quality theory, Becker and Tomes (1976)) outline a U-shape model for the desired number of children as a function of income. Their model predicts that an exogenous shock reducing the price of children would have low-income mothers spend extra income on children they already have rather than having more children. This suggests that a baby bonus may not induce low-income families to have more children.[3] On the other hand, the fixed baby bonus may not translate into a large enough percentage increase in income to induce high-income families to have another child.

We find heterogeneous responses to the ANC by income, education, and parity (birth order). In alignment with the theory, we find a hump shape response to the ANC by income group showing that low-income families are not responding much, and in fact, mid-income families respond the most to a baby bonus, while high-income families respond the least. By using a more relaxed model specification, we find this result contrary to Milligan (2005) finding an increasing response in income. Consistent with recent literature, we also find that more highly educated women respond to the ANC more than those less educated. [4] Due to

[3] Riphahn and Wiynck (2017) also find that low-income families are not induced to have more children when they examine a child benefit program in Germany. See also Raute (2017).

[4] Shang and Weinberg (2013) study the case in the United States.

the generous nature of the baby bonus for third or higher children, we observe a large response to the policy for these children. Interestingly, we find that a third birth is more likely when there are two previous sons or a previous son and daughter than if both are daughters. Also, we find that parents having a previous son are more likely to have another child with the baby bonus comparing to having a previous daughter. That is consistent with studies in both Canada and the United States that find that a gender preference for sons exists (Almond et al., 2013; Dahl and Moretti, 2008). These results remain the same under various specifications and sensitivity tests. We also confirm, both graphically and through regression analysis, that the baby bonus created both a transitory and permanent effect, where Quebec women not only chose to have their children sooner, but also to have more children. Thus, the increase in completed fertility rates implies that the ANC was successful in its endeavor to increase fertility. Our findings suggest that this pro-natalist policy could have been more cost-effective if it was targeted to mid-income families (C$20,000 to C$59,999), ceteris paribus, saving 33 percent of baby bonus payments.[5]

The next section of the paper explains the institutional background of the ANC. Section II and III examine the two datasets and the empirical methods respectively. In section IV we discuss our results, followed by a conclusion in section V.

3.2 Institutional Background

The ANC was a non-taxable in-cash transfer to all legal residents of Quebec that had a newborn, or adopted a child under the age of five, between May 1, 1988 and September 30, 1997.[6] The amount of the benefit depended on the parity (birth order) of the child. The amount and exact timing of these payments are in Table 3.1. Also, the value of the benefit

[5] Authors' calculation.

[6] The baby bonus was paid to all births that were registered; we find no evidence of differences in ANC take-up rates by income.

for third or higher children continuously rose over the policy period. By the end of the policy parents of three or more children received C$8000, which, according to Milligan (2005), accounts for around 30 percent of the direct cost of the first five years of a child's life. Not surprisingly, the policy became expensive to continue, costing over C$1.4 billion between 1989 and 1996 according to Milligan (2002).[7] In September 1997, with the termination of the universal ANC, the provincial government instead implemented a universal C$5 a day childcare policy to encourage mothers' participation in the labor force. Also, the ANC was replaced with a new act that gave baby bonuses to low-income families.

Table 3.1: Benefit Payments Under the Allowance for Newborn Children

	First child	Second child	Third or higher child
May 1988 to April 1989	C$500 at birth	C$500 at birth	8 quarterly payments of C$375=C$3000
May 1989 to April 1990	C$500 at birth	C$500 at birth, C$500 on 1st birthday	12 quarterly payments of C$375=C$4500
May 1990 to April 1991	C$500 at birth	C$500 at birth, C$500 on 1st birthday	16 quarterly payments of C$375=C$6000
May 1991 to April 1992	C$500 at birth	C$500 at birth, C$500 on 1st birthday	20 quarterly payments of C$375=C$7500
May 1992 to Sept. 1997	C$500 at birth	C$500 at birth, C$500 on 1st birthday	20 quarterly payments of C$400=C$8000

Note: Each cell reports the payments made for a child born within the specified period. Source: Milligan (2005)

Using the Canadian Tax and Credit Simulator Milligan (2016) , we calculate the total family benefits for different income levels in Quebec and Ontario from 1985 to 2000.[8] Figure 3.1 shows the total family benefits for family earning C$20,000 across different birth parities in Quebec and Ontario. Figure 3.2 shows the total family benefits for family earning C$60,000 across two provinces. Both figures show the total family benefits are significantly higher in Quebec than Ontario for three birth parities during the ANC policy period.

During the almost decade-long duration of the ANC policy two other policies could have potentially affected the number of births in Quebec. First, abortions were decriminalized in Canada following the strike down of Section 251 by the Supreme Court in 1991 with regards

[7]We confirm this calculation.

[8]The total family benefits include all refundable credits from federal government and provincial government.

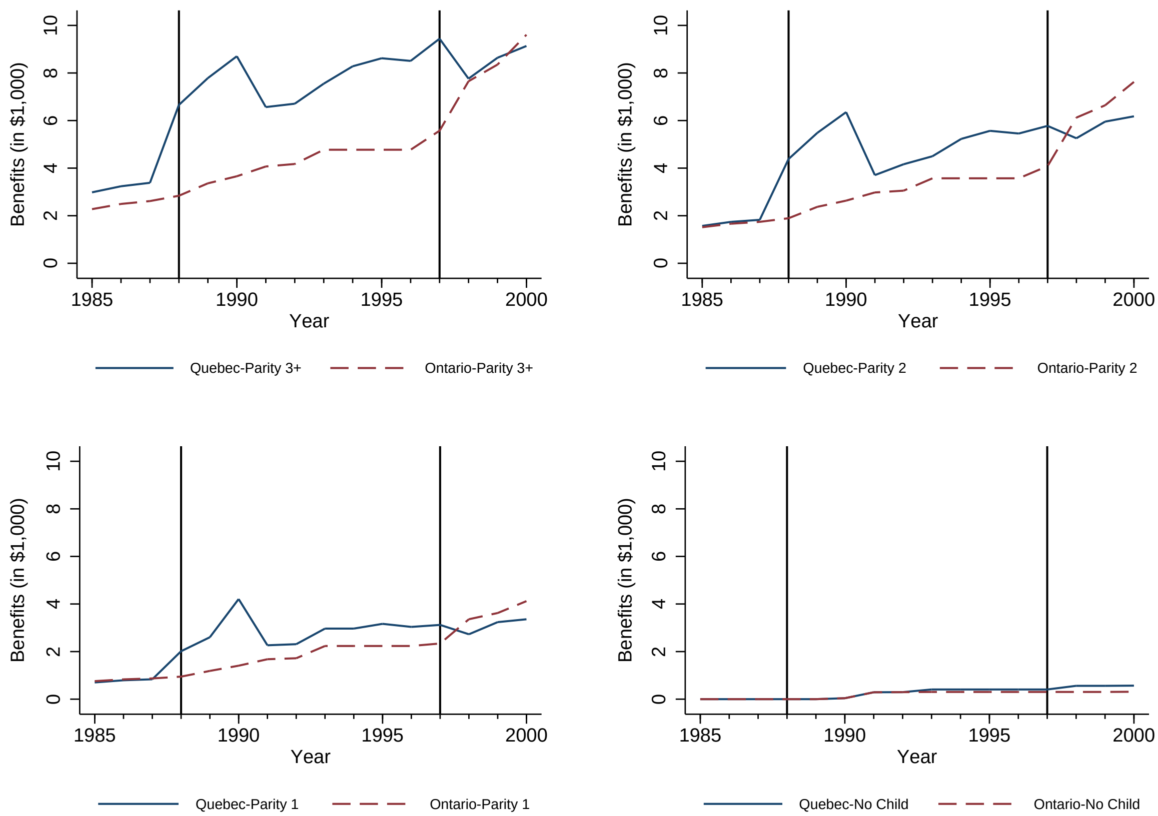

Figure 3.1: Simulated Total Family Benefit of QC and ON for Household Earning $20,000

Source: Milligan (2016).

to R. v. Morgentaler (1991). The fading stigma of abortions can potentially influence fertility; however, the rate of abortion per 100 live births in Quebec showed only a slight increase between 1986 and 1992, from 14.7 to 16.6.[9] Moreover, we check to ensure that there is a parallel trend and that our difference-in-differences model is not contaminated by varying abortion rates between Quebec and Ontario. Second, Quebec was given constitutional power with regards to immigration in the Canada-Quebec Accord of 1991 (Young, 1998). If there is a difference in the fertility behavior of immigrants selected by Quebec, then variation from immigrants' fertility is misleadingly assumed to be attributed to the ANC instead. We address

[9]Source: Statistics Canada. Table 106-9013.

this concern and find that the exclusion of immigrants results in the same findings; we conclude that the Canada-Quebec Accord of 1991 does not affect our analysis. We also examine the response of the ANC by immigrant status and find that immigrant and non-immigrant families respond similarly.

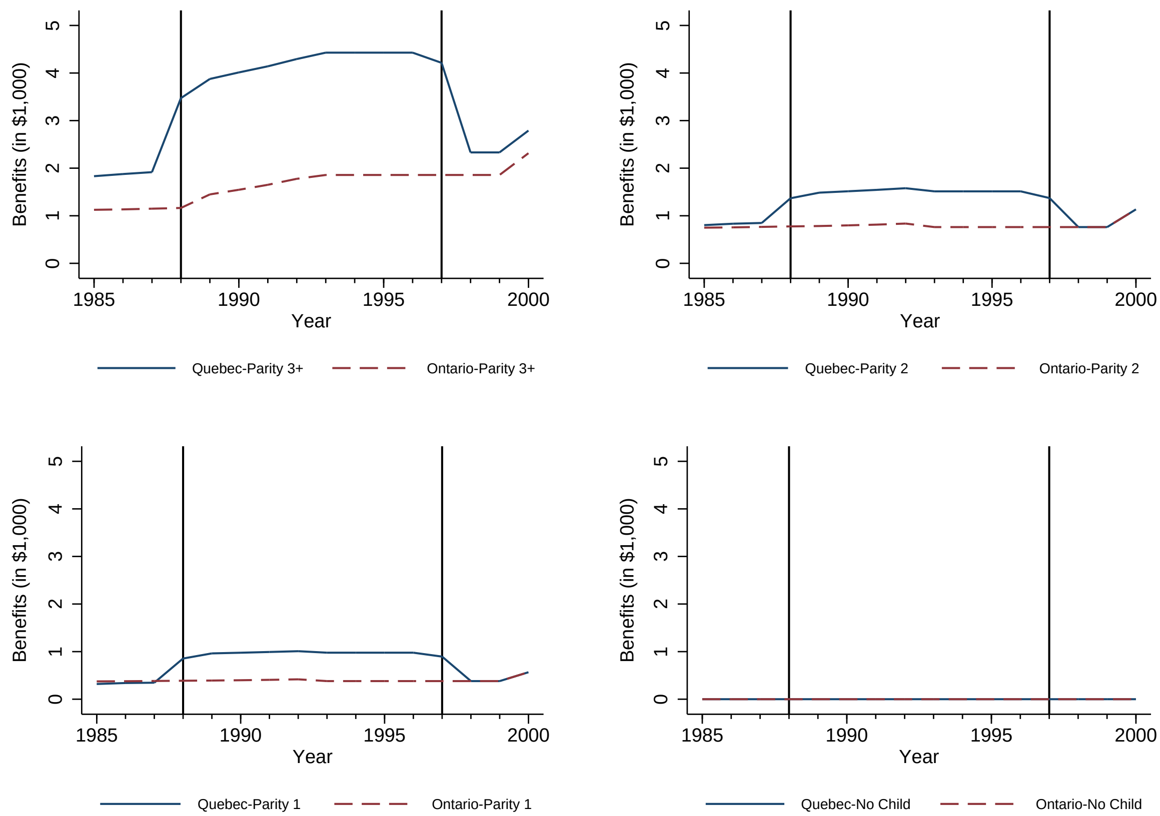

Figure 3.2: Simulated Total Family Benefit of QC and ON for Household Earning $60,000

Source: Milligan (2016).

3.3 Datasets

In this section we first describe the birth vital statistics dataset and discuss our graphical findings. Then we describe the census dataset that we use for regression analysis in Section

3.4.

3.3.1 Vital Statistics

Using the confidential birth vital statistics from 1974 to 2011 we know the province of each birth, the mother's age, and the parity.[10] With these three critical variables we are able to look at trends in fertility between Quebec and Ontario to assess the impact of the ANC.[11] Figure 3.3 shows the total fertility rate (TFR), the cross-section of the sum of age-specific fertility rates in each year from 1974 to 2011, for women between the ages of 15 and 49.[12] The figure makes a very compelling argument for the positive effect the ANC had in Quebec.[13] The TFR in Quebec diverged from Ontario in the early 1980s and remain elevated for 5 years, then displays a narrowing of this gap starting in 1988.[14] Since the exact structure and payment plan of the baby bonus was not announced until the provincial budget speech of May 1988, the slight increase of births in 1988 could not have been affected by the ANC policy. However, Ontario also illustrated an increase in the same year, albeit not as steep as in Quebec. Furthermore, in the previous year's budget speech, the Quebec Minister of Finance, Gérard D. Levesque, announced that family assistance was an important aspect of

[10]With the confidential data we are able to look at annual TFR for each year of age, whereas past papers using the public use data have had to use five-year age intervals.

[11]From all the Canadian provinces, the province of Ontario is the most comparable to Quebec; they are neighbors, as well as the two most populated provinces in Canada. There are many cities and towns on the border of these two provinces, and in one instance they even share the same metropolitan area (Ottawa-Gatineau).

[12]See Hotz et al. (1997) for a detailed comparison on total fertility rates (TFR) and completed fertility rates (CFR).

[13]In addition to graphical findings, we estimate a difference-in-differences (DID) model using the TFR as the outcome of interest for Quebec and Ontario with 1995 as the treatment year and 1988 as the comparison year; The DID model results in a 0.11 increase in the number of children born to Quebecois women in the treated year. As Manski and Pepper (2017)) point out, such DID estimates require strong assumption on DID invariance. Following Manski and Pepper (2017), we apply a class of the bounded-variation assumptions. We use the data prior to 1988 to calculate the bound parameter of bounded time variation, bounded inter-province variation, and bounded DID variation. The bounded DID estimates are between 0.104 and 0.199. These models are available upon request.

[14]We also compared Quebec to the Rest of Canada and find that it closely mirrors that of Ontario illustrating that the gaps we are observing in Quebec are not just in comparison to Ontario.

the new budget, with a specific mention of allowances for families with three or more children being considered (Bernard, 1989). Perhaps, some families may have anticipated that a baby bonus of some sort would be implemented shortly.

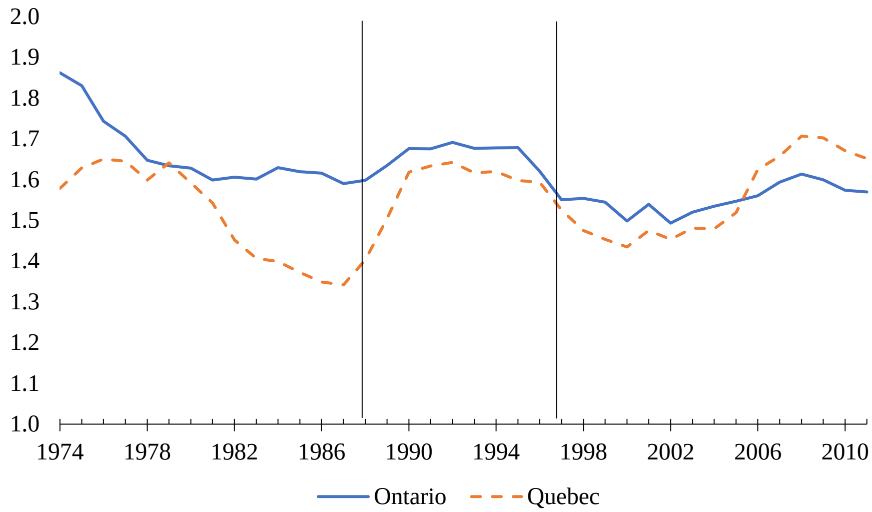

Figure 3.3: Total Fertility Rate, Age 15–49

Notes: The first vertical bar signifies the start of the ANC policy in May 1988, and the second vertical bar signifies the end of the policy in September 1997. Source: Birth Vital Statistics, 1974 to 2011.

Although the termination of the ANC is not experimentally ideal due to the immediate introduction of universal childcare and the change in Ontario's child benefit policy, we do see some evidence that Quebec's TFR fell immediately after its cancellation. This suggests the effect of in-cash transfers is stronger than in-kind transfers.[15] Figure 3.4 further decomposes the TFR by birth order. Here we observe Quebec first-order births surpass Ontario during the policy period. We also suggest that first-order births respond immediately to the policy, followed by second, and then third and higher. This illustrates parents having more children during the policy window in order to receive the substantially higher baby bonus for third and higher children. Milligan (2002) writes that the rate for third and subsequent births in

[15]In Norway, Havnes and Mogstad (2011) find that formal childcare acts as a substitute for informal childcare (arrangements with relatives, friends, and so forth) instead of encouraging new female labor force participation. Baker et al. (2008) examine child care use in Quebec and do find some crowding out of existing arrangements is evident.

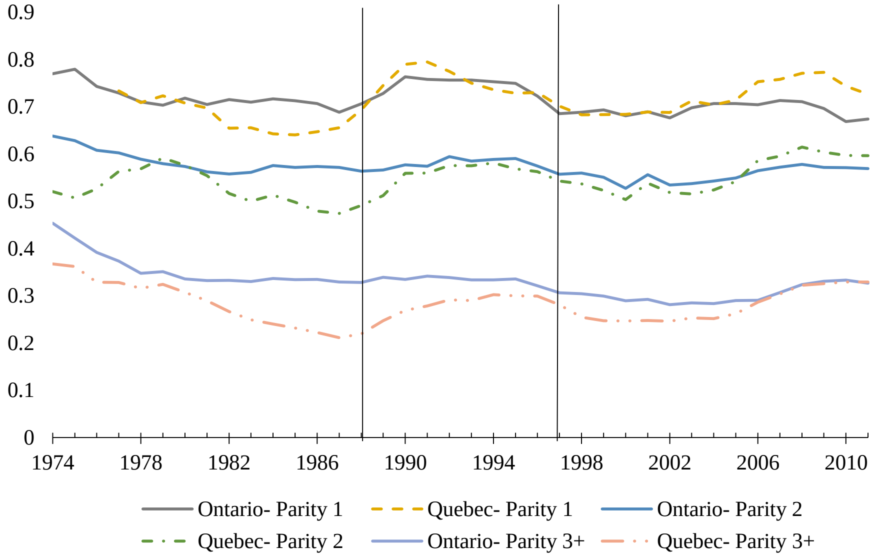

Figure 3.4: Total Fertility Rate by Birth Order, Age 15–49

Notes: The first vertical bar signifies the start of the ANC policy in May 1988, and the second vertical bar signifies the end of the policy in September 1997. Source: Birth Vital Statistics, 1974 to 2011.

Quebec increased by 35 percent, from 0.217 per woman in 1987 to 0.294 in 1993, while falling elsewhere in Canada by 3 percent.

Figure 3.5 provides an alternative view of the impact of the ANC policy. It shows the birth cumulative distribution function for each of three cohorts by age of mother and parity, separately for Ontario and Quebec. The three cohorts are those that would have been most directly affected by the policy - the "old cohort," those affected by the policy from ages 29 to 38, the "middle cohort," from ages 22 to 32, and the "young cohort," from ages 15 to 25. The "old cohort" was born between 1959 and 1962; the "middle cohort" was born between 1963 and 1968; and the "young cohort" was born between 1969 and 1972. The three cohorts follow in sequential order in Ontario, indicating a trend towards later births. That is not the case in Quebec where the "middle cohort" has its children earlier. The difference between Ontario and Quebec is most evident for the third child, where one can observe the "middle cohort" in Quebec having children much earlier than their Ontario counterparts. That suggests that the policy affected the timing of births in Quebec, but not necessarily the level of completed fertility which was the target. If only the timing changed the same number of births would have happened without the bonuses, and the government could have saved the expense.

To assess the permanent impact of the ANC policy we need to look to the completed fertility rates. Figure 3.6 displays the CFR's for both Quebec (solid line) and Ontario (dashed line) starting from cohorts born in 1931. For the cohorts born from the late 1930's to the late 1950's the Ontario and Quebec completed fertility rates run in parallel, with Quebec lower by about 0.5 children per woman. For later cohorts, the ones that would have been most affected by the ANC, the gap narrows and then disappears altogether, indicating a permanent effect of the policy on their completed fertility.

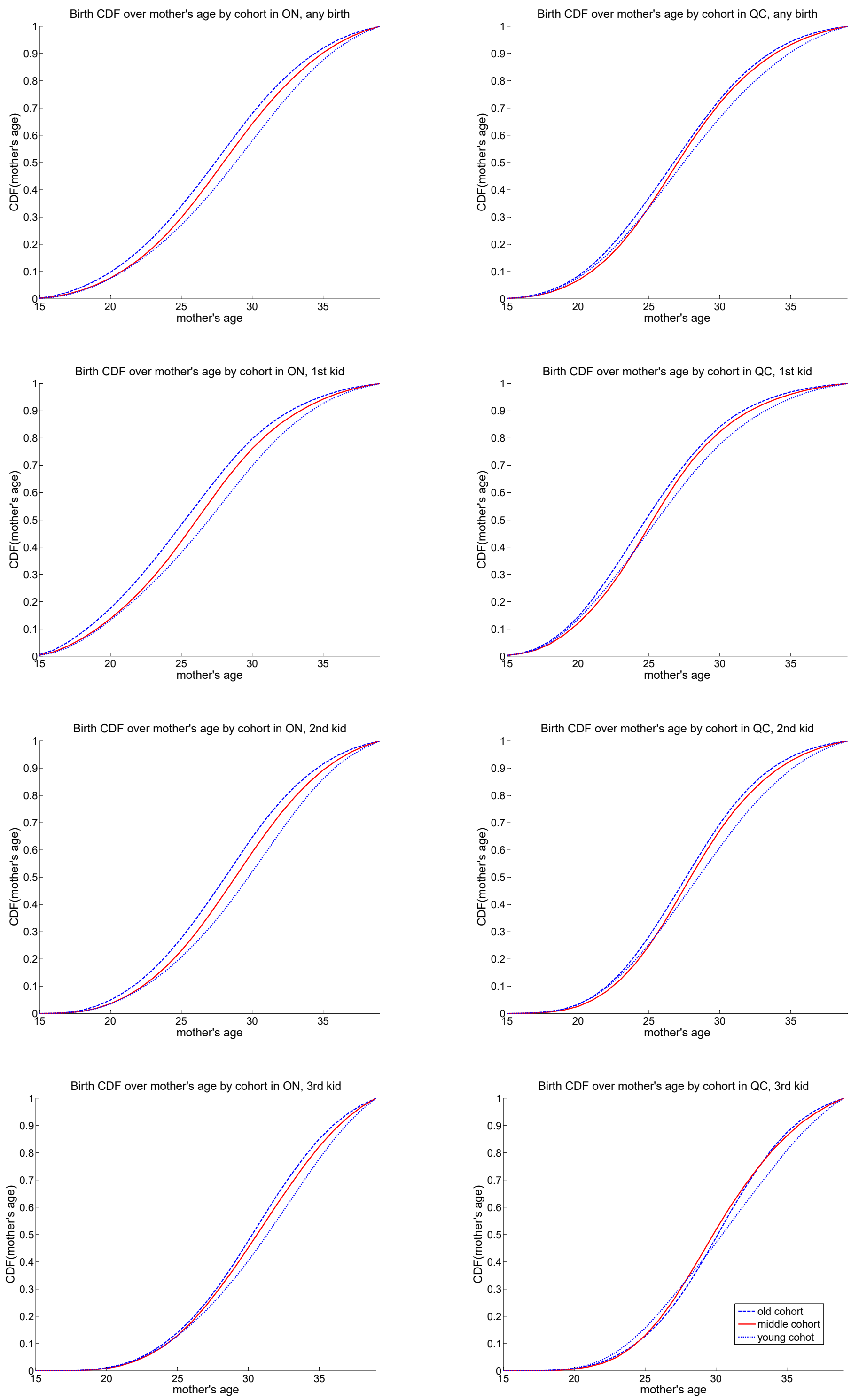

Figure 3.5: Birth Cumulative Distribution Function by Mother's Age, Cohorts Aged 15–39
Note: Birth Vital Statistics source. The "old cohort" was born between 1959 and 1962, and aged 26-38 during the policy; the "middle cohort" was born between 1963 and 1968, and aged 20-34 during the policy; and the "young cohort" was born between 1969 and 1972, and aged 16-28 during the policy.

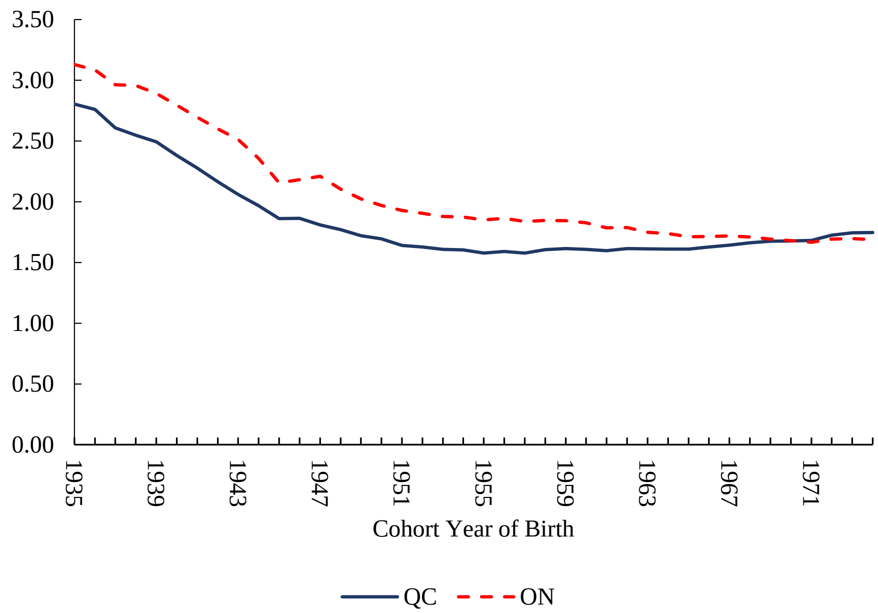

Figure 3.6: Completed Fertility Rate, Cohorts Aged 15–39

Note: Birth Vital Statistics, 1946 to 2011.

3.3.2 Census Data

The Canadian Population Census is conducted every five years; it provides household information recorded on Census Day. Our main results are based on the 1991 Census and the 1996 Census. We also use the 1986 Census for sensitivity analysis and the 2001 Census to analyze completed fertility rates. With the de identified files we observe the exact year a child is born.[16] To create a control group we choose to examine all married or common-law women from 1987 and 1988 from the 1991 census file. Since the policy was announced in the spring of 1988, any mothers who would have been incentivized by the ANC would have given birth, at the earliest, nine months later, which falls into 1989. Therefore, the closest control group to the start of the ANC is all married or common-law women in 1987 and 1988. When conducting robustness checks we change our control group to examine, for example, the number of births that take place in 1984 and 1985 from the 1986 Census. Our treatment group is all married or common-law women from 1994 and 1995. We use only two years for the treatment group so that the time period is balanced with our control group and for three additional reasons.[17] First, after seven years of the policy, every family should be familiar with the ANC, and would have had time to exploit it should they wish to. That is, the choice of treatment period avoids a heterogeneous information problem (e.g., more educated households know about the policy earlier than others). Second, it is before the cancellation of the policy was announced, thus residents are unaware of a possible change to the policy. Third, by choosing 1994 and 1995 from the 1996 Census, our income observations are from 1995, allowing for the most accurate estimates.

We limit our sample to married or common-law females between the age of 15 and 34, who

[16]The main shortcoming of Milligan (2005)'s study of the ANC is that the public-use census does not provide year of birth. This meant that the ANC policy period overlaps the 1991 census window, making it difficult to disentangle which births are part of the policy period. Also, the public-use census file has a very small sample size and does not allow for a thorough examination of heterogeneous effects like the confidential census file.

[17]As a robustness check we also use a three year and five-year window. See Section 3.5.2 for more detail.

have not changed provinces in the last five years prior to Census day, who are residents of Canada, and have positive income as defined below.[18] Only 11 percent of births from Quebec women under the age of 35, who have not changed provinces in the last five years, were to single women. We remove single mothers for two reasons: (1) we are trying to create a homogeneous group of women to compare, and (2) due to the way we define income all single mothers' income calculation would be misleading in our model.[19] We define income to be equal to the spouse's wage and self-employment income plus all investment income from both the spouse and woman.[20] Female wages are excluded because of the endogeneity between female labor force participation and fertility decisions. In addition to income, we observe birth order and whether or not the family lives in an urban versus rural neighborhood in Quebec or Ontario.[21] We also control for age, education level, mother tongue, and immigrant status of both the woman and her spouse. Table 3.2 shows proportions of the weighted sample for all variables of each census file.

[18]We limit the sample to women aged 34 to ensure we can identify all children; there is a concern that if the woman is older than 34 years of age she may have children living outside the home.

[19]Another reason we only look at married women is because we do not want to model the relationship between the decision to be married and fertility as studied in Baudin et al. (2015).

[20]We use the Canadian Consumer Price Index (CPI) for each province to convert nominal income into real income in 1992 constant Canadian dollars.

[21]A household is located in an urban dwelling if it is located in a census metropolitan area (CMA), which is one or more municipalities with at least one hundred thousand people.

Table 3.2: Census Summary Statistics

	Quebec			Ontario		
	1986	1991	1996	1986	1991	1996
Had a child	0.239	0.207	0.268	0.269	0.236	0.282
Zero older children	0.497	0.633	0.488	0.46	0.603	0.471
One older child	0.232	0.194	0.243	0.225	0.193	0.234
Two or more older children	0.272	0.174	0.27	0.316	0.205	0.296
Female: 15-24 years old	0.207	0.176	0.16	0.192	0.136	0.112
Female: 25-29 years old	0.39	0.369	0.333	0.379	0.378	0.333
Female: 30-34 years old	0.404	0.455	0.507	0.43	0.487	0.556
Female: allophone	0.051	0.053	0.074	0.093	0.143	0.169
Female: francophone	0.869	0.88	0.862	0.031	0.056	0.052
Female: anglophone	0.081	0.063	0.065	0.877	0.799	0.78
Female: high school dropout	0.259	0.211	0.156	0.277	0.198	0.148
Female: high school diploma	0.231	0.193	0.166	0.216	0.216	0.17
Female: some post-secondary	0.42	0.479	0.504	0.386	0.445	0.494
Female: university degree	0.089	0.118	0.176	0.12	0.142	0.189
Female: immigrant	0.054	0.048	0.059	0.18	0.161	0.196
Immigrant (either parent)	0.086	0.079	0.091	0.272	0.244	0.272
Male: immigrant	0.07	0.062	0.071	0.214	0.186	0.208
Male: 15-24 years old	0.102	0.084	0.074	0.096	0.065	0.054
Male: 25-29 years old	0.317	0.286	0.242	0.299	0.28	0.231
Male: 30-34 years old	0.355	0.374	0.382	0.352	0.386	0.408
Male: 35-39 years old	0.177	0.189	0.226	0.195	0.196	0.232
Male: 40-44 years old	0.038	0.047	0.053	0.043	0.053	0.055
Male: 45 and older	0.011	0.021	0.024	0.016	0.022	0.022
Male: allophone	0.051	0.062	0.075	0.091	0.155	0.174
Male: francophone	0.867	0.87	0.854	0.03	0.055	0.05
Male: anglophone	0.083	0.065	0.067	0.88	0.788	0.774
Male: high school dropout	0.268	0.245	0.205	0.273	0.225	0.179
Male: high school diploma	0.163	0.155	0.158	0.145	0.163	0.157
Male: some post-secondary	0.439	0.463	0.476	0.43	0.456	0.487
Male: university degree	0.131	0.137	0.162	0.151	0.156	0.177
Live in urban area	0.765	0.762	0.762	0.826	0.82	0.835
Income: under C$19,999	0.262	0.261	0.331	0.191	0.178	0.242
Income: C$20,000-39,999	0.449	0.461	0.429	0.407	0.428	0.413
Income: C$40,000-59,999	0.227	0.209	0.182	0.308	0.289	0.248
Income: C$60,000-79,999	0.042	0.046	0.038	0.065	0.068	0.061
Income: C$80,000 & higher	0.019	0.022	0.019	0.03	0.036	0.033
Sum of weights	476,435	468,445	377,825	610,005	589,105	510,670

Notes: Each entry is the proportion of the weighted sample for each variable of each census file. For variable Had a child, we use periods from 1984 to 1986 for census 1986, from 1987 to 1988 for census 1991, and from 1994 to 1995 for census 1996. Observations are weighted and are rounded to the nearest multiple of 5.

3.4 Empirical Methods

To start, we replicate Milligan (2005) difference-in-differences model to ensure continuity before examining heterogeneous responses and testing for permanent and transitory effects. After replicating Milligan (2005) model with our data, we estimate the same model by sub-sampling different income groups, maternal education, birth order, sex of previous two children, and immigrant status. We first estimate the following equation with Milligan's specification, and then proceed to run the same equation but with the abovementioned subgroups of the population:

$$\text{Had a Child}_{ijt} = \beta_0 + \beta_1 \text{Quebec}_j + \beta_2 1996_t + \beta_3 \text{Quebec}_j \times 1996_t + X'_{ijt}\beta + \epsilon_{ijt} \tag{3.1}$$

In addition, we use a triple difference approach to compare across time (pre-policy versus during policy), jurisdictions (Quebec versus Ontario), and different subgroups of interest (income, and birth order) as another way to estimate the heterogeneous responses of the sub-samples. The triple difference approach alleviates the concern of potential trends in unobserved characteristics that may be diverging in the treatment and control provinces, which would lead to biased estimates in the difference-in-differences model. We estimate the same model separately for each subgroup to examine the heterogeneous impact of the ANC on whether the household had a child.[22] The following equation is estimated:

[22]The marginal effect in this specification allows us to interpret the impact of the ANC policy on different subgroups.

$$
\begin{aligned}
\text{Had a Child}_{ijt} = \beta_0 + \beta_1 \text{Quebec}_j + \beta_2 1996_t + \sum_{k \in S} \beta_{3,k} \text{Subgroup}_k + \beta_4 \text{Quebec}_j \times 1996_t \\
+ \sum_{k \in S} \beta_{5,k} \text{Quebec}_j \times \text{Subgroup}_{k,ijk} + \sum_{k \in S} \beta_{6,k} 1996_t \times \text{Subgroup}_{k,ijt} \\
+ \sum_{k \in S} \beta_{7,k} \text{Quebec}_j \times 1996_t \times \text{Subgroup}_{k,ijt} + X'_{ijt}\beta + \epsilon_{ijt}
\end{aligned}
\tag{3.2}
$$

For both equation (1) and (2), i indexes the individual females, j indexes jurisdictions, t indexes time, and k (exclusive to equation (2)) indexes the subgroup of interest in set S. The dependent variable indicates whether a child is born. Dummy variables are included to control for time effects, 1996_t, and Quebec fixed effects, $Quebec_j$. The interaction of the two, $Quebec_j \times 1996_t$, is our main variable of interest in equation (1) and accounts for any differential trend in fertility among residents of Quebec relative to those in Ontario. Our main variable of interest in equation (2) is the triple interaction of each subgroup (income, and birth order) with Quebec and the 1996 Census dummy. This triple dummy interaction allows us to examine if there are any differential trends in fertility among the specific subgroup in Quebec at the time of the ANC. However, the triple interaction term gives rise to multiple possible interpretations since there are many different relative cases to compare; therefore, we prefer the ease of interpretation provided by sub-sampling the difference-in-differences model. These models are estimated using probit regression and all standard errors (ϵ_{ijt}) are adjusted for heteroscedasticity. Average marginal effects are reported to allow for easier interpretation of the estimates.[23] These marginal probabilities are interpreted as the marginal probability of having a child for a change in the independent variable of interest.

[23]Special care is taken into calculating average partial effects instead of partial effects evaluated at the mean. We observe individual's characteristics to calculate an individual probability and then average all those probabilities, as opposed to mean marginal effects, where the mean for each variable is plugged in to calculate a probability. We calculate the marginal probability using the method described inAi and Norton (2003).

The variables included in X_{ijt} relate to the individual woman, her spouse, and her household. Age dummies signify whether the woman is between 15 to 24, 25 to 29, or 30 to 34 years of age, immigrant status, and, mother tongue.[24] Highest level of education is one of the subgroups we model for heterogeneous responses; we categorize education as high school dropout, high school diploma, some post-secondary, and a bachelor's degree or more. Similar variables are included for the spouse; the only difference is age, for which the categories are 15 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, and 45 and older. Real annual family income excluding the woman's wage is categorized as under C$19,999, C$20,000 to C$39,999, C$40,000 to C$59,999, C$60,000 to C$79,999, and C$80,000 and over. These same categories are used when we examine income in the triple difference model. We also account for the number of children already in the household: none, one, and two or more. Again, we use these categories when examining the triple interaction term of the impact of ANC on birth order. A dummy variable is included to signify whether the household lives in an urban area.

To show how the ANC affected the timing of births we modify the outcome variable in equation (1) to be a binary indicator to signify two or more births within three years, two or more births within five years, and three or more births within five years; the probit estimates will show whether the ANC affected the timing of births and for which subgroups. It is important also to examine how the policy affected the total number of children born to each mother. For married women aged 35 to 39 from the 1991 and 2001 Censuses we estimate both linear and probit models similar to equation (1); the dependent variable in the linear model is the total number of children born to each woman and the outcome variable in the probit models is a binary indicator signifying that the woman had n children in total, where $n = 1, 2,$ or 3 or more in each separate model.[25] Table 3.3 contains summary statistics from the 1991 and 2001 Censuses for married women aged 35 to 39 in both Ontario and Quebec.[26]

[24]The definition of immigrant in this case comes from the Census definition, which represents all individuals not born as a Canadian citizen.

[25]We also estimated $n = 4$ or more children and find that the results are similar to those for$n = 3$ or more.

[26]We limit our sample to women aged 35 to 39 because they are near the end of child-bearing, while still

Table 3.3: Census Summary Statistics for Married Women 35-39 years Old

	Quebec		Ontario	
	1991	2001	1991	2001
Number of Children	1.753	1.746	1.875	1.819
Had one child	0.196	0.199	0.167	0.17
Had two children	0.445	0.427	0.441	0.44
Had three or more children	0.205	0.211	0.251	0.231
Female: allophone	0.075	0.106	0.199	0.249
Female: francophone	0.851	0.826	0.058	0.047
Female: anglophone	0.074	0.068	0.743	0.704
Female: high school dropout	0.259	0.167	0.212	0.161
Female: high school diploma	0.26	0.195	0.219	0.163
Female: some post-secondary	0.367	0.452	0.401	0.465
Female: university degree	0.114	0.186	0.168	0.211
Female: immigrant	0.083	0.097	0.257	0.282
Male: immigrant	0.1	0.1	0.29	0.271
Male: allophone	0.085	0.122	0.214	0.269
Male: francophone	0.844	0.812	0.055	0.045
Male: anglophone	0.071	0.066	0.731	0.686
Male: high school dropout	0.268	0.221	0.23	0.2
Male: high school diploma	0.168	0.169	0.136	0.14
Male: some post-secondary	0.402	0.43	0.429	0.459
Male: university degree	0.162	0.18	0.205	0.201
Live in urban area	0.754	0.767	0.827	0.861
Income: under C$19,999	0.228	0.258	0.162	0.209
Income: C$20,000-39,999	0.361	0.365	0.312	0.312
Income: C$40,000-59,999	0.272	0.236	0.322	0.269
Income: C$60,000-79,999	0.089	0.081	0.126	0.113
Income: C$80,000 & higher	0.05	0.06	0.078	0.097
Sum of weights	211,320	210,920	295,400	342,490

Notes: Each entry is the proportion of the weighted sample for each variable of each census file. Observations are weighted and are rounded to the nearest multiple of 5.

3.5 Results

3.5.1 Findings

Table 3.4 displays the average marginal effects for equation (1) with our entire sample as a replication exercise of Milligan (2005), but using the confidential data file. Our average marginal effects provide more accurate estimates and almost all are statistically significant at the one percent level. The first column displays controls with female characteristics, the second male characteristics, and the third family income and whether or not the family lives in an urban area. With all our variables included in the regression, the marginal effect of the interaction $Quebec_j \times 1996_t$ displays a 1.8 percent increase in the probability of having a child. This translates to an 8.6 percent implied increase in the probability of having a child.[27] When comparing this same regression with Milligan (2005)'s estimates we find similar results where the interaction term is 1.3 and the implied percentage increase is 8.7.

Table 3.5 and 3.6 shows the average marginal effect of the ANC policy on having a child from equation (1) with each panel displaying a different group of interest (i.e., income group, education level, birth parity, etc.). Each column represents the sub-sample for which a separate probit regression is estimated. The rows in each panel display the average marginal effect for the interaction term $Quebec_j \times 1996_t$, its standard error, the implied percentage increase in the probability of having a child, the probability of having a child based on a representative woman, the pseudo R-squared from the probit model, and the number of observations used in the regression. The implied percentage increase in probability of having a child is calculated by dividing the average marginal effect of the ANC policy (the interaction

being young enough to have their children living at home. The Census only accounts for the number of children present in the household, thus if we include older women we may be missing children that are no longer living at home.

[27] This calculation is based on the average marginal effect for the interaction term divided by the proportion of women that had a child in Quebec in our pre-policy period (1987-88), which was 0.207. The implied probability is calculated as follow: $\frac{1.8}{20.7} \times 100\% = 8.6\%$.

Table 3.4: Average Marginal Effect

	(a)	(b)	(c)
Quebec 1996	0.0100	0.0201	0.0178
	(0.0017)	(0.0016)	(0.0015)
Census1996	-0.0042	-0.0133	0.0020
	(0.0011)	(0.0011)	(0.0010)
Quebec	0.0024	-0.0117	0.0003
	(0.0012)	(0.0015)	(0.0014)
One older child	0.4509	0.2314	0.1560
	(0.0016)	(0.0017)	(0.0014)
Two or more older children	0.1214	-0.0358	-0.0736
	(0.0017)	(0.0013)	(0.0012)
Female: 25-34 years old		0.2864	0.1174
		(0.0009)	(0.0010)
Female: immigrant		0.0755	0.0597
		(0.0014)	(0.0014)
Female: francophone		0.1276	0.1201
		(0.0015)	(0.0017)
Female: anglophone		0.1136	0.1107
		(0.0012)	(0.0013)
Female: high school diploma		0.0018	-0.0173
		(0.0012)	(0.0011)
Female: some post-secondary		-0.0177	-0.0353
		(0.0010)	(0.0010)
Female: university degree		-0.0790	-0.0888
		(0.0012)	(0.0012)
Male: 25-34 years old			0.0822
			(0.0021)
Male: 35-44 years old			0.0466
			(0.0022)
Male: 45 and older			-0.1171
			(0.0038)
Male: immigrant			-0.0511
			(0.0012)
Male: francophone			-0.1397
			(0.0012)
Male: anglophone			-0.1203
			(0.0011)
Male: high school diploma			-0.0081
			(0.0013)
Male: some post-secondary			-0.0050
			(0.0010)
Male: university degree			0.0006
			(0.0014)
Married			0.1947
			(0.0034)
Live in urban area			-0.0277
			(0.0009)
Income			0.00018
			(0.00001)
Pseudo R-squared	0.0778	0.1789	0.2986
Number of observations	953,630	953,630	953,630

Notes: Dependent variable is Had a Child. Robust standard errors are in parenthesis. Observations are rounded to the nearest multiple of 5.

term for $Quebec_j \times 1996_t$) by the proportion of women in each sub-sample that had a child in Quebec in our pre-policy period (1987-1988). The probability of having a child based on a representative woman is calculated using the probit coefficients, and the representative woman is described in the notes section of Table 3.5 and 3.6.

Table 3.5: Average Marginal Effects of ANC On Child Birth For Selected Groups

Panel A: Subsamples by income group	Under C$19,999	C$20,000 - C$39,999	C$40,000- C$59,999	C$60,000- C$79,999	C$80,000 higher
Average marginal effect	0.0057	0.0193	0.0312	0.0233	-0.0006
(Quebec × 1996)	(0.0052)	(0.0042)	(0.0060)	(0.0129)	(0.0190)
Implied percentage increase in probability of having a child	1.6%	9.5%	13.6%	9.1%	-0.2%
Probability of having a child*	20.4%	30.2%	34.2%	34.1%	17.8%
Pseudo R-squared	0.0722	0.0654	0.0710	0.0823	0.0878
Number of observations	97,410	168,170	92,300	21,300	10,850

Panel B: Subsamples by women's education	High school dropout	High school diploma	Some post-secondary	Bachelor degree or higher
Average marginal effect	0.0117	0.0121	0.0231	0.0263
(Quebec × 1996)	(0.0065)	(0.0065)	(0.0039)	(0.0068)
Implied percentage increase in probability of having a child	5.3%	5.2%	11.7%	15.2%
Probability of having a child*	25.4%	28.6%	30.9%	33.8%
Pseudo R-squared	0.0629	0.0693	0.0740	0.1211
Number of Observations	72,545	72,775	185,170	59,540

Panel C: Subsamples by birth order	No older children	One older child	Two or more older children
Average marginal effect	0.0179	0.0127	0.0288
(Quebec × 1996)	(0.0045)	(0.0068)	(0.0050)
Implied percentage increase in probability of having a child	10.4%	3.2%	23.3%
Probability of having a child*	36.4%	42.2%	12.5%
Pseudo R-squared	0.0536	0.0215	0.0310
Number of observations	213,010	83,940	93,080

Note: Dependent variable is Had a Child. Robust standard errors are in parenthesis. Number of observations is rounded to the nearest multiple of 5.
*The probability of having a child is calculated based on a representative woman who is married, francophone, lives in an urban area in Quebec, 30-34 years old, during the policy period, and:(in Panel A)is a non-immigrant with some post-secondary education, and has no previous children;(in Panel B) is a non-immigrant with a family income between $20,000-$40,000 and has no previous children;(in Panel C)is a non-immigrant with some post-secondary education, a family income between $20,000-$40,000.

In panel A of Table 3.5 we observe a hump shape response to the ANC by income groups. Interestingly, the lowest (under C$20,000) and highest (over C$80,000) income groups'

Table 3.6: Average Marginal Effects of ANC On Child Birth For Selected Groups (continue)

Panel D: Subsamples by gender of first child			
	Son	Daughter	
Average marginal effect	0.0215	0.0042	
(Quebec × 1996)	(0.0095)	(0.0097)	
Implied percentage increase in probability of having a child	11.0%	2.1%	
Probability of having a child*	42.5%	41.8%	
Pseudo R-squared	0.021	0.0224	
Number of observations	42,990	40,950	
Panel E: Subsamples by gender composition for previous two children			
	Son & daughter	Two sons	Two daughters
Average marginal effect	0.0282	0.0356	0.0278
(Quebec × 1996)	(0.0076)	(0.0119)	(0.0125)
Implied percentage increase in probability of having a child	24.8%	24.3%	18.1%
Probability of having a child*	11.8%	15.3%	13.2%
Pseudo R-squared	0.0328	0.0281	0.0306
Number of observations	35,770	17,975	16,255
Panel F: Subsamples by immigration status			
	Non-immigrant	Immigrant	
Average marginal effect	0.0171	0.0233	
(Quebec × 1996)	(0.0030)	(0.0083)	
Implied percentage increase in probability of having a child	8.4%	9.7%	
Probability of having a child*	28.7%	31.2%	
Pseudo R-squared	0.0686	0.0560	
Number of observations	321,245	68,780	

Note: Dependent variable is Had a Child. Robust standard errors are in parenthesis. Number of observations is rounded to the nearest multiple of 5.
*The probability of having a child is calculated based on a representative woman who is married, francophone, lives in an urban area in Quebec, 30-34 years old, during the policy period, and:(in Panel D)is a non-immigrant with some post-secondary education, a family income between $20,000-$40,000, and already has two previous children;(in Panel E)has some post-secondary education, a family income between $20,000-$40,000, and has no previous children.

response is not statistically significant, and the coefficients are very small. The second lowest (C$20,000-C$40,000) and highest (C$60,000-C$80,000) income groups both have an implied 9.5 percent increase in the probability of having a child that is statistically significant. Finally, the mid-income group (C$40,000-C$60,000) has the largest response with an implied increase of almost 14 percent in the probability of having a child; this result is statistically significant at the one percent level. Figure 3.7 displays, for the representative woman in Quebec and Ontario, the difference in the estimated probability of having a first child before and after the policy is announced.[28] The solid line illustrates that prior to the policy the probability of having a child for the representative female in Quebec was much lower than in Ontario and formed a U-shape across income groups. However, once the policy is implemented, we see Quebecois women with a higher probability of having a child, and the rise is predominantly in the mid-income range.

Panel B shows the response by level of education of the women. All the results are statistically significant; however we observe that women with a high school diploma or less have a five percent increase in the implied probability of having a child due to the baby bonus and an even greater response among women with more education: the implied percentage increase is twice as great for women with some post-secondary education and three times as great for those with a bachelor's degree or higher. This is consistent with recent work that suggests highly educated women are opting for more children (see Shang and Weinberg (2013)). Moreover, the probability of having a child follows the same positive gradient across female education levels.[29]

In Panel C, we also find a large and statistically significant effect on birth order, specifically for families that already have two children: the estimates imply a twenty-three percent increase

[28] The representative female used to calculate the probability of having a child is a married non-immigrant francophone woman who is 30-34 years old, with some post-secondary education, lives in an urban area, and has no previous children. These characteristics are chosen as they are the most common female we encounter and thus make the most general comparison.

[29] Since younger women are likely to return to school, as a robustness check we estimate our specification considering only women over 25 years of age and results do not change significantly.

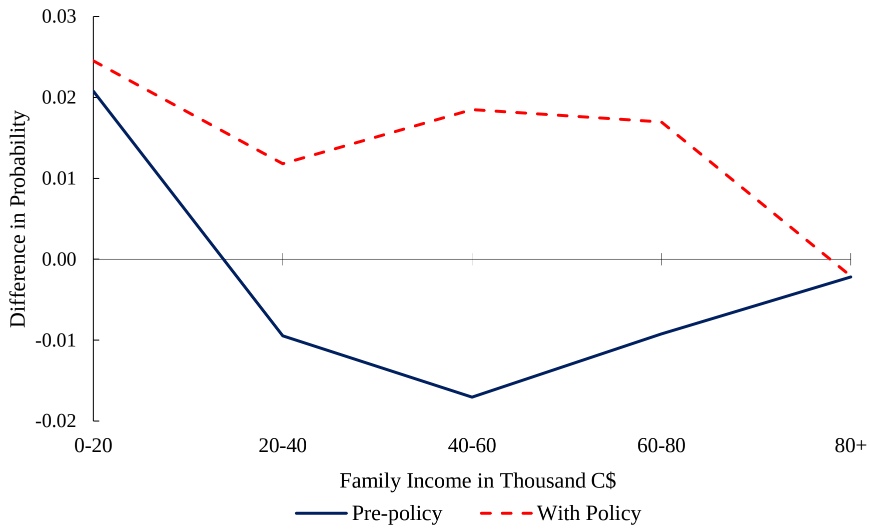

Figure 3.7: Quebec Ontario Different in Probability of Having a First Child by Income Group

Note: The values used to calculate these probabilities come from the probit model estimated for each income group separately. The representative female used to calculate the probability of having a child is a married non-immigrant francophone woman who is 30-34 years old, with some post-secondary education, lives in an urban area, and has no previous children. Due to our specification the same shape would appear for second or third and higher children with a vertical shift.

in the probability of having their third or higher child. The baby bonus also increases the implied marginal probability for first and second children by ten and three percent, respectively; however it is clear the baby bonus supported higher birth order children most by providing a very generous baby bonus ($8000 for third or higher order children). Women with a previous child have a very high probability of having a second (42.2 percent based on our representative woman), so the baby bonus was more likely to encourage third or higher birth order children.

Panel D of Table 3.6 indicates that a gender preference for sons is present. We find that there is a statistically significant effect of the ANC policy for families that already have a son, but not for those who already have a daughter. The implied percentage increase is much higher for those with a previous son, demonstrating that families with a strong preference of son and a previous daughter were planning to have another child regardless of the baby bonus, whereas families with a son were more encouraged to have another child. These results are in line with studies that find a stronger preference for sons (see Almond et al. (2013); Dahl and

Moretti (2008)). Panel E of Table 3.6 further delves into sex preference with the third child by controlling for the sex of the previous two children. We find that the baby bonus provided the same incentive to have a third child for parents with two previous sons or with a son and a daughter (by 24.3 percent and 24.8 percent respectively) but somewhat less for parents with two daughters (18.1 percent). That suggests that the baby bonus encouraged more births from parents who otherwise would have stopped at two: prior to the policy, parents with two daughters were more inclined to have a third child than parents with both a son and daughter. In Quebec during our pre-policy period (1987-1988) the percent of parents with two previous daughters that had a third child was 15 percent, whereas the percent of parents with a previous son and daughter was only 11 percent.

Finally, in Panel F of Table 3.6 we examine the response based on immigrant status. The results for both immigrant and non-immigrants are positive statistically significant at the one percent level and suggest that the immigrant response is only slightly greater. When both parents are non-immigrants there is an implied eight percent increase in the probability of having a child; when either or both are immigrants it is almost ten percent. Both have around a thirty percent likelihood of having a child.

Table 3.7 and 3.8 examine the impact of family income, mother's education, and immigrant status on the spacing of children to assess whether the baby bonus encouraged families to have their children closer together. In Panel A we find as family income increases more children are spaced closer together; the results are statistically significant. In Panel B, all the marginal effects by mother's education are positive and mostly statistically significant; that suggests that the baby bonus encouraged parents to space their children closer together. Panel C continues to show that the baby bonus affected non-immigrant and immigrant families similarly. The final row of Panel C does show a much larger implied percentage increase in the probability of non-immigrants having three or more children in five years, but it is based on relatively few observations.

Table 3.7: Average Marginal Effects of ANC on Child Spacing by Subsample

Panel A: Subsamples by income group

	Under C$19,999	C$20,000-C$39,999	C$40,000-C$59,999	C$60,000-C$79,999	C$80,000 and higher
Dependent Variable: Had 2 or more kids in 3 years					
Average marginal effect	0.0050	0.0081	0.0135	0.0152	0.0194
(Quebec × 1996)	(0.0021)	(0.0021)	(0.0033)	(0.0073)	(0.0104)
Implied percentage increase in probability	17.7%	29.0%	37.6%	37.2%	45.1%
Dependent Variable: Had 2 or more kids in 5 years					
Average marginal effect	0.0161	0.0238	0.0338	0.0417	0.0385
(Quebec × 1996)	(0.0034)	(0.0034)	(0.0052)	(0.0114)	(0.0171)
Implied percentage increase in probability	19.1%	24.5%	28.2%	28.6%	24.7%
Dependent Variable: Had 3 or more kids in 5 years					
Average marginal effect	0.0041	0.0044	0.0050	0.0127	0.0052
(Quebec × 1996)	(0.0013)	(0.0012)	(0.0019)	(0.0052)	(0.0056)
Implied percentage increase in probability	59.3%	73.9%	83.3%	141.1%	37.3%
Number of Observations	137,785	168,170	92,300	21,295	10,845

Panel B: Subsamples by women's education

	High School Dropout	High School Diploma	Some post-secondary	Bachelor degree or higher
Dependent Variable: Had 2 or more kids in 3 years				
Average marginal effect	0.0089	0.0078	0.0089	0.0052
(Quebec × 1996)	(0.0035)	(0.0033)	(0.0020)	(0.0035)
Implied percentage increase in probability	27.1%	22.2%	30.7%	18.6%
Dependent Variable: Had 2 or more kids in 5 years				
Average marginal effect	0.0040	0.0266	0.0269	0.0229
(Quebec × 19996)	(0.0055)	(0.0055)	(0.0033)	(0.0054)
Implied percentage increase in probability	3.4%	22.7%	28.7%	28.6%
Dependent Variable: Had 3 or more kids in 5 years				
Average marginal effect	0.0034	0.0041	0.0053	0.0023
(Quebec × 1996)	(0.0021)	(0.0019)	(0.0012)	(0.0017)
Implied percentage increase in probability	41.9%	51.5%	88.5%	45.8%
Number of Observations	72,540	72,780	185,165	59,540

Note: The implied percentage increase is calculated by dividing the average marginal effect from the Quebec pre-policy dependent variable by each respective subsample. Robust standard errors are in parenthesis. Number of observations is rounded to the nearest multiple of 5.

Table 3.8: Average Marginal Effects of ANC on Child Spacing by Subsample (continue)

Panel C: Subsamples by immigrant status

	Non-immigrant (both parents)	Immigrant (either or both parents)
Dependent Variable: Had 2 or more kids in 3 years		
Average marginal effect	0.0077	0.0106
(Quebec × 1996)	(0.0015)	(0.0042)
Implied percentage increase in probability	25.8%	28.6%
Dependent Variable: Had 2 or more kids in 5 years		
Average marginal effect	0.0220	0.0252
(Quebec × 1996)	(0.0025)	(0.0068)
Implied percentage increase in probability	21.8%	21.2%
Dependent Variable: Had 3 or more kids in 5 years		
Average marginal effect	0.0044	0.0040
(Quebec × 1996)	(0.0009)	(0.0023)
Implied percentage increase in probability	73.6%	44.9%
Number of Observations	321,245	68,780

Note: The implied percentage increase is calculated by dividing the average marginal effect from the Quebec pre-policy dependent variable by each respective subsample. Robust standard errors are in parenthesis. Number of observations is rounded to the nearest multiple of 5.

Using the 1991 and 2001 Censuses, Table 3.9 asks whether the ANC increased fertility and thus had a permanent effect. Panel A displays the results from a linear model where the dependent variable is the total number of children each family has. Here we see that there was a positive statistically significant effect which implied a 2.4 percent increase in the total number of children. To further examine how the ANC affected the total number of children born per family, probit models are estimated. The results in Panel B suggest that the baby bonus had a statistically insignificant and economically negligible effect on the probability of having one child and a negative effect on having two children.[30] However, the ANC policy had a positive, large, and statistically significant effect on families with three or more children. Specifically, there was a 10.2 percent increase in the probability of having a family with three or more kids due to the Quebec baby bonus.

Table 3.10 follows the same probit model as Panel B of Table 3.9 but subgroups by family income, mother's education, and immigrant status. Here again we see that the ANC was mostly statistically insignificant for one child families, has a negative coefficient on the two-child household, and had a major impact on increasing family size to three or more children.

[30]Households' response to having two children is negative since they are likely moving to a family with three children given the large cash incentive.

Table 3.9: Average Marginal Effects of ANC on Completed Fertility

Panel A: Linear Model	
Dependent Variable: Total Number of Children	
Average marginal effect (Quebec × Census2001)	0.0417
	(0.0099)
Implied percentage increase	2.4%
Number of Observations	208,560
Panel B: Probit Model	
Dependent Variable: Family Had 1 Child	
Average marginal effect (Quebec × Census2001)	0.0008
	(0.0034)
Implied percentage increase in probability	0.4%
Dependent Variable: Family Had 2 Children	
Average marginal effect (Quebec × Census2001)	-0.0176
	(0.0044)
Implied percentage increase in probability	-4.0%
Dependent Variable: Family Had 3 or more Children	
Average marginal effect (Quebec ×Census2001)	0.0208
	(0.0038)
Implied percentage increase in probability	10.2%
Number of Observations	208,560

Note: The implied percentage increase is calculated by dividing the average marginal effect from the Quebec pre-policy dependent variable. Robust standard errors are in parenthesis. Number of observations is rounded to the nearest multiple of 5.

Table 3.10: Average Marginal Effects of ANC on Number of Children by Subsample

Panel A: Subsamples by income group					
	Under C$19,999	C$20,000-C$39,999	C$40,000-C$59,999	C$60,000-C$79,999	C$80,000 higher
Dependent Variable: Family Had 1 Child					
Average marginal effect	0.0082	0.0006	-0.0062	0.0100	-0.0197
(Quebec × Census2001)	(0.0074)	(0.0061)	(0.0066)	(0.0107)	(0.0129)
Implied percentage increase in probability	3.9%	0.3%	-3.3%	5.7%	-12.2%
Dependent Variable: Family Had 2 Children					
Average marginal effect	-0.0137	-0.0189	-0.0128	-0.0370	-0.0148
(Quebec × Census2001)	(0.0091)	(0.0076)	(0.0086)	(0.0144)	(0.0177)
Implied percentage increase in probability	-3.4%	-4.2%	-2.7%	-7.8%	-3.3%
Dependent Variable: Family Had 3 or more Children					
Average marginal effect	0.0037	0.0216	0.0161	0.0375	0.0411
(Quebec × Census2001)	(0.0081)	(0.0064)	(0.0072)	(0.0123)	(0.0158)
Implied percentage increase in probability	1.7%	11.0%	8.2%	17.7%	16.3%
Number of Observations	43,920	69,020	57,830	21,900	15,350
Panel B: Subsamples by women's education					
	High School Dropout	High School Diploma	Some post-secondary	Bachelor degree or higher	
Dependent Variable: Family Had 1 Child					
Average marginal effect	0.0152	-0.0010	-0.0061	-0.0193	
(Quebec × Census2001)	(0.0084)	(0.0078)	(0.0055)	(0.0090)	
Implied percentage increase in probability	7.8%	-0.5%	-3.1%	-9.6%	
Dependent Variable: Family Had 2 Children					
Average marginal effect	-0.0502	-0.0239	-0.0111	0.0143	
(Quebec × Census2001)	(0.0108)	(0.0101)	(0.0070)	(0.0113)	
Implied percentage increase in probability	-11.2%	-5.0%	-2.4%	3.6%	
Dependent Variable: Family Had 3 or more Children					
Average marginal effect	0.0387	0.0362	0.0163	0.0373	
(Quebec × Census2001)	(0.0098)	(0.0086)	(0.0060)	(0.0091)	
Implied percentage increase in probability	16.4%	19.2%	8.2%	20.1%	
Number of Observations	35,505	40,130	84,860	35,130	
Panel C: Subsamples by immigrant status					
	Non-immigrant	Immigrant			
Dependent Variable: Family Had 1 Child					
Average marginal effect	0.0033	-0.0090			
(Quebec × Census2001)	(0.0041)	(0.0088)			
Implied percentage increase in probability	1.6%	-5.1%			
Dependent Variable: Family Had 2 Children					
Average marginal effect	-0.0202	-0.0201			
(Quebec × Census2001)	(0.0052)	(0.0115)			
Implied percentage increase in probability	-4.4%	-4.6%			
Dependent Variable: Family Had 3 or more Children					
Average marginal effect	0.0211	0.0334			
(Quebec × Census2001)	(0.0043)	(0.0103)			
Implied percentage increase in probability	10.8%	12.3%			
Number of Observations	146,450	49,170			

Note: The implied percentage increase is calculated by dividing the average marginal effect from the Quebec pre-policy dependent variable by each respective subsample. Robust standard errors are in parenthesis. Number of observations is rounded to the nearest multiple of 5.

3.5.2 Sensitivity Analysis

In Table 3.11 we use equation (2), the triple difference model, as a robustness check to examine the heterogeneous responses we find for different income groups, education groups and birth order in the difference-in-differences model. We find the hump shape response by income group still emerges, and that mid-income women respond the most to the policy, whereas high-income women respond the least compared to the lowest income bracket. Specifically, Quebecois women with a family income in the C$40,000-C$59,999 range respond 2.5 percent more to the policy as compared to other Quebecois women with family income below C$20,000. This estimate is statistically significant at the one percent level. We find that Quebecois women with two previous children are 1.2 percent more likely to respond to the baby bonus compared to those with no previous children. This result matches well with the average marginal effects in 3.5 Panel C where the difference in the marginal effects between two older children and no older children is one percent.

As a second robustness check we estimate the same specification using a linear probability model instead of a probit model; we find similar results.[31] As a third robustness check we re-estimate Table 3.5 and 3.6 without controlling for male characteristics since, as a consequence of assortative mating, they may be highly correlated with income and the female's characteristics. The exclusion of spousal characteristics does not alter our findings. These estimates can be found in the Appendix section under Table 3.12. Fourth, we use 1984 and 1985 from the 1986 census file as our control group, instead of 1987 and 1988 from the 1991 census file. The results, found in Table 3.13, are substantially unchanged qualitatively, but exact estimates do vary because of the substantial decline in fertility in the mid-1980s. For example, we find the same hump shape by income but it is shifted up because the new control group (1984-1985) had fewer children, thereby creating a larger difference from the treatment group (1994-1995).

[31]Linear probability models allow for negative probabilities, as opposed to probit models, which keep probability estimates between zero and one.

Fifth, to minimize the cultural dissimilarity between our treated and control group, we conduct the two following exercises. First, we estimate our model using only households living near the border of the two provinces and find Table 3.14 results are qualitatively similar.[32] Second, we estimate our model using New Brunswick as the comparison province instead of Ontario. New Brunswick has the second highest number of French speaking people after Quebec, and the official languages of New Brunswick are English and French. Results are reported in Table 3.15.

We re-estimate Table 3.5 and 3.6 with a three-year and five-year window inside and outside the policy to ensure our two-year window from all previous regressions is reliable. In the three-year window (Table 3.16) we use 1986 to 1988 as the pre-policy window and 1993 to 1995 as the within-policy window. For the five-year window (Table 3.17) we examine 1984 to 1988 versus 1991 to 1995. Qualitatively the results are the same and statistically significant with the same hump shape response in income, as well as the same heterogeneous responses in education and parity. Since immigrants may respond differently to the baby bonus, we exclude them from the sample and re-estimate the model. The results are shown in Table 3.18. In Table 3.19, we limit the sample to only females aged 25-34 since females younger than 25 are likely still in school. We find the response is weaker at the margin, but is consistent with our birth CDF findings shown in Figure 3.6; more females gave birth at younger ages under the ANC policy. These robustness checks confirm that the baby bonus did create heterogeneous responses among women.

[32] The sample size drops to 90,000 households. Also, Quebec has almost 4 times the number of observations than Ontario. Thus, this is not our preferred specification. The CMAs we selected are: Temiskming Shores, North Bay, Petawawa, Pembroke, Hawkesbury, Cornwall, Rouyn-Noranda, Lachute, Salaberry-de-Valleyfield, Val-d'Or, and Amos.

3.6 Conclusion

When examining the heterogeneous response of the ANC by income group, we find a hump shape result that is robust to many different specifications. Interestingly, Becker and Tomes (1976) model a U-shaped path for the desired number of children as income rises. This model predicts that a negative exogenous shock in the price of children would have low-income mothers spend extra income on children they already have rather than having more children. Moreover, the amount of the transfer may not be enough for high income individuals to be induced to have another child. Mid-income families are most responsive to financial incentives on fertility.

When we examine the impact of the ANC on fertility by birth order we find a strong increase in the probability of having a third child or higher. We are aware that these results are due to the specific payment structure of the ANC. From May 1992 until the cancellation of the policy in September 1997, the transfer payments were C$500 for the first child, C$1,000 for the second, and C$8,000 for the third child or higher. Had the payment structure provided a constant amount regardless of parity, we believe estimates for third or higher parity children would not be as large. The Quebec government continuously increased the transfer payment for third or higher children, from C3, 000*toC*8,000, demonstrating that they were also aware that families with two children already present in the household require a larger income transfer to induce them to have a third child.

North American parents prefer to have one-of-each gender, with a secondary preference for sons (Williamson, 1983). Interestingly, parents with two previous sons, or a previous son and daughter, were more inclined to have a third child after the ANC was implemented. This illustrates that parents who were more likely to stop at two children were successfully encouraged by the ANC to have another child. These results provide strong evidence to suggest that Quebec's baby bonus did in fact accomplish its goal of increasing fertility.

The heterogeneous responses we find suggest that baby bonuses do work. Pro-natalist policies can encourage household births by targeting the subgroups whose fertility decisions are highly responsive to cash incentives. Mid-income families seem poised to take advantage of a baby bonus, and if structured strategically pro-natalist policies can increase higher parity births. We are able to observe the completed fertility rates of many cohorts that were exposed to the ANC. We see that, in addition to a transitory effect where women were having their children earlier, there was also an increase in completed fertility of women aged 15 to 39, illustrating that the pro-natalist policy does have a permanent effect on fertility in Quebec. Pro-natalist policies, if structured correctly, could cost-effectively increase fertility and alleviate the immense concern of below-replacement rates for developed nations.

3.7 References

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3.8 Appendix

Table 3.11: Average Marginal Effects from Triple Interactions

By income group		*By birth order*	
Quebec×Census1996×UnderC$20,000	ref.	Quebec×Census1996×No older children	ref.
Quebec×Census1996×C$20,000-39,999	0.0150	Quebec×Census1996×One older child	-0.0009
	(0.0071)		(0.0078)
Quebec×Census1996×C$40,000-59,999	0.0254	Quebec×Census1996×Two or more children	0.0118
	(0.0084)		(0.0059)
Quebec×Census1996×C$60,000-79,999	0.0193		
	(0.0146)		
Quebec×Census1996×OverC$80,000	-0.0053		
	(.0206)		
Pseudo R-squared	0.0664	Pseudo R-squared	0.0680
Number of Observations	390,025	Number of Observations	390,025

Note: Dependent variable is Had a Child. Robust standard errors are in parenthesis. The number of observations is rounded to the nearest multiple of 5.

Table 3.12: Average Marginal Effects of ANC on Child Birth- Excluding Male Characteristics

Panel A: Subsamples by income group	Under C$19,999	C$20,000-C$39,999	C$40,000-C$59,999	C$60,000-C$79,999	C$80,000 higher
Average marginal effect	0.0050	0.0168	0.0294	0.0222	-0.0055
(Quebec × 1996)	(0.0052)	(0.0042)	(0.0060)	(0.0130)	(0.0190)
Number of observations	97,410	168,170	92,300	21,300	10,850

Panel B: Subsamples by women's education	High school dropout	High school diploma	Some post-secondary	Bachelor degree or higher
Average marginal effect	0.0103	0.0106	0.0218	0.0256
(Quebec × 1996)	(0.0066)	(0.0065)	(0.0039)	(0.0067)
Number of Observations	72,545	72,775	185,170	59,540

Panel C: Subsamples by birth order	No older children	One older child	Two or more older children
Average marginal effect	0.0165	0.0112	0.0305
(Quebec × 1996)	(0.0038)	(0.0068)	(0.0049)
Number of observations	213,010	83,940	93,080

Panel D: Subsamples by immigration status	Non-immigrant	Immigrant
Average marginal effect	0.0161	0.0220
(Quebec × 1996)	(0.0030)	(0.0083)
Number of observations	321,250	68,780

Note: Dependent variable is Had a Child. Robust standard errors are in parenthesis. Number of observations is rounded to the nearest multiple of 5.

Table 3.13: Average Marginal Effects of ANC on Child Birth- 84 to 85 vs. 94 to 95

Panel A: Subsamples by income group

	Under C$19,999	C$20,000-C$39,999	C$40,000-C$59,999	C$60,000-C$79,999	C$80,000 higher
Average marginal effect	0.0128	0.0225	0.0386	0.0518	0.0020
(Quebec × 1996)	(0.0053)	(0.0042)	(0.0058)	(0.0129)	(0.0194)
Number of observations	100,650	168,310	98,630	21,080	10,080

Panel B: Subsamples by women's education

	High school dropout	High school diploma	Some post-secondary	Bachelor degree or higher
Average marginal effect	0.0079	0.0345	0.01894	0.0420
(Quebec × 1996)	(0.0062)	(0.0064)	(0.0041)	(0.0077)
Number of Observations	89,370	78,480	176,670	55,290

Panel C: Subsamples by birth order

	No older children	One older child	Two or more older children
Average marginal effect	0.0286	0.0284	0.0195
(Quebec × 1996)	(0.0041)	(0.0065)	(0.0043)
Number of observations	187,900	93,420	118,480

Panel D: Subsamples by immigration status

	Non-immigrant	Immigrant
Average marginal effect	0.0259	0.0179
(Quebec × 1996)	(0.0030)	(0.0081)
Number of observations	324,220	74,530

Note: Dependent variable is Had a Child. Robust standard errors are in parenthesis. Number of observations is rounded to the nearest multiple of 5.

Table 3.14: Average Marginal Effects of ANC on Child Birth – Border Cities

Panel A: Subsamples by income group

	Under C$19,999	C$20,000-C$39,999	C$40,000-C$59,999	C$60,000-C$79,999	C$80,000 higher
Average marginal effect	-0.0019	0.02891	0.0305	-0.0021	0.0066
(Quebec × 1996)	(0.0123)	(0.0099)	(0.0133)	(0.0268)	(0.0392)
Number of observations	25,610	43,730	23,390	5,780	2,780

Panel B: Subsamples by women's education

	High school dropout	High school diploma	Some post-secondary	Bachelor degree or higher
Average marginal effect	0.0031	0.0016	0.0260	0.0334
(Quebec × 1996)	(0.0189)	(0.0160)	(0.0091)	(0.0131)
Number of Observations	15,570	17,710	48,890	19,130

Panel C: Subsamples by birth order

	No older children	One older child	Two or more older children
Average marginal effect	0.0257	0.0084	0.0189
(Quebec × 1996)	(0.0084)	(0.0166)	(0.0113)
Number of observations	60,230	21,290	19,780

Panel D: Subsamples by immigration status

	Non-immigrant	Immigrant
Average marginal effect	0.0236	0.0054
(Quebec × 1996)	(0.0069)	(0.0164)
Number of observations	85,770	15,520

Note: Dependent variable is Had a Child. Robust standard errors are in parenthesis. Number of observations is rounded to the nearest multiple of 5.

Table 3.15: Average Marginal Effects of ANC on Child Birth- Québec vs. New Brunswick

Panel A: Subsamples by income group

	Under C$19,999	C$20,000-C$39,999	C$40,000-C$59,999	C$60,000-C$79,999	C$80,000 higher
Average marginal effect	0.0464	0.0380	0.0752	0.0639	0.0038
(Quebec × 1996)	(0.0098)	(0.0099)	(0.0178)	(0.0446)	(0.0602)
Number of observations	57,560	83,430	36,090	7,580	3,610

Panel B: Subsamples by women's education

	High school dropout	High school diploma	Some post-secondary	Bachelor degree or higher
Average marginal effect	0.0522	0.0209	0.0593	0.0310
(Quebec × 1996)	(0.0137)	(0.0141)	(0.0097)	(0.0188)
Number of Observations	36,840	34,530	90,650	26,250

Panel C: Subsamples by birth order

	No older children	One older child	Two or more older children
Average marginal effect	0.0277	0.0537	0.0253
(Quebec × 1996)	(0.0098)	(0.0154)	(0.0085)
Number of observations	103,860	41,280	43,140

Panel D: Subsamples by immigration status

	Non-immigrant	Immigrant
Average marginal effect	0.0469	0.0223
(Quebec × 1996)	(0.0066)	(0.0288)
Number of observations	173,250	15,020

Note: Dependent variable is Had a Child. Robust standard errors are in parenthesis. Number of observations is rounded to the nearest multiple of 5.

Table 3.16: Average Marginal Effects of ANC on Child Birth – 1986 to 1988 vs 1993 to 1995

Panel A: Subsamples by income group

	Under C$19,999	C$20,000- C$39,999	C$40,000- C$59,999	C$60,000- C$79,999	C$80,000 higher
Average marginal effect	0.0128	0.0263	0.0336	0.0330	0.0122
(Quebec × 1996)	(0.0056)	(0.0045)	(0.0064)	(0.0136)	(0.0197)
Number of observations	97,410	168,170	92,300	21,300	10,850

Panel B: Subsamples by women's education

	High school dropout	High school diploma	Some post-secondary	Bachelor degree or higher
Average marginal effect	0.0077	0.0189	0.0285	0.0347
(Quebec × 1996)	(0.0070)	(0.0070)	(0.0042)	(0.0071)
Number of Observations	72,545	72,775	185,170	59,540

Panel C: Subsamples by birth order

	No older children	One older child	Two or more older children
Average marginal effect	0.0226	0.0135	0.0417
(Quebec × 1996)	(0.0038)	(0.0070)	(0.0063)
Number of observations	236,050	78,240	75,740

Panel D: Subsamples by immigration status

	Non-immigrant	Immigrant
Average marginal effect	0.0218	0.0248
(Quebec × 1996)	(0.0032)	(0.0088)
Number of observations	321,250	68,780

Note: Dependent variable is Had a Child. Robust standard errors are in parenthesis. Number of observations is rounded to the nearest multiple of 5.

Table 3.17: Average Marginal Effects of ANC on Child Birth- 1984 to 1988 vs 1991 to 1995

Panel A: Subsamples by income group	Under C$19,999	C$20,000-C$39,999	C$40,000-C$59,999	C$60,000-C$79,999	C$80,000 higher
Average marginal effect	0.0137	0.0324	0.0497	0.0593	0.0450
(Quebec × 1996)	(0.0060)	(0.0047)	(0.0065)	(0.0137)	(0.0195)
Number of observations	97,410	168,170	92,300	21,300	10,850

Panel B: Subsamples by women's education	High school dropout	High school diploma	Some post-secondary	Bachelor degree or higher
Average marginal effect	0.0223	0.0344	0.0245	0.0423
(Quebec × 1996)	(0.0072)	(0.0072)	(0.0044)	(0.0075)
Number of Observations	72,545	72,775	185,170	59,540

Panel C: Subsamples by birth order	No older children	One older child	Two or more older children
Average marginal effect	0.0266	0.0239	0.0633
(Quebec × 1996)	(0.0038)	(0.0067)	(0.0077)
Number of observations	258,920	71,230	59,880

Panel D: Subsamples by immigration status	Non-immigrant	Immigrant
Average marginal effect	0.0311	0.0341
(Quebec × 1996)	(0.0033)	(0.0090)
Number of observations	321,250	68,780

Note: Dependent variable is Had a Child. Robust standard errors are in parenthesis. Number of observations is rounded to the nearest multiple of 5.

Table 3.18: Average Marginal Effects of ANC on Child Birth – Excluding Immigrants

Panel A: Subsamples by income group					
	Under C$19,999	C$20,000-C$39,999	C$40,000-C$59,999	C$60,000-C$79,999	C$80,000 higher
Average marginal effect	0.0033	0.0136	0.0319	0.0265	-0.0227
(Quebec × 1996)	(0.0058)	(0.0045)	(0.0065)	(0.0140)	(0.0210)
Number of observations	79,710	140,000	76,130	17,010	8,390

Panel B: Subsamples by women's education				
	High school dropout	High school diploma	Some post-secondary	Bachelor degree or higher
Average marginal effect	0.0070	0.0111	0.0192	0.0236
(Quebec × 1996)	(0.0071)	(0.0070)	(0.0043)	(0.0075)
Number of Observations	59,550	60,680	154,090	46,930

Panel C: Subsamples by birth order			
	No older children	One older child	Two or more older children
Average marginal effect	0.0161	0.0149	0.0239
(Quebec × 1996)	(0.0041)	(0.0075)	(0.0053)
Number of observations	179,000	67,400	74,840

Note: Dependent variable is Had a Child. Robust standard errors are in parenthesis. Number of observations is rounded to the nearest multiple of 5.

Table 3.19: Average Marginal Effects of ANC on Child Birth – Female aged 25 to 34

Panel A: Subsamples by income group

	Under C$19,999	C$20,000-C$39,999	C$40,000-C$59,999	C$60,000-C$79,999	C$80,000 higher
Average marginal effect	0.0078	0.0116	0.0284	0.0204	-0.0069
(Quebec × 1996)	(0.0062)	(0.0046)	(0.0062)	(0.0132)	(0.0194)
Number of observations	72,400	143,310	86,420	20,480	10,510

Panel B: Subsamples by women's education

	High school dropout	High school diploma	Some post-secondary	Bachelor degree or higher
Average marginal effect	-0.0003	0.0193	0.0166	0.0260
(Quebec × 1996)	(0.0071)	(0.0070)	(0.0044)	(0.0072)
Number of Observations	68,680	68,240	167,450	58,140

Panel C: Subsamples by birth order

	No older children	One older child	Two or more older children
Average marginal effect	0.0125	0.0106	0.0285
(Quebec × 1996)	(0.0045)	(0.0070)	(0.0050)
Number of observations	162,670	78,860	91,590

Panel D: Subsamples by immigration status

	Non-immigrant	Immigrant
Average marginal effect	0.0135	0.0201
(Quebec × 1996)	(0.0033)	(0.0088)
Number of observations	270,810	62,310

Note: Dependent variable is Had a Child. Robust standard errors are in parenthesis. Number of observations is rounded to the nearest multiple of 5.

Conclusion

Understanding how society makes choices is the essential part of applied economics. This thesis shows the explanatory power of economics in various settings. Chapter 1 explains the Great Trade Collapse by allowing firms to choose how much to invest in the home or foreign market. Chapter 2 examines the sub-optimal policy among some developing countries by allowing policymaker to choose between the size of rent and the risk of staying in power. Chapter 3 studies the heterogeneous effects of a pro-natalist policy in Quebec where we find people responded to the policy as it can reduce the cost of having a child.

Chapter 1 explains the unusual collapse in trade during the Great Recession during 2008 to 2009. The trade to GDP ratio fell more than 31% from the peak to the trough. A standard international business cycle model predicts small movements in total trade that are not significantly different from GDP. Thus, the behaviour of trade during this recession was unusual not only in its severity relative to past episodes but is also puzzling. We contribute to the existing literature by using a real two-country business cycle model with relationship capital and credit shocks to generate a size-able collapse in trade that explains roughly 44 percent of the fall in the trade-GDP ratio seen in the data. In the model, firm build a long-term enduring relationships between costumers. Also, there is a cost differential between marketing expenses to acquire supply-chain relationships in the home market relative to abroad. These key features of the model contribute to trade moving more than GDP. Given the financial crisis happened during the same period, we focus on its effect on the trade to

GDP ratio. First, a tightening in credit creates a drop in demand for the product of firms. These firms respond by switching scarce resources from the foreign country to the home country. This happens because of the cost differential. As a result, cross-border trade drops more than domestic trade, leading to a large movement in the trade-GDP ratio.

Chapter 2 studies international productivity differences, which is an important component to explain the divergent growth paths among low-income countries. In the model firms are born with different technology adoption abilities, and they choose a production technology according to their profitability to adopt or not to adopt the frontier technology. Changes in the property rights structure can alter firms' behaviour. Policymaker determines the level of intellectual property rights enforcement. Firms with different preferences of the IPR enforcement would influence the policymaker to have the policy in favour of them. More specifically, as a collective unit, the non-frontier firms can oppose stricter protection by supporting the opponents. Since non-frontier firms are not as competitive in the market, they protect their profit by supporting the incumbent's political opposition when the level of enforcement is not in their favour. The policymaker, as a rent-seeker, wants to maximize lifetime rent and may choose a low-productivity state that allows he/she to stay in power for a longer period. The other choice would be that policymaker earn a bigger per-period rent but having higher chance to lose power. Such interaction determines the path of economic performance through the choice of IPR enforcement. The model features multiple equilibria and can be interpreted as path-dependent. That is, if an economy starts at a low state, it is likely to stay there, and vice versa. The model shows that the strength of institutions, market fundamentals and the substitutability of goods matter, and that countries with a weaker ability to adopt technology are more likely to converge to the low productivity state.

Chapter 3 examines the heterogeneous response of the ANC by income group, we find a hump shape result that is robust to many different specifications. The result is in line with Becker's quantity and quality model where the household makes trade-off between wages, having children and also the quality of children (e.g., education, etc.). This model predicts that lowering the price of children would have low-income mothers spend extra income on children they already have rather than having more children. Moreover, the amount of the transfer may not be enough for high-income individuals to be induced to have another child. In other words, the baby bonus contributes a small percentage increase in income for those households. Mid-income families are most responsive to financial incentives on fertility. Using the Census Masterfile, we find households response to the cash-incentive. This suggests that baby bonuses do work. In particular, when we examine the impact of the Allowance for Newborn Children on fertility by birth parity, we find a strong increase in the probability of having a third child or more. These results are due to the specific payment structure of the ANC, where the cash transfer is at least double for having a third child compare to that of having their first and second children. These findings suggest that pro-natalist policies, if structured correctly, could cost-effectively increase fertility and alleviate the immense concern of below-replacement rates for developed nations. Mid-income families seem poised to take advantage of a baby bonus, and if structured strategically pro-natalist policies can increase higher parity births. Also, we observe an increase in completed fertility rates of the cohorts exposed to the ANC during the prime age of having child. Interestingly, parents with two previous sons, or a previous son and daughter, were more inclined to have a third child after the ANC was implemented. The result illustrates that parents who were more likely to stop at two children were successfully encouraged by the ANC to have another child, as having two sons could satisfy some households with son preference. These results provide some evidence to suggest that Quebec's baby bonus accomplished its goal of increasing fertility.