FINANCIAL MARKET PARTICIPATION AND BUSINESS CYCLES IN TURKEY

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ABSTRACT

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Thesis Supervisor: Assoc. Prof. Inci Gumus

Keywords: Small open economy, Business cycles, Financial development

This study examines the effect of limited financial participation on business cycle characteristics of emerging market economies using the model of Özbilgin (2010), where the standard small open economy business cycle model is extended to include heterogeneous agents that are differentiated by their ability to borrow and accumulate capital. First, I document that developing countries have less financial market participation than advanced economies. I then calibrate this model to the Turkish economy and analyze the effect of changes in the level of financial inclusion on business cycle characteristics. The results show that having higher financial inclusion, similar to the levels of advanced economies, results in higher consumption smoothing and lower countercyclicality of the trade balance. I also extend the model by adding interest rate shocks and show that the combined model matches business cycle statistics better than the limited participation model.

ÖZET

TÜRKİYE'DE FİNANSAL PİYASALARA KATILIM VE REEL İKTİSADİ DALGALANMALAR

SERTAN ÖZSOY

EKONOMİ YÜKSEK LİSANS TEZİ, MAYIS 2021

Tez Danışmanı: Doç. Dr. İNCİ GÜMÜŞ

Anahtar Kelimeler: Küçük dışa açık ekonomi, Reel iktisadi dalgalanmalar, Finansal gelişim

Bu çalışma finansal piyasalara sınırlı katılımın, gelişmekte olan piyasa ekonomilerinin iş çevrimi karakteristiklerine etkilerini incelemektedir. Çalışmada, standart küçük ekonomi iş çevrimi modelinin Özbilgin (2010) tarafından sınırlı finansal katılım içerecek şekilde genişletilmiş hali kullanılmaktadır. Sınırlı finansal katılım modeli, borç alma ve sermaye biriktirme kabiliyetleri açısından farklılaşmış heterojen ajanlar içermektedir. Çalışmada öncelikle finansal piyasalara katılımın gelişmekte olan ülkelerde, gelişmiş ülkelere oranla daha az olduğu gösterilmiştir. Daha sonra model Türkiye için kalibre edilip finansal katılımdaki değişikliklerin iş çevrimi karakteristiklerine etkileri incelenmiştir. Modelin sonuçları artan finansal katılımın hem tüketimdeki dalgalanmaların hem de dış ticaret dengesinin konjonktüre karşı hareketinin azalmasına yol açtığını göstermektedir. Ayrıca model, faiz oranı şokları eklenerek genişletilmiş ve bileşik modelin reel iktisadi dalgalanma niteliklerini sınırlı katılım modelinden daha iyi açıkladığı gösterilmiştir.

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Lastly, I would like to thank my friends and my family for their support.

To my family

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GHH Greenwood–Hercowitz–Huffman 13

TFP Total Factor Productivity 16, 17, 18, 32

1. INTRODUCTION

Business cycle characteristics of emerging market economies are different from advanced economies in certain aspects. Starting with Mendoza (1991), the small open economy business cycle literature has aimed to explain these business cycle features. Part of the literature tried to explain these by considering different shocks for emerging economies like trend shocks (Aguiar and Gopinath 2007), interest rate shocks (Neumeyer and Perri 2005; Uribe and Yue 2006), terms of trade shocks (Kose 2002; Mendoza 1995), or movement in commodity prices (Shousha 2016). Another strand of literature focuses on financial frictions in explaining these differences (Fernández and Gulan 2015; Garcia-Cicco, Pancrazi, and Uribe 2010). Financial frictions have been analyzed in relation to overborrowing (Bianchi 2011; Uribe 2006) and sovereign default (Roldán-Peña 2012). Within this literature, Özbilgin (2010) analyzes the implications of limited participation in financial markets by incorporating agents with different levels of financial access into a standard small open economy model. This paper follows Özbilgin (2010) framework to address a similar question for the Turkish economy.

Cross-country data show that financial inclusion levels differ significantly across countries at different income levels. According to Demirguc-Kunt et al. (2018), 94 percent of adults have an account at a financial institution or with a mobile-money-service provider in high-income economies whereas 63 % do in developing economies. Allen et al. (2016) reports that account ownership disparity persists among developing economies and adults in low-income economies are three times less likely to have an account as adults in upper-middle-income countries. They also document that national income explains 73 percent of the variation in the country-level percentage of adults with a formal account around the world. They add that correlation is much slimmer for the bottom 50% of the country-level income distribution of their sample. In Section 2, I will analyze the financial access statistics with an emphasis on the difference between developed and developing economies. These statistics show the disparity between countries at different income levels in terms of financial access. If we distinguish between financial inclusion for firm owners

and consumers, the gap between developed and developing[1] countries is even more significant for consumers while there is still a significant gap on the firm owner side[2].

In order to analyze the effects of financial market access on business cycles, Özbilgin (2010) considers a model that consists of heterogeneous agents differentiated by their ability to borrow and accumulate capital. In particular, there are three types of households. First, a type of household can borrow/lend in international financial markets and accumulate capital, which are standard features in representative agent models. The second type of household can borrow/lend but can not accumulate capital. These households have access to financial markets but are not involved in entrepreneurial activities. Lastly, there is another type of household that cannot borrow/lend and cannot accumulate capital. These households are bound to consume their income generated by their wage. Özbilgin (2010) calibrates his model to an average developing country by using data averages of low and middle income countries according to World Bank. Özbilgin's model improves the explanation of business cycle characteristics on two fronts: high volatility of consumption and high negative correlation between trade balance and output. Then, to find the effects of financial integration, Özbilgin uses a counterfactual analysis where more households have financial access. Results indicate that higher financial integration leads to higher investment and output volatility.

I use the same model as Özbilgin (2010) and calibrate this model to the Turkish economy since it is a standard emerging market economy considering both the business cycle characteristics and the level of financial inclusion. The business cycle statistics of Turkey make it a standard emerging market economy since it displays high output volatility, more consumption volatility than its output, and countercyclicality of net exports (Aguiar and Gopinath 2006; Neumeyer and Perri 2005). Table 5.1 presents Turkey's business cycle properties. Evidence in Section 2.3 shows that Turkey is also similar to other emerging market economies considering financial inclusion.

I calibrate the model to Turkey for the period from the first quarter of 1998 to the third quarter of 2019. I use the Global Findex Database from World Bank to calculate the household ratios with different financial access. Relative to the standard model, the model with limited financial access improves the matching of business cycle statistics of several variables: consumption volatility, trade balance volatility, and consumption-output correlation. Impulse response analysis shows

[1] In this paper, low and middle income countries are called "developing countries" and high income countries are called "developed countries" following Özbilgin (2010).

[2] See Figure 2.2

the negative correlation of the trade balance is caused by the sharp changes in the asset position of households that accumulate capital. It also indicates that consumption smoothing behavior is higher in less constrained households which explains the higher consumption volatility relative to the standard model. Another contribution of this paper is documenting the effect of financial development on the differences of business cycle characteristic in developing and developed economies. I conduct a counterfactual analysis by increasing the percentage of households with financial access and firm owners to the levels of the developed economies. The results indicate that financial development causes lower consumption volatility and smaller countercyclicality of the trade balance-to-output ratio.

Further, this paper inspects the relation between country-specific interest rate shocks and limited financial market access. The effect of interest rate shocks differs from the standard model as it only affects the households with financial access. Both extensions to the standard model significantly improves the matching of the moments in different aspects and the combined model explains the moments with higher accuracy.

Section 2 documents empirical evidence for limited financial participation across countries with different income levels and in Turkey. The model is introduced in Section 3. In section 4, calibration is discussed. Section 5 presents the results for the benchmark model in comparison to a standard small open economy model. The effects of higher financial market access on business cycle statistics are analyzed in section 6. Section 7 extends the model with interest rate shocks and Section 8 concludes.

2. FINANCIAL INCLUSION AND ECONOMIC DEVELOPMENT

2.1 Cross Country Evidence

This section evaluates financial inclusion in developing countries and compares them to advanced economies using annual data for the period 2004-2018 from the IMF's Financial Access Survey. In addition, since the division between financial access for entrepreneurs and consumers is lacking in this dataset, I also use survey microdata from the years 2011, 2014, and 2017 from World Bank's Global Findex Database for distinguishing between financial access for entrepreneurs and consumers.

Figure 2.1 shows the median values of some financial access indicators for countries at different income levels for an overall sample of 110 countries. These financial access indicators are as follows: number of ATMs (per 100,000 adults), number of commercial bank branches (per 100,000 adults)[1], number of borrowers from commercial banks (per 1,000 adults) from Financial Access survey of IMF, and account ownership at a financial institution or with a mobile-money-service provider (% of population ages 15+) from the Global Findex Database of World Bank, which is only available for years 2011, 2014 and 2017. These indicators overall show that there are important differences in terms of financial inclusion between countries at different income levels, and financial inclusion increases with income level. Even though financial inclusion increased globally over the years, the increase happened mainly in middle-income and high-income countries. The low-income economies still suffer from low financial inclusion.

[1]ATM numbers and commercial bank branches are proxies for financial inclusion since demand for these services come only from those who are financially included.

[2]Data on "Borrowers from commercial banks" are not available for the high income group.

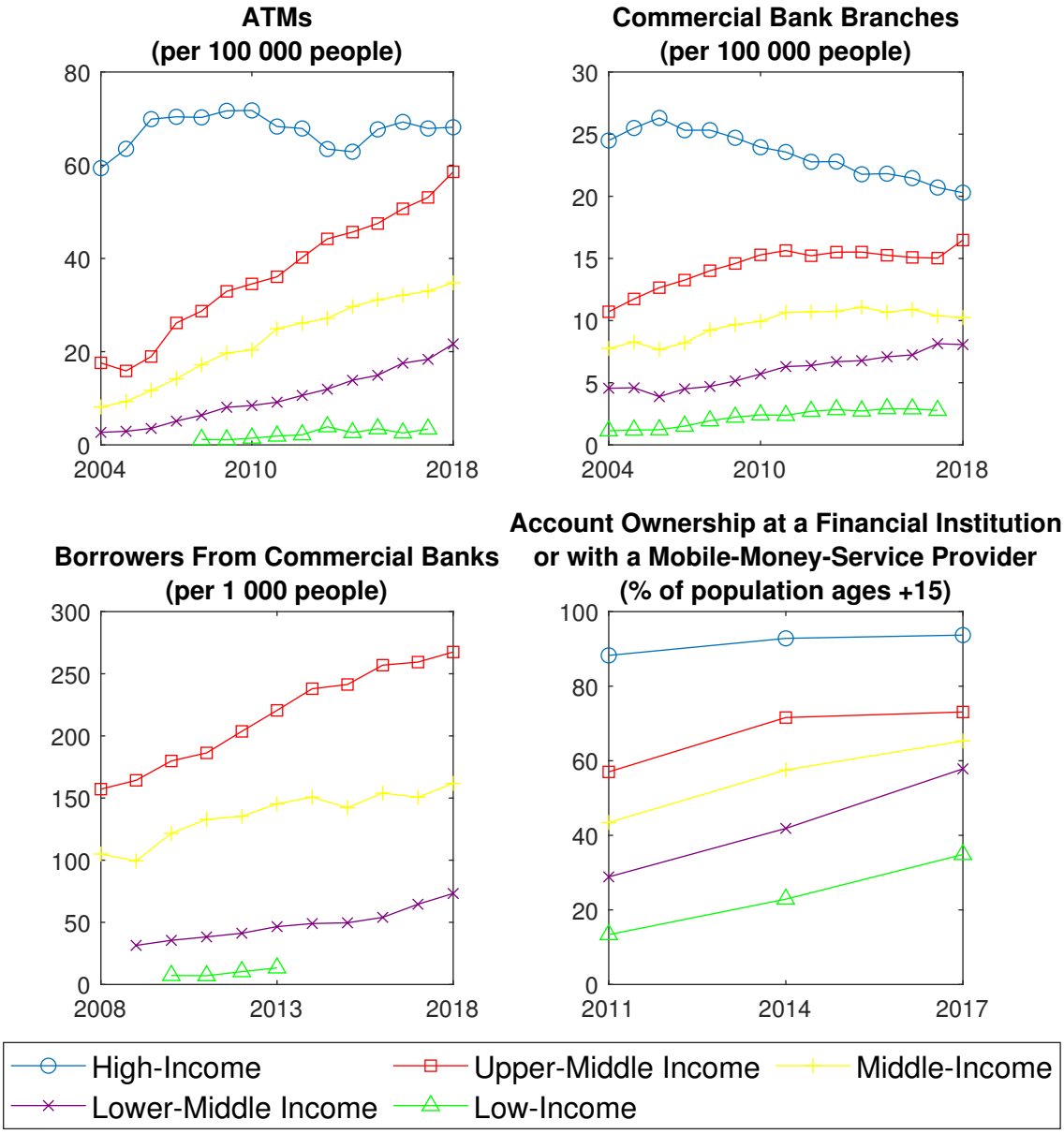

Figure 2.1 Financial inclusion by income levels[2]

Source: Number of ATMs (per 100,000 adults), number of commercial bank branches (per 100,000 adults), number of borrowers from commercial banks (per 1,000 adults) are from Financial Access survey of IMF and account ownership at a financial institution or with a mobile-money-service provider (% of population ages 15+) is from the Global Findex Database of World Bank.

2.2 New Financial Inclusion Proxies

In this section, I use Global Findex survey data for years 2014 and 2017 to construct and present new financial inclusion indicators, which will divide the population into three groups by their ability to access capital and financial services: the percentage of firm owners who hold capital and have financial access, the percentage of financially integrated consumers who do not hold capital but have financial access, and the percentage of rule-of-thumb consumers who do not have financial access, thus can only consume their current income. This categorization is aimed to represent the agents in the model with different levels of financial access. I group the questions used in the Global Findex survey into these three categories and construct financial inclusion indicators that represent these three levels of financial access. The details are given in Appendix A. These indicators use individual-level information and therefore, may capture information that is not available in the aggregate data. The questions used in the survey allow us to distinguish between financial access at the firm owner and consumer levels, which will be used to calibrate the model later.

Table 2.1 shows the correlations of proposed indicators with the indicators used in Figure 2.1. New financial indicators are in line with the previous ones. The correlations between the rule-of-thumb consumer and three of the four previously used indicators are below -0.65. Rule-of-thumb consumers reflect the same information with previous ones since both rule-of-thumb consumers and previously used financial indicators divide the population into two by their ability in financial access. The other newly proposed indicators take into account the ability to hold capital which is relevant to the model. However, the distinction about holding capital is not captured by the previous indicators, which is why there is a more mixed pattern in terms of the correlations. Still, the correlations for these two indicators are positive as expected.

Table 2.1 The correlations of proposed financial inclusion proxies with the indicators from aggregate data

	FI1	FI2	FI3	FI4
Firm owner	0.5	0.05	0.41	0.64
Financially integrated consumer	0.64	0.4	0.77	0.84
Rule-of-thumb consumer	-0.66	-0.35	-0.76	-0.87

Notes: Financial indicators(FI) are as follows: number of ATMs (per 100,000 adults), number of commercial bank branches (per 100,000 adults), number of borrowers from commercial banks (per 1,000 adults), account ownership at a financial institution or with a mobile-money-service provider (% of population ages 15+). Correlations are calculated using 2017 data and maximum number of available countries (ranges from 75 to 142). Firm owners, financially integrated consumers and rule-of thumb consumers are author's calculations. See Appendix A for details.

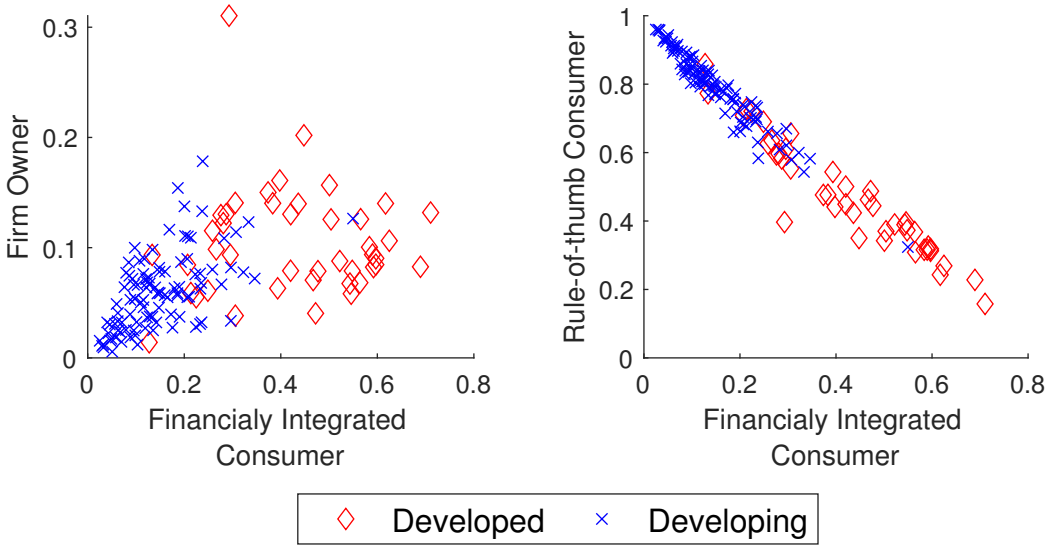

Figure 2.2 Cross-sectional analysis of financial inclusion by income level

Source: Author's calculations based on the Global Findex Database. See Appendix A for details.

Figure 2.2 compares these new indicators by the income levels. As expected, financial access is lower in developing countries. As the country's income increases, the fraction of people who do not have financial access decreases. Financial access for consumers positively correlates with financial access for entrepreneurs. On the left scatterplot, the percentages for both firm owners and consumers in nearly all developing countries are below 20%. On the right scatterplot, it is seen that there is a high negative correlation between percentage of rule-of-thumb consumers and percentage of financially integrated consumers whereas there seems to be a more moderate correlation between percentage of firm owners and percentage of financially integrated consumers. These results are in line with the literature. Campbell and Mankiw (1991) estimate that the percentage of rule-of-thumb consumers is 35% in the US and 20% in the UK. According to a 2004 Survey of Consumer Finances, 80% of US households and 75% of Japanese households do not own stocks. Further, Guiso, Haliassos, and Jappelli (2003) estimate that several developed European countries have even smaller ratios.

2.3 Financial Inclusion In Turkey

This section analyses financial inclusion in Turkey and documents that Turkey is similar to other emerging markets in terms of financial inclusion. Figure 2.3 shows the financial inclusion indicators used in Section 2.2 for Turkey and a group of emerging market economies.

For all three graphs, Korea's values seem like outliers since it achieves much greater financial inclusion than the rest of the emerging markets. If we exclude Korea, the financial inclusion levels for Turkey are at similar levels as the other emerging markets in the sample. The account ownership ratio for Turkey is about the average of the sample for all years. The same is true for financial access ratios on the firm owner side and consumer side.

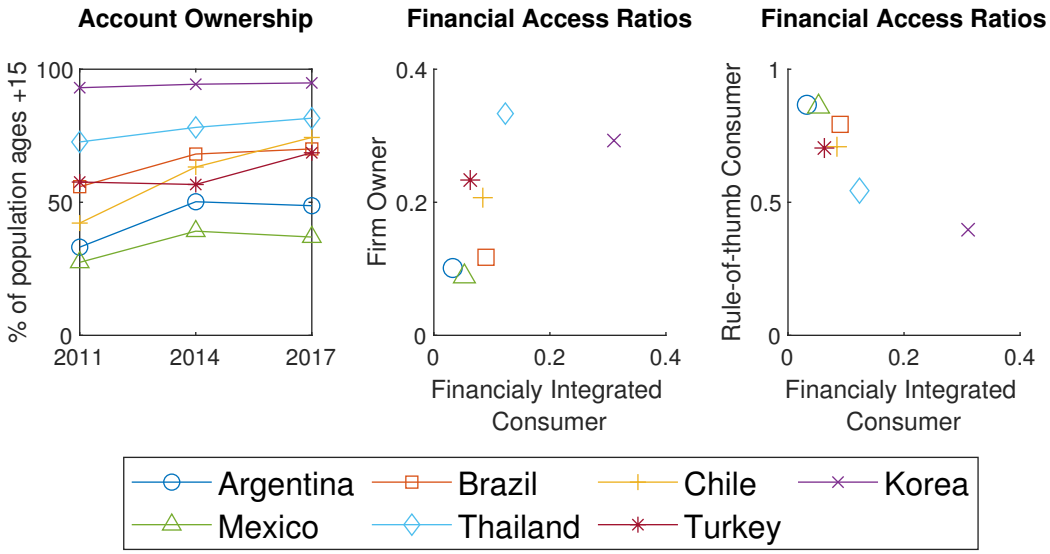

Figure 2.3 Financial indicators for Turkey and other emerging markets

Source: Account ownership is from Global Findex Database. Financial access ratios are author's calculations based on the Global Findex Database. See Appendix A for details.

3. MODEL

I use a small open economy real business cycle model extended to include heterogeneous agents and limited participation, following Özbilgin (2010). There are three types of agents: Type-A agents own capital and have access to global financial markets, type-B agents cannot own capital but have access to global financial markets and type-C agents cannot own capital and do not have access to global financial markets. The fraction of households are λ_A, λ_B, λ_C for type-A, type-B, and type-C agents, respectively; and they are fixed across time. Type-A and type-B agents only trade non-contingent one-period real bonds in international financial markets. All households provide labor to firms.

3.1 Households

All households maximize the following utility function by choosing consumption, labor and, if they are able, investment and debt positions. Expected utility is given by

$$E_0 \sum_{n=1}^{\infty} \beta^t U_j(c_{j,t}, n_{j,t}), \quad j = A, B, C \tag{3.1}$$

where j denotes the types of agents, β represents the discount factor, n represents labor and c is consumption in period t.

Budget constraint for type-A, type-B and type-C agents are as follows:

$$c_{A,t} + i_t + (1 + r_{A,t}) b_{A,t} = w_t n_{A,t} + q_t k_t + b_{A,t+1} \tag{3.2a}$$

$$c_{B,t} + (1 + r_{B,t}) b_{B,t} = w_t n_{B,t} + b_{B,t+1} \tag{3.2b}$$

$$c_{C,t} = w_t n_{B,t} \tag{3.2c}$$

where $b_{j,t+1}$ denotes debt position at the end of period t and i_t represents investment. The variables w and q are wage rate and rental rate of capital, respectively. They are determined in the aggregate economy, and all agents are price takers.

Law of motion for capital is given by:

$$i_t = k_{t+1} - (1 - \delta) k_t + \Phi(k_{t+1} - k_t) \tag{3.3}$$

where k_t is capital holding to be used in period t, δ is the depreciation rate and Φ is the capital adjustment cost function. It is a convex function added to the model to ensure realistic volatility of investment.

$r_{j,t}$ is the interest rate for debt maturing in period t. The method used from Schmitt-Grohé and Uribe (2003) to induce stationarity requires that each agent's interest rate is different.

$$r_{j,t} = \bar{r} + p(\zeta_{j,t} - \bar{\zeta}), \quad j = A, B \tag{3.4}$$

where $\bar{r}$ denotes the world real interest rate, which is exogenously given and $p(\zeta_{j,t} - \bar{\zeta})$ is the risk premium function. It punishes the deviation of agent's solvency indicator from its steady state level. I follow Özbilgin (2010) and assume that each type's debt holding relative to the income equals their solvency indicators.

$$\zeta_{A,t} = \frac{b_{A,t}}{q_t k_t + w_t n_{A,t}} \tag{3.5a}$$

$$\zeta_{B,t} = \frac{b_{B,t}}{w_t n_{B,t}} \tag{3.5b}$$

Following transversality conditions must also hold to ensure optimality.

$$\lim_{t\to\infty} \beta^t E_0[\Theta_{A,t} k_{t+1}] = 0 \tag{3.6a}$$

$$\lim_{t\to\infty} \beta^t E_0[\Theta_{j,t} b_{t+1}] = 0, \quad j = A, B \tag{3.6b}$$

where $\Theta_{j,t}$ is the marginal utility from wealth at time t for agent j.

3.2 Aggregate Economy

The aggregate economy consists of type-A, type-B, and type-C households.

Aggregate consumption C_t^{agg} is the sum of consumption in the economy at time t.

$$C_t^{agg} = \lambda_A c_{A,t} + \lambda_B c_{B,t} + (1 - \lambda_A - \lambda_B) c_{C,t} \tag{3.7}$$

Aggregate labor N_t^{agg} is the sum of labor at time t.

$$N_t^{agg} = \lambda_A n_{A,t} + \lambda_B n_{B,t} + (1 - \lambda_A - \lambda_B) n_{C,t} \tag{3.8}$$

Aggregate capital at time t, K_t^{agg}, is fraction of type-A households multiplied by type-A household's capital.

$$K_t^{agg} = \lambda_A k_t \tag{3.9}$$

Aggregate investment at time t is I_t^{agg}

$$I_t^{agg} = \lambda_A i_t \tag{3.10}$$

Total foreign asset position is denoted by B_t^{agg}

$$B_t^{agg} = \lambda_A b_{A,t} + \lambda_B b_{B,t} \tag{3.11}$$

The economy-wide resource constraint is

$$TB_t = Y_t - C^t_{agg} - I^{agg}_t \tag{3.12}$$

where Y_t is total production. Consequently, the law of motion for asset positions could be written as following:

$$TB_t = \sum_{j=A,B} \lambda_i(1+r_{j,t})B_{j,t} - \sum_{j=A,B} \lambda_j B_{j,t+1} \tag{3.13}$$

3.3 Firms

Firms' problem is to maximize profits. Profit is given by

$$Y_t - q_t K^{agg}_t - w_t N^{agg}_t \tag{3.14}$$

Total production is as follows

$$Y_t = e^{A_t} F(K^{agg}_t, N^{agg}_t) \tag{3.15}$$

where A is an exogenously given stochastic total productivity shock and F(.) is the production function.

3.4 Equilibrium

Given initial conditions $b_{A,0}$, $b_{B,0}$, k_0, and the sequence of total factor productivity shocks, the competitive equilibrium for this economy is defined as a set of allocations and prices [$n_{A,t}$, $n_{B,t}$, $n_{C,t}$, N^{agg}_t, k_t, K^{agg}_t, i_t, I^{agg}_t, $c_{A,t}$, $c_{B,t}$, $c_{C,t}$, C^{agg}_t, $b^{A,t}$, $b^{B,t}$, B^{agg}_t, q_t, w_t] such that (i) allocations solve the problems of the households and the firm at the equilibrium prices and (ii) factor markets clear.

3.5 Parametrization

In this section, I will assign functional forms to the model.

All households have GHH preferences.

$$U_j(c_{j,t}, n_{j,t}) = \frac{(c_{j,t} - \frac{(n_{j,t})^{\omega}}{\omega})^{\gamma}}{1-\gamma}, \quad j = A, B, C \tag{3.16}$$

γ is the risk aversion parameter, and ω is the intertemporal elasticity of substitution in labor.

The capital adjustment cost function for type-A household is as follows:

$$\Phi(k_{t+1} - k_t) = (\frac{\phi}{2})(k_{t+1} - k_t)^2, \quad \phi > 0 \tag{3.17}$$

In the model, ϕ is set to match the volatility of investment.

The risk premium function takes the form:

$$p(\zeta_{j,t} - \bar{\zeta}) = \psi_j(e^{\zeta_{j,t} - \bar{\zeta}} - 1), \quad \psi_j > 0, \quad j = A, B \tag{3.18}$$

ψ_j is going to be calibrated to induce stationary with minimal effect to model dynamics.

The production function is Cobb-Douglas:

$$F(K_t^{agg}, N_t^{agg}) = (K_t^{agg})^{\alpha}(N_t^{agg})^{1-\alpha} \tag{3.19}$$

where α determines the importance of capital in production relative to labor.

Total factor productivity is modelled using an AR(1) process, that is,

$$A_t = \rho^A A_{t-1} + \varepsilon^A \tag{3.20}$$

where ε^A is normally distributed and serially uncorrelated errors.

4. CALIBRATION

I calibrate the model to Turkey using data from 1998Q1 to 2019Q3. The data sources and details about the construction of the series used in calibration are given in Appendix A. For some parameters, I use values from the literature. In the rest of the analysis, model 1 refers to the standard small open economy real business cycle model, model 2 is the limited participation model, model 3 is the small open economy real business cycle model with interest rate shocks and model 4 is the limited participation model with interest rate shocks. Details for models with interest rate shocks are given in Section 7.

The relative risk aversion coefficient, γ, is set to 2 for all agents, which is a standard value used in the real business cycle literature. Following Mendoza (1991), I set the intertemporal elasticity of substitution out of disutility from labor effort, ω, to 1.455. The quarterly depreciation rate, δ, is set to 0.02. Share of capital input, α, is set to 0.32 following the previous literature. The coefficients for risk premium functions, ψ_A and ψ_B, are set to a small number 10^{-5}.

Turkey's real interest rate series is constructed using the method by Neumeyer and Perri (2005). The mean value of the quarterly real interest rate in Turkey, which corresponds to $\bar{r}$ in the model, equals 0.976%. The discount factor, β , is set to $1/(1+\bar{r})$. The capital adjustment cost parameter, ϕ, is set to match the relative volatility of investment-to-output. The economy-wide capital adjustment cost remains the same for all models[1]. In order to match the mean trade balance-to-output ratio of -18% in the steady state, $\bar{\zeta}$ is calibrated to -1.935 in the standard model and to -3.792 in the limited participation model.

Extending the standard small open economy model to the limited participation model brings additional parameters that need to be calibrated. These parameters, λ_A, λ_B and λ_C, capture how the economy is divided from the financial access perspective. Özbilgin (2010) calibrates his model to an average developing economy and sets the values for the fractions of the agents using proxies from the litera-

[1]See Appendix B for the proof.

ture (Guiso, Sapienza, and Zingales 2008; Pereira 2011). I use the Global Findex database as discussed in Section 2 to find the percentage of people that resembles the agents in the theoretical model for Turkey. λ_A is set to the average percentage of firm owners, 5%, and λ_B is set to the average percentage of consumers with financial access, 23%, which gives λ_c=72%.

Total factor productivity shocks are estimated as an AR(1) using HP filtered Solow residual series. Calculating the Solow residual requires data on total hours worked and capital stock. Total hours worked series is calculated as the product of employment and average hours worked. The capital stock series is constructed using the perpetual inventory method following (Young 1995).

For models with interest rate shocks, Turkey's quarterly real interest rate series mentioned above is used. The interest rate shock series for the risk-free interest rate and Turkey's risk premium is calculated following Neumeyer and Perri (2005). For country risk premiums I follow Tiryaki (2012) and model them as a function of productivity shocks with serially correlated errors. The gross world interest rate is set to 1.0023%, the average US real interest rate for the calibration period. Because years after great recession yield negative real interest rates, the average US real interest rate is close to 0 for the calibration period. To add working capital to the model, percentage of the wage paid in advance, θ, is set to 41% following Tiryaki (2012).

Table 4.1 Parameter Values.

Parameter	Description	Value			
Parameters that remain unchanged for all models					
γ	Risk aversion parameter	2			
ω	Intertemporal elasticity of substitution in labor supply	1.455			
δ	Rate of depreciation	0.02			
α	Share of capital stock	0.32			
$\bar{tb}/\bar{Y}$	Steady state trade balance-to-output ratio	-1.89%			
ρ^A	Persistence of TFP shock	0.627			
$\sigma(\varepsilon^A)$	Standard deviation of TFP shock	0.016			
Parameters that change across models		Model (1)	Model (2)	Model (3)	Model (4)
λ_A	Fraction of type-A households	100%	5%	100%	5%
λ_B	Fraction of type-B households	0%	23%	0%	23%
λ_C	Fraction of type-C households	0%	72%	0%	72%
$\bar{\zeta}$	Solvency ratio	-1.935	-3.792	-1.935	-3.792
ϕ	Capital adjustment coefficient	4.09^{-03}	2.04^{-04}	4.46^{-03}	1.88^{-04}
ψ_A	Coefficient of risk premium function (standard model) or for type-A households(limited participation model)	1.00^{-05}	1.00^{-05}	1.00^{-05}	1.00^{-05}
ψ_B	Coefficient of risk premium function for type-B households	-	1.00^{-05}	-	1.00^{-05}
$\bar{r}$	Steady state interest rate	0.976%	0.976%	-	-
$\bar{R}$	Steady state gross world interest rate	-	-	1.0023%	1.0023%
β	Discount factor	0.96	0.96	0.99	0.99
θ	Ratio of wage bill paid in advance	-	-	0.41	0.41
ρ^{R^*}	Persistence of world interest rate shock	-	-	0.901	0.901
$\sigma(\varepsilon^{R^*})$	Standard deviation of world interest rate shock	-	-	1.60^{-05}	1.60^{-05}
ρ^D	Persistence of risk premium shock	-	-	-0.082	-0.082
ρ^u	Persistence of error of risk premium shock	-	-	0.600	0.600
$\sigma(\varepsilon^u)$	Standard deviation of error of risk premium shock	-	-	0.002	0.002

Notes: Model 1 is the standard small open economy real business cycle model. Model 2 is the limited participation model. Model 3 is the small open economy real business cycle model with interest rate shocks. Model 4 is the limited participation model with interest rate shocks.

5. RESULTS

5.1 Impulse Response Analysis

Figure 5.1 presents the impulse responses to a 1% TFP shock. It shows the reactions of different households, if applicable, and the aggregate economy.

Once the 1% TFP shock happens, total output is increased by 2%. Even though output is increased by 2%, it does not homogeneously affect households' income. Type-B and type-C households benefit from a 0.6% increase in wage but type-A households benefit from wage increase as well as a 2% increase in the rental rate of capital. Due to the functional form of the risk premium, each household has an optimal debt proportional to their income. Holding more debt than the optimal one will cost the household as increased interest rate and holding less debt will decrease their risk premium by only small amount; thus, it will yield a higher opportunity cost. Thus, an increase in their income moves their optimal debt to a higher percentage. This could be interpreted as an increase in household creditworthiness in the eyes of foreign lenders.

Type-B households directly increase their asset positions to benefit from their higher income bearing the cost of interest rate risk premium. In contrast, type-A households decrease their asset position to increase their capital investments. When the rental rate of capital is increased with TFP shock, holding more capital, consequently, investing is a more desirable option compared to asset position. Initially, investing in asset positions is not a desired for type-A households compared to type-B households since capital with increased rental rate gives better returns. As the opportunity cost of capital fades, the tradeoff between foreign investment and capital investment, moves in favor of former option. Thus, type-A households increase their asset position.

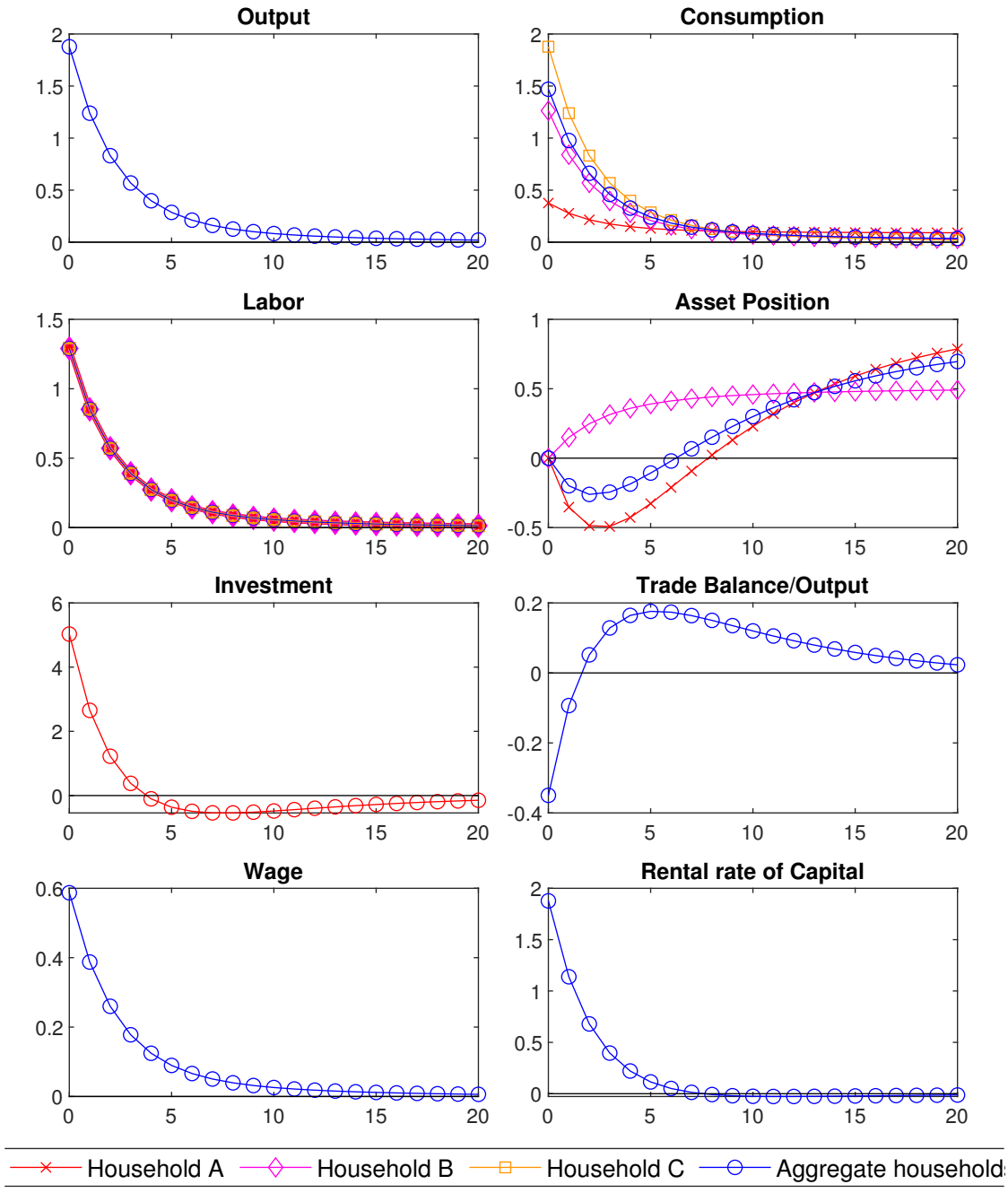

Figure 5.1 Positive shock to TFP: percent deviation of variables from their steady-state values

All households increase their consumption due to the increase in their total income but with different magnitudes. Opportunity cost of increasing consumption is higher for type-A households thus they increase their consumption the least. For type-B households opportunity cost is smaller than type-A households, thus they increase their consumption more than type-A. Since there are no investment options for type-C, opportunity cost is zero; thus, they increase their consumption with all their new income.

Type-A households borrow from international markets to invest in initial periods causing trade balance to decrease. Another interpretation is that they import machines as a form of capital. After the initial investment, type-A households as well as type-B households export more and invest in foreign assets, causing the trade balance to become higher.

The labor response is the same for all agents. Firms do not distinguish between labor from different households. Hence, there is no heterogeneity in offered wages. Also, due to the utility function, households do not consider their wealth when deciding on their labor. Therefore, only wage changes affect labor decisions and a 0.6 % increase in the wage rate increases labor by 1.3% regardless of the household type.

5.2 Business Cycle Statistics

I will evaluate the limited participation model using (1) its ability to match the business cycle characteristics of Turkey and (2) whether it improves on the standard small open economy real business cycle model calibrated to the same period. The models are log linearized around the steady-state. HP-filtered results are reported for all business cycle statistics. Different calibration values required to match the steady-state trade balance-to-income ratio and relative volatility of investment to output are given in Table 4.1.

The standard small open economy model does a good job of matching the output volatility. The correlations of investment and consumption with output are slightly higher than the data. However, it can not match the high consumption volatility and it generates a countercyclical trade balance that is much weaker compared to the data. The limited participation model performs better than the standard model to match the volatilities of consumption and trade balance but the volatilities are still lower than the data. It also generates a higher countercyclicality for the

Table 5.1 Business cycle statistics.

	Data	Standard model	Limited participation
Standard deviations			
$\sigma(Y)$	3.43	3.30	3.30
$\sigma(C)/\sigma(Y)$	1.01	0.60	0.78
$\sigma(I)/\sigma(Y)$	2.71	2.71	2.71
$\sigma(\frac{TB}{Y})/\sigma(Y)$	0.57	0.16	0.23
Correlations			
$\rho(C,Y)$	0.89	1.00	1.00
$\rho(I,Y)$	0.84	0.96	0.96
$\rho(\frac{TB}{Y},Y)$	-0.55	-0.12	-0.72

Notes: Trade balance (TB) is exports minus imports. Output (Y), consumption (C) and investment (I) are in logs. Data series are seasonally adjusted and all series are HP filtered. Standard deviations are reported as percentages. Data values are author's calculations. See Appendix A for data sources.

trade balance. Both models generate the same output volatility and correlations of consumption-output and investment-output.

The relative volatility of consumption increases by nearly 30% from 0.6 in the standard model to 0.78 in the limited participation model. This increase is due to lack of consumption smoothing by type-C households. Type-C households consume all of their income; thus, their consumption volatility equals volatility of output. Also, type-B households' lack of investment alternatives results in their consumption being more correlated with output.

The volatility of trade balance-to-output ratio changes in the right direction but still does not match the empirical moment. The relative volatility value for the trade balance in the limited participation model, 0.23, is closer to the observed moment, 0.57, compared to the standard model, 0.16. However, there is still a gap between the limited participation model and data. When a smaller fraction of households have access to capital markets, per firm owner households' share in investment to get to optimal capital is more. Thus, they borrow more to invest. Also, since per firm owner households' share in optimal capital is more than standard model, their capital income is more. Thus, after the opportunity cost of capital fades, they increase their asset position more. These more drastic changes cause a less smooth asset position.

This effect carries out in the reasoning why the limited participation model achieves a higher countercyclicality of the trade balance-to-output ratio than the standard model. Increasing asset position with the positive shock is more drastic in the limited participation model compared to the standard model. Also, Özbilgin (2010) explains this phenomenon in the limited participation model using lower capital adjustment cost parameter required to match the investment volatility of the data. It enables

agents to invest more in the same period with less capital adjustment cost, making borrowing for investing more preferable.

6. EFFECTS OF FINANCIAL DEVELOPMENT IN TURKEY

To inspect the effects of financial development in terms of financial access, business cycle statistics for economies with higher percentages of firm owners and consumers are presented in Table 6.1. Increased percentages for firm owners and financially integrated consumers are set to the average and highest levels of the high-income country sample from Section 2. Since higher financial participation is a trait of developed countries, in this analysis, increasing financial market participation is thought to represent moving from being an developing country to a developed country. In this interpretation, counterfactual experiment inspects whether financial integration plays an integral part in differences of business cycle facts between developing countries and developed countries.

In all of the analyses, the capital adjustment cost parameter is changed to match the volatility of investment but as explained in Appendix B this will coincide with keeping the economy-wide capital adjustment cost the same. As expected, only changes in type-A household fraction require an adjustment to match the investment. Since type-B households cannot invest, and interest rates are set exogenously, this type does not influence investment. Further, the relative volatility of the investment is proportional to capital adjustment cost per type-A household. Designing this experiment with fixed investment volatility lets us inspect the effects of an increase in financial access where economy-wide costs remain the same.

Only three properties change significantly with improved financial access: relative volatility of consumption, the relative volatility of trade balance-to-output ratio, and trade balance-output correlation. These changes are in the expected direction in explaining the business cycle differences between emerging countries and developed countries.

Consumption volatility decreases with financial integration. With more people having access to borrowing/lending and accumulating capital, there is a higher level of consumption smoothing. Thus, the volatility of consumption goes down.

Countercyclicality of trade balance-to-output ratio decreases and becomes acyclical

in the most extreme case. When financial integration levels reach the levels of developed countries, trade balance-to-output correlation results get closer to values found in the literature for the developed countries. (Uribe and Schmitt-Grohé 2017).

There is also a small but persistent decrease in trade balance-to-output volatility. Since the initial level was also small, changes are significant if we look at the values relative to the initial level. The other moments remain unchanged.

Table 6.1 Business cycle statistics by the changes in financial access.

	Data	Limited participation			
		λ_A	λ_B=0.23	λ_B=0.43	λ_B=0.7
$\sigma(Y)$	3.43	0.05	3.30	3.30	3.30
		0.1	3.30	3.30	3.30
		0.3	3.30	3.30	3.30
$\sigma(C)/\sigma(Y)$	1.01	0.05	0.78	0.73	0.65
		0.1	0.77	0.71	0.64
		0.3	0.71	0.66	0.58
$\sigma(I)/\sigma(Y)$	2.71	0.05	2.71	2.71	2.71
		0.1	2.71	2.71	2.71
		0.3	2.71	2.71	2.71
$\sigma(\frac{TB}{Y})/\sigma(Y)$	0.57	0.05	0.23	0.20	0.17
		0.1	0.22	0.19	0.17
		0.3	0.19	0.17	0.16
$\rho(C,Y)$	0.89	0.05	1.00	1.00	1.00
		0.1	1.00	1.00	1.00
		0.3	1.00	1.00	1.00
$\rho(I,Y)$	0.84	0.05	0.96	0.96	0.96
		0.1	0.96	0.96	0.96
		0.3	0.96	0.96	0.96
$\rho(\frac{TB}{Y},Y)$	-0.55	0.05	-0.72	-0.60	-0.35
		0.1	-0.70	-0.57	-0.28
		0.3	-0.57	-0.37	-0.01

Notes: See the notes in Table 5.1 for the definitions of the variables and description of how statistics are computed.

7. LIMITED FINANCIAL PARTICIPATION AND INTEREST RATE SHOCKS

This section will compare the effects of interest rate shocks in explaining business cycle characteristics of emerging economies using both the standard and the limited participation models. Both models are extended to include interest rate shocks following Neumeyer and Perri (2005).

7.1 Changes In The Model

To extend the model to include interest rate shocks, the model explained in Section 3 is changed on two fronts. First, a working capital constraint is added. Firms need to pay a fraction, θ, of the wage before the production; thus, they borrow from the international markets and bear the cost of borrowing. Since type-A agents are the firm owners, I assume that firm borrowing is made at their interest rate. New profit function for the firms is given by

$$Y_t - q_t K_t^{agg} - w_t N_t^{agg} - r_{A,t-1}\theta w_t N_t^{agg} \tag{7.1}$$

The other required change is in the functional form of gross interest rate.

$$1 + r_{j,t} = \bar{R} e^{R_t^*} e^{D_t} + \psi_j (e^{\zeta_{j,t} - \bar{\zeta}}), \quad j = A, B \tag{7.2}$$

where e^{R^*} is the deviation from the steady-state world interest rate and e^D is the country risk premium. I keep the extra small risk premium from solvency to induce stationarity.

The world interest rate is modelled as an AR(1) process.

$$R_t^* = \rho^{R^*} R_{t-1}^* + \varepsilon^{R^*}, \quad \varepsilon^{R_t^*} \overset{i.i.d.}{\sim} \mathcal{N}(0, \sigma(\varepsilon^{R_t^*})^2)\,. \tag{7.3}$$

I follow Tiryaki (2012) and model the country risk premium as a function of total factor productivity with errors that follow an AR(1) process.

$$D_t = \rho^d A_t + u_t \tag{7.4a}$$

$$u_t = \rho^u u_{t-1} + \varepsilon_t^u, \quad \varepsilon_t^u \overset{i.i.d.}{\sim} \mathcal{N}(0, \sigma(\varepsilon^u)^2)\,. \tag{7.4b}$$

The parameter values for the models with interest rate shocks are given in Table 4.1.

7.2 Business Cycle Statistics

Table 7.1 The effects of interest rate shocks

	Data	Standard model	Limited participation	Interest rate shocks	Limited participation + Interest rate shocks
Standard deviations					
$\sigma(Y)$	3.43	3.30	3.30	3.26	3.28
$\sigma(C)/\sigma(Y)$	1.01	0.60	0.78	0.70	0.93
$\sigma(I)/\sigma(Y)$	2.71	2.71	2.71	2.71	2.71
$\sigma(\frac{TB}{Y})/\sigma(Y)$	0.57	0.16	0.23	0.54	0.71
Correlations					
$\rho(C,Y)$	0.89	1.00	1.00	1.00	1.00
$\rho(I,Y)$	0.84	0.96	0.96	0.80	0.78
$\rho(\frac{TB}{Y},Y)$	-0.55	-0.12	-0.72	-0.30	-0.46

Notes: See the notes in Table 5.1 for the definitions of the variables and description of how statistics are computed.

In Table 7.1, columns 1-3 show the results from Table 5.1 for comparison purposes. Column 4 shows the results for the standard model with the addition of interest rate shocks and the last column shows the results for the limited participation model with the interest rate shocks.

As discussed in Section 5, the limited participation model performs better than the standard model in all fronts. Also, the addition of the interest rate shocks

improves the performance of the standard model. The model with interest rate shocks matches the relative volatility of the trade balance quite closely. Compared to the standard model, it also generates a higher volatility of consumption and a higher countercyclicality of the trade balance. However, in terms of its ability to match the data these values are still lower.

The addition of limited participation leads to an improvement in matching these moments. The models with the limited participation have the highest volatility of consumption. Even though interest rate shocks affect the desirability of borrowing; thus, affect the consumption smoothing behavior of the agents, these fluctuations are not enough to match the volatility of consumption in the data. Stricter limitations to borrowing and elimination of consumption smoothing through limited access is required to generate a higher consumption volatility. Since in the limited participation case, type-A agents change their asset position more drastically as discussed in Section 5, the addition of interest rate shocks further intensifies borrowing cost fluctuations. It should be noted that even the combined model cannot generate the volatility of consumption being higher than the volatility of output. This result is in line with the results of Özbilgin (2010) and Tiryaki (2012) where financial friction of limited access and interest rate shocks could not simulate this behavior for average developing country and Turkey, respectively. Whereas, Neumeyer and Perri (2005) calibrates the model with interest rate shocks to Argentina and documents this behavior.

The correlation of output with the trade balance-to-output ratio also improves with limited participation. Adding only limited participation generates a higher countercyclicality, albeit too high. The addition of interest rate shocks to the limited participation model moderates this behavior and generates the best match with the data.

The model with interest rate shocks generates near a perfect match of the data in terms of volatility of trade balance-to-output ratio and investment-output correlation. On these two moments, combined model performs worse than model with just interest rate shocks albeit not much. Overall, the addition of interest rate shocks provides an improvement on the limited participation model on every front.

8. CONCLUSION

The effects of having limited financial access on business cycle characteristics in an emerging market economy are analyzed in this paper. First, it is documented that emerging markets have limited financial access using cross-country evidence. Then, new financial participation parameters are introduced, which differentiates financial access for consumers and firm owners. Cross-country evidence with these parameters also suggests that high-income countries have significantly higher participation on both ends.

I then use a small open economy real business cycle model with limited participation following Özbilgin (2010) to analyze the implications of limited financial access. It extends a standard small open economy model where households are grouped into three categories: households with no financial access, households with financial access to borrowing/lending, and households that can borrow/lend and hold capital. The model is calibrated to Turkey and evaluated using impulse response analysis and its ability to match business cycle statistics. Impulse response analysis suggests the negative correlation between trade balance and output is caused mainly by households with full financial access. The impulse responses also show that households who have higher financial access can smooth their consumption better.

Then, the effect of changes in financial access on business cycle characteristics is inspected. Access to financial access for firm owners and consumers are differentiated. The results show that increasing financial participation causes lower volatility of consumption and lower countercyclicality of trade balance, which are two critical business cycle statistics in emerging markets. Thus, it follows that financial access is an essential factor to consider when explaining the differences in business cycle characteristics between emerging market economies and advanced economies.

I then analyze the effect of interest rate shocks on the standard model and the limited participation model. Both interest rate shocks and limited financial access have a part in explaining the business cycle characteristics of an emerging market. The combination of interest rate and limited participation model gives very close

moments to data. Improvement on both of these fronts, financial access and financial depth, are necessary to achieve proper financial development for emerging countries.

One limitation of this paper is the lack of financial access data for extended periods of time. The data used in this paper is available for only two years and using data for a longer time period could have improved the accuracy of the results.

This paper contributes to the literature by evaluating the performance of the limited participation model by calibrating it to Turkey. Despite its limitations, the paper also suggests an alternative way to calibrate the household fraction parameters for the limited participation model. It also contributes to the literature by analyzing the effects of different levels of financial development on business cycles.

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APPENDIX A

Cross-country data

Data for Figure 2.1 comes from the World Bank Financial development indicators database. This database uses IMF's Financial Access Survey from 2004 to 2018 and World Bank income level groups to aggregate for the first three indicators. The fourth indicator is the aggregation of the World Bank's Global Findex survey results for 2011, 2014, and 2017. For Table 2.1, previously used financial indicators are the above data unaggregated for their income group. For the rest of the cross-country statistics, I used the Global Findex Database to create new indicators. Global Findex database is a survey conducted in over 140 economies. For every country, the survey is conducted on 1000 adults. While the main questions remain the same, the survey questions change and get more detailed as it iterates. I used 2014 and 2017 microdata to partition the population since they are the years with necessary detail. I used weighted ratios to find partitions where weights are provided by the World Bank and are representative of respondent's representation in that particular countries' demographic. Final fractions are average values of partitions from the years 2014 and 2017. Fraction of people (weighted) who either saved or borrowed money past year to start, operate, or grow a business and use financial institutions (not necessarily exclusively) is used for estimating firm owners. Fraction of people(weighted) who either saved or borrowed money and uses financial institutions (not necessarily exclusively) is used to estimate the financially integrated part of population, thus, the total of firm owners and financially integrated consumers. The rest of the population is used for estimating the rule-of-thumb of the consumer.

Turkish business cycle statistics data

Data used for calculating business cycle characteristics 1998q1 to 2019q3 from Turkstat. HP filtered per capita series are used for calculating business cycle moments.

GDP: GDP series with 2009 prices. Investment: Gross fixed capital formation at 2009 prices.

Consumption: Final consumption expenditure of households at 2009 prices.

Trade balance: Exports minus imports of goods and services.

Population: Yearly population is extrapolated linearly to quarterly to create quarterly population.

Total factor productivity series construction

TFP series are calculated using the following functional form:

$$A_t = \log Y_t - \alpha \log K_t - (1-\alpha)\log(l_t) \tag{A.1}$$

where Y is output, K is capital stock, and l is total hours worked. A series is then HP filtered.

Output series: The series are calendar and seasonally adjusted GDP series with 2009 prices.

Capital stock: Capital series are constructed following Young (1995). Since longer series gives us a better result, I combined two series from Turkstat and OECD to increase the span of the investment series. For the period 1998 to 2019q3, calendar-adjusted quarterly gross fixed capital formation series are used. For the period are 1970 to 1998, quarterly gross fixed capital formation series, which are interpolated from annual gross fixed capital formation series, are used. For interpolation, I assume equal investment for all quarters. Annual OECD series are available from 1970 to 2018; thus, to test the difference between series from different sources, I aggregated the quarterly Turkstat series and compared them to the same period's OECD series. The difference is negligible.

Young uses the growth of investment in the first five years and depreciation rate to decide the initial capital. Following Young (1995) average of the first 20 quarters is used for calculating average growth. Alternatively, for the first five years, annual growth is extrapolated to quarterly assuming equal quarterly growth; then, average of 20 quarters is taken. Another alternative method is to take five-year average growth of the yearly growth rates and then calculate quarterly growth assuming equal quarterly growth. Quarterly depreciation is taken as 0.02 for all methods following Meza and Quintin (2007). Differences between the resulting series are negligible.

Total hours worked: Total hours worked series are calculated by scaling average annual hours worked data from OECD with working indexes. There is no one index for all required timespan. Thus, for 1998-2009, seasonally adjusted quarterly manufacturing series with the base year 1997 is used, and for 2009 to 2019Q3, manufacturing with NACE code C series with the base year 2015 is used. Base years values are multiplied with indexes to get total hours worked series. These series are chosen among other series since they constitute the best continuous line for the necessary span.

Real interest rate series construction

I follow Neumeyer and Perri(2005) to construct the real interest rate series. First, the inflation series is constructed using US GDP deflator series. Next, the expected inflation is taken as the average inflation rate of three previous quarters. Then, to construct the US real interest rate, 3-month treasury interest rates are inflated with the expected inflation series. Turkey's risk premium is added to find Turkey's real interest rates. Turkey's risk premium is taken as J.P. Morgan's emerging market bond index global (EMBIG). Then index series for modeling stochastic processes are constructed using following equations:

$$R_t^* = \frac{USRealInterestRate_t}{USRealInterestRateAverage} \tag{A.2}$$

$$D_t = \frac{TurkeyRealInterestRate_t}{USRealInterestRate_t} \tag{A.3}$$

APPENDIX B

Proof

This appendix will prove that economy-wide capital adjustment cost parameter remains the same both the standard model and the limited participation model.

Consider law of motion capital for type-A agent.

$$i_t = k_{t+1} - (1-\delta)k_t + (\frac{\phi}{2})(k_{t+1} - k_t)^2 \tag{B.1}$$

Multiply by λ_A, to find economy-wide law of motion.

$$\lambda_A i_t = \lambda_A k_{t+1} - \lambda_A * (1-\delta)k_t + \lambda_A(\frac{\phi}{2})(k_{t+1} - k_t)^2 \tag{B.2}$$

$$\lambda_A i_t = \lambda_A k_{t+1} - \lambda_A(1-\delta)k_t + \frac{1}{\lambda_A}(\frac{\phi}{2})(\lambda_A(k_{t+1} - k_t))^2 \tag{B.3}$$

$$I_t^{agg} = K_{t+1}^{agg} - (1-\delta)K_t^{agg} + \frac{1}{\lambda_A}(\frac{\phi}{2})(K_{t+1}^{agg} - K_t^{agg})^2 \tag{B.4}$$

Define economy-wide capital adjustment cost, ϕ_2, as follows:

$$\phi_2 := (\frac{\phi}{\lambda_A})$$

Then, the law of motion for aggregate capital is

$$I_t^{agg} = K_{t+1}^{agg} - (1-\delta)K_t^{agg} + (\frac{\phi_2}{2})(K_{t+1}^{agg} - K_t^{agg}))^2 \tag{B.5}$$

Table B.1 shows economy-wide capital adjustment cost parameter along with type-A capital adjustment cost parameter. All things kept equal, economy-wide resource constraint roughly stays the same. The binary search algorithm and tolerance for volatility of investment-to-output might explain the differences.

Table B.1 Capital adjustment cost parameters.

Parameter	Standard model	Limited participation	Interest rate shocks	Limited participation + interest rate shocks
ϕ	4.09^{-03}	2.04^{-04}	4.46^{-03}	1.88^{-04}
λ_A	100%	5%	100%	5%
ϕ_2	4.09^{-03}	4.08^{-03}	4.46^{-03}	3.76^{-03}

APPENDIX C

Solution

This appendix will give equations that describe the solutions for models.

Equations describe the solution for models without interest rate are given below. Setting $\lambda_A = 1$ will give the standard model.

$$c_{A,t} + i_t + (1 + r_{A,t})b_{A,t} = w_t n_{A,t} + q_t k_t + b_{A,t+1} \tag{C.1}$$

$$c_{B,t} + (1 + r_{B,t})b_{B,t} = w_t n_{B,t} + b_{B,t+1} \tag{C.2}$$

$$c_{C,t} = w_t n_{B,t} \tag{C.3}$$

$$i_t = k_{t+1} - (1 - \delta)k_t + (\frac{\phi}{2})(k_{t+1} - k_t)^2) \tag{C.4}$$

$$r_{A,t} = \bar{r} + psi_A(e^{\zeta_{A,t} - \bar{\zeta}} - 1) \tag{C.5}$$

$$r_{B,t} = \bar{r} + psi_B(e^{\zeta_{B,t} - \bar{\zeta}} - 1) \tag{C.6}$$

$$\zeta_{A,t} = \frac{b_{A,t}}{q_t k_t + w_t n_{A,t}} \tag{C.7}$$

$$\zeta_{B,t} = \frac{b_{B,t}}{w_t n_{B,t}} \tag{C.8}$$

$$\lambda^{\mathcal{L}}_{A,t}(1 + \phi(k_{t+1} - k_t)) = \beta\lambda^{\mathcal{L}}_{A,t+1}(q_{a,t+1} + 1 - \delta + \phi(k_{t+2} - k_{t+1})) \tag{C.9}$$

$$\lambda_{A,t}^{\mathcal{L}} = \beta(1+r_{A,t+1})\lambda_{A,t+1}^{\mathcal{L}} \tag{C.10}$$

$$(c_{A,t} - \frac{(n_{A,t})^{\omega}}{\omega})^{-\gamma} = \lambda_{A,t}^{\mathcal{L}} \tag{C.11}$$

$$\lambda_{B,t}^{\mathcal{L}} = \beta(1+r_{B,t+1})\lambda_{B,t+1}^{\mathcal{L}} \tag{C.12}$$

$$(c_{B,t} - \frac{(n_{B,t})^{\omega}}{\omega})^{-\gamma} = \lambda_{B,t}^{\mathcal{L}} \tag{C.13}$$

$$(c_{C,t} - \frac{(n_{C,t})^{\omega}}{\omega})^{-\gamma} = \lambda_{C,t}^{\mathcal{L}} \tag{C.14}$$

$$(c_{A,t} - \frac{(n_{A,t})^{\omega}}{\omega})^{-\gamma}(n_{A,t})^{(\omega-1)} = \lambda_{A,t}^{\mathcal{L}}(1-\alpha)\frac{y_t}{n_{A,t}} \tag{C.15}$$

$$(c_{B,t} - \frac{(n_{B,t})^{\omega}}{\omega})^{-\gamma}(n_{B,t})^{(\omega-1)} = \lambda_{B,t}^{\mathcal{L}}(1-\alpha)\frac{y_t}{n_{B,t}} \tag{C.16}$$

$$(c_{C,t} - \frac{(n_{C,t})^{\omega}}{\omega})^{-\gamma}(n_{C,t})^{(\omega-1)} = \lambda_{C,t}^{\mathcal{L}}(1-\alpha)\frac{y_t}{n_{C,t}} \tag{C.17}$$

$$K_t^{agg} = \lambda_A k_t \tag{C.18}$$

$$N_t^{agg} = \lambda_A n_{A,t} + \lambda_B n_{B,t} + (1-\lambda_A-\lambda_B)n_{C,t} \tag{C.19}$$

$$C_t^{agg} = \lambda_A c_{A,t} + \lambda_B c_{B,t} + (1-\lambda_A-\lambda_B)c_{C,t} \tag{C.20}$$

$$B_t^{agg} = \lambda_A b_{A,t} + \lambda_B b_{B,t} \tag{C.21}$$

$$Y_t = e^{A_t}(K_t^{agg})^{\alpha}(N_t^{agg})^{1-\alpha} \tag{C.22}$$

$$w_t = (1-\alpha)\frac{Y_t}{N_t^{agg}} \tag{C.23}$$

$$q_{A,t} = \alpha\frac{Y_t}{K_t^{agg}} \tag{C.24}$$

$$A_t = \rho^A A_{t-1} + \varepsilon^A, \quad \varepsilon^A \overset{i.i.d.}{\sim} \mathcal{N}(0, \sigma(\varepsilon_t^A)^2)\,. \tag{C.25}$$

$$\frac{TB_t}{Y_t} = \frac{\sum_{j=A,B}\lambda_i(1+r_{j,t})B_{j,t} - \sum_{j=A,B}\lambda_j B_{j,t+1}}{Y_t} \tag{C.26}$$

Solution for models with interest rate shocks

In order to extend the model to include interest rate shocks some changes are made.

Since profit function is changed, price of labor equation is changed as:

$$w_t = (1-\alpha)\frac{Y_t}{N_t^{agg}((R_A-1)\theta+1)} \tag{C.27}$$

New interest rates are in equations are as follows:

$$R_{A,t} = \bar{R}e^{R_t^*}e^{d_t} + \psi_j(e^{\zeta_{A,t}-\bar{\zeta}}) \tag{C.28}$$

$$R_{B,t} = \bar{R}e^{R_t^*}e^{d_t} + \psi_j(e^{\zeta_{B,t}-\bar{\zeta}}) \tag{C.29}$$

$$R_{A,t} = r_{A,t} + 1 \tag{C.30}$$

$$R_{B,t} = r_{B,t} + 1 \tag{C.31}$$