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IMF Working Paper

Assessing the Macroeconomic Impact of Structural
Reforms in Ukraine

by Anil Ari and Gabor Pula

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I N T E R N A T I O N A L M O N E T A R Y F U N D

IMF Working Paper

European Department

Assessing the Macroeconomic Impact of Structural Reforms in Ukraine

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Authorized for distribution by Ivanna Vladkova Hollar

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Abstract

Ukraine's economic performance has been anemic since the early 1990s. A major impediment to productivity growth has been low investment, held back by lack of strong and independent institutions. This paper aims to assess the major areas of institutional weakness in Ukraine and quantify the long-term growth impact of catching-up to Poland in terms of the quality of major economic institutions and market development. Our analysis identifies the legal system as the area where the institutional quality is weakest compared to Poland, followed distantly by market competition, openness to trade and financial depth. Using a methodology that accounts for positive spillovers between the structural reform areas, we estimate that even under the most optimistic scenario, where institutional gaps are fully addressed, Ukraine would need 15 years to catch up to Poland's current income level.

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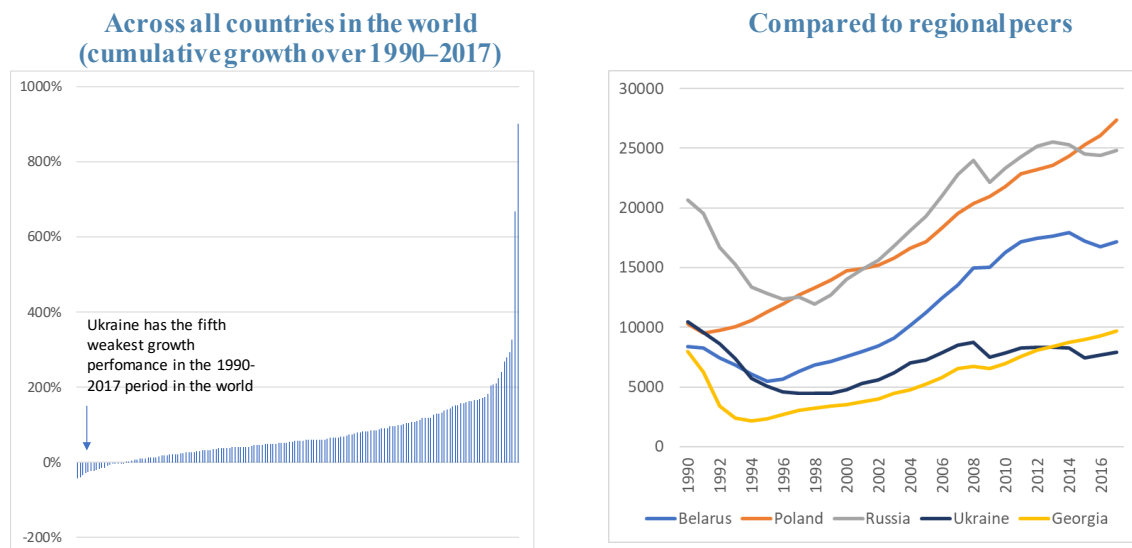
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I. INTRODUCTION

Ukraine's economic performance has been anemic since the early 1990s. Ukraine had the fifth lowest growth rate among all countries in the world between 1990–2017. According to WDI data, there were only 18 countries in the world with negative cumulative growth since 1990 and Ukraine's -0.2 percent annual growth rate qualifies as fifth worst only topping the Democratic Republic of Congo, the United Arab Emirates, Burundi and Yemen. Ukraine has also underperformed compared to its regional peers. While Ukraine experienced an economic downturn similar to other CIS countries in the early nineties, the recovery that followed was less pronounced and growth was further depressed by the military conflict in 2014–15. As a result, despite starting from the same level of development in the early nineties, Ukraine's GDP per capita has fallen behind and currently stands at 30, 45 and 80 percent of Poland, Belarus and Georgia, respectively.

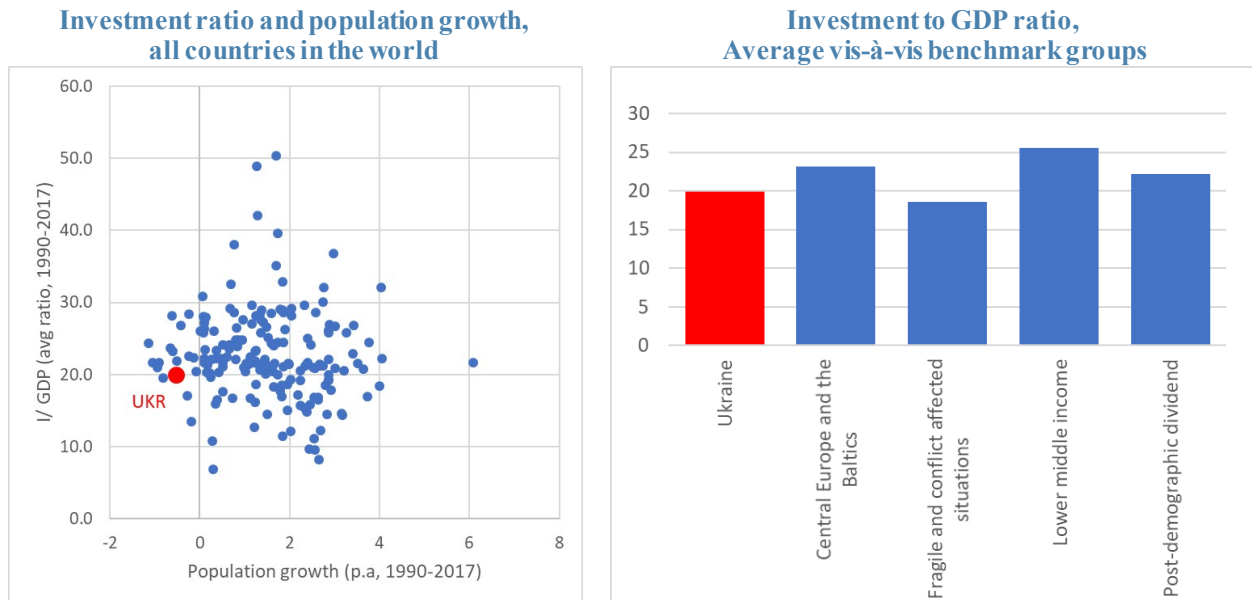
Figure 1. Ukraine's GDP per capita growth 1990–2017



Source: WDI, GDP per capita in PPP (2011 international \$)

Long-term economic growth has been held back by an unfavorable combination of adverse demographics and low investment rates. Similar to many Eastern European countries, Ukraine has a shrinking population. Since 1990 population growth averaged -0.5 percent per year, which is the tenth fastest decline in the world. At the same time, Ukraine also has a low investment rate, the third lowest among countries with a shrinking population. In the 1990–2017 period Ukraine's investment to GDP ratio averaged at 20 percent, which is well-below the average of lower middle-income countries (25.5 percent), Central European countries (23.1 percent) and countries with adverse demographic trends (22.2 percent). The investment ratio fell to 16.2 percent between 2010–17, which places Ukraine in the bottom 10 percentile of the world distribution.

Figure 2. Shrinking Population and Weak Investment, 1990–2017



Source: WDI

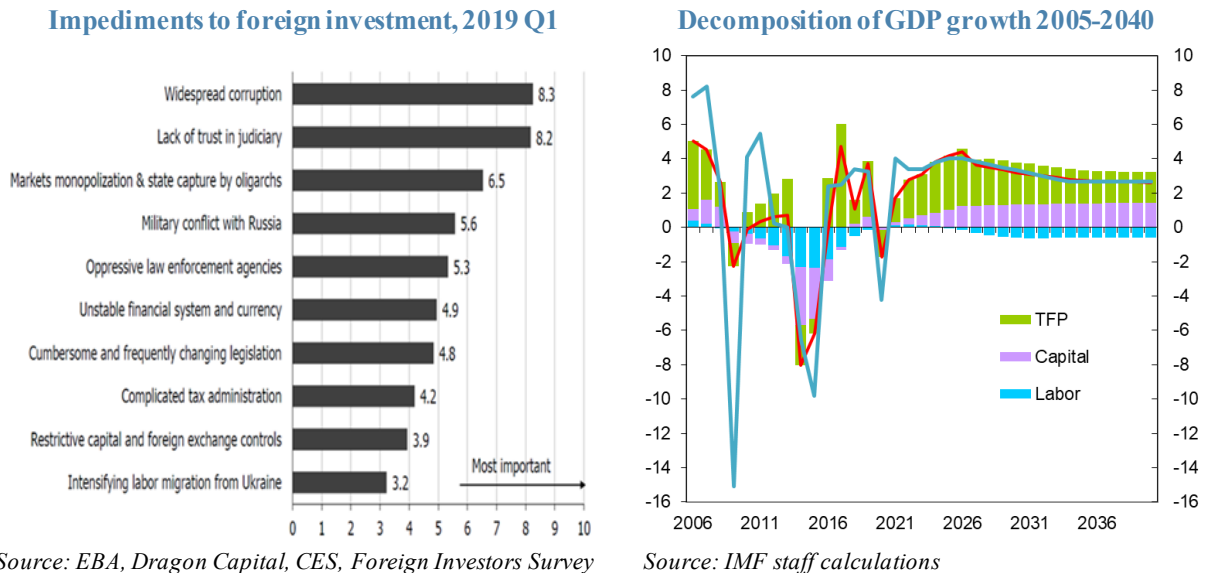
Investment is held back by the lack of strong and independent institutions. While formal market institutions (such as private property rights and a private sector) were established in Ukraine, the state has remained an important player in the economy due to its ownership of a substantial part of productive assets (World Bank, 2019). A commitment to protect property rights is undermined by a weak court system, with widespread concerns remaining regarding the ability of courts to function free from the influence of business insiders and political interference, and the capture of key sectors by powerful oligarchs. Lack of competition and markets often monopolized by the state or oligarchs also weigh on investments. Regulated markets continue to generate highly concentrated rents to powerful special vested interest groups and to undermine the effectiveness of Ukraine’s economic institutions. This has severely undermined incentives to accumulate capital, to attract foreign investment, and to reorient exports away from commodities. Widespread corruption, lack of trust in the judiciary, and monopolization and capture by oligarchs are the top three impediments to investment cited by foreign investors for years (see Figure 3).¹

Unless institutional weaknesses are addressed, Ukraine will remain on a low-growth trajectory. Better institutions not only enhance TFP growth, but also strengthen the resilience of economies to adverse shocks (IMF (2015)). Based on recent updates by the ILO, the Ukrainian labor force is projected to shrink by 1.2 percent per annum over 2018–2030. Assuming a gradual decrease in TFP growth and a constant investment to GDP ratio, potential

¹ Under such circumstances efficient public investment could play a complementary role – both through central government investment strategies and through a SOE investment strategy, assuming that SOEs are run efficiently, independently, and with a profitability objective. However, the impediments to private investments, such as corruption and lack of competitive markets also hinder public investment efficiency and SOE governance.

GDP growth is expected to decelerate to 2.7 percent in the long run. This baseline scenario would imply no catching-up with Poland, as Ukraine's GDP per capita would account for half of that of Poland's by 2040.

Figure 3. Weak institutions hinder investment



This analysis extends the existing literature by quantifying the growth impact of major structural reforms in Ukraine. The growth diagnostics conducted by IMF (2013) identify shortcomings of the legal system (weak rule of law, weak governance, high corruption) and lack of market competition as main impediments to growth, however it falls short of quantifying the macroeconomic impact of removing these constrains. IMF (2017) establish a link between the extent of corruption and growth and claims that reducing corruption to the EU average would increase GDP per capita above 50 percent of the EU level by 2040 (from the current 20 percent). IER (2018) calculate that governance reforms in the gas market, tax administration, public procurement and data provisioning contributed to public savings of US\$6 billion in the 2014–18 period. In a similar vein, a forward looking, bottom-up approach by the Centre for Economic Strategy (2018) estimates that lack of good governance costs US\$13.4 billion (cca. 12 percent of GDP) annually, due to tax evasion, the moratorium on land sales, foregone revenues from privatization, and non-taxed activities in the sizeable shadow economy.²

The paper follows the methodology established by Hausmann et al. (2005), IMF (2015), Egert and Gal (2016) and Egert (2017). The analysis is conducted on an updated version of the panel database used by IMF (2015) that is also in line with the IMF's Third-Party Indicator Policy (IMF (2018)). Principal component analysis is used to disentangle the effect of highly

² The low recovery rate of NPLs in state-owned banks would add another US\$10 billion (9 percent of GDP) as a one-off sum to the estimated cost of bad governance.

correlated variables and to control for potential positive spillovers between the various reform measures.

The methodology consists of three main steps. Section II identifies the main areas of structural gaps vis-à-vis a chosen benchmark (Poland). Section III uses the cross-country variance of the data to estimate the total-factor productivity growth (TFP) impact of the various policy scenarios, controlling for the correlation among the individual structural measures. Section IV uses a small open economy New Keynesian DSGE model to simulate a broader set of macroeconomic outcomes under the various reform scenarios. Finally, Section V concludes.

I. INSTITUTIONAL WEAKNESSES AND REFORM GAPS

A. Database

The key structural reform gaps are identified using quantitative indicators. Cross-country data on a large set of structural indicators are obtained from the Fund's Macrostructural Indicators Database,³ which combines data from several sources (Table 1). These indicators are then categorized to seven broader macrostructural areas, listed as:

- *Legal system*, which includes structural indicators related to corruption, governance, crime, the rule of law and the protection of property rights.
- *Financial system*, which covers structural indicators pertaining to financial development, access to financial services and the soundness of the banking sector and financial markets.
- *Product markets*, which contains structural indicators on competition, informality, and administrative and regulatory burdens in product markets.
- *Labor markets*, which includes structural indicators related to minimum wages and other regulations that affect labor market flexibility.
- *Taxation system*, which captures distortions in incentives associated with various taxes.
- *Trade and openness*, which covers tariffs and non-tariff barriers to trade.
- *Research and development (R&D)*, which contains structural indicators related to innovation and adoption of new technologies.

³ The Fund's Macrostructural Indicators Database provides a one-stop shop for data on selected macro-structural indicators from various sources to support the enhanced coverage of macro-structural issues in surveillance. The indicators are organized along key macro-structural reform areas, identified in IMF (2015), including agriculture, financial, fiscal, innovation, institutions and governance, labor market, product market, and trade and investment. The database is built on a web-based interface and most indicators are linked to their sources through machine-to-machine connections to ensure timely updating.

Structural reform areas do not cover agricultural land markets and use, which are assessed separately. Further details are provided on land reform in Section IIIB.

B. Identifying Institutional Weaknesses and Reform Gaps

In this section we compare Ukraine's indicator values with that of Poland. We consider that Poland is an adequate benchmark for a number of reasons. Poland and Ukraine had similar level of development in terms of GDP per capita in the early nineties; they share a cultural heritage and history; and Poland is considered an economic role model by most policymakers in Ukraine. That said, there are also significant differences. As a robustness check we repeated the exercise using Central and Eastern European countries as benchmark and ended up with similar findings.

Ukraine compares unfavorably to Poland in a large number of individual indicators.⁴ In particular, Ukraine demonstrates weak protection of property rights, high levels of corruption, bribes and favoritism, an ineffective judiciary, shortcomings in the legal framework when settling disputes, and low transparency in government decisions (Table 1). Other areas where Ukraine falls behind Poland are market competition (e.g. the extent of market dominance and the effectiveness of anti-monopoly regulation), product market regulatory quality (e.g. the administrative burden of regulation, access to electricity), financial access (e.g. number of accounts at financial institutions, share of firms with bank loans), and non-tariff barriers to trade (e.g. the cost of and administrative burden of foreign trade). At the same time, labor market flexibility (at least in terms of employment protection, and dismissal rules) was found to fare well compared to Poland and Ukraine also performs relatively well in indicators pertaining to R&D and taxation.

While the individual indicators are useful in signaling the main areas of institutional weaknesses their large number and strong correlation poses a challenge for deeper analysis. Particularly, a weighting scheme is needed to rank the aggregated macrostructural areas by the size of their gap vis-à-vis Poland. We solve this aggregation problem by using principal component analysis to construct a composite indicator for each macrostructural area (legal system, product market, financial market, etc). This has the advantage of making full use of the available information to minimize noise related to any individual structural indicator

⁴ Our findings are similar under alternative benchmarks, e.g. for Central and Eastern Europe.

and it also provides a weighting scheme that accounts for the correlation between individual indicators.⁵

Table 1. Heatmap of Institutional Weaknesses and Reform Gaps vis-à-vis Poland

Category	Sub-Category	2008-2013	2013-2018
Legal system	Corruption		
Legal system	Rule of law		
Legal system	Governance		
Product markets	Regulatory burden		
Product markets	Competition		
Product markets	Informality		
Financial system	Financial access		
Financial system	Financial depth		
Financial system	NPL resolution		
Trade and openness	Non-tariff barriers		
Trade and openness	Tariffs		
R&D	R&D		
Taxation system	Tax		
Labour markets	Labour market regulation		
Labour markets	Minimum wage		

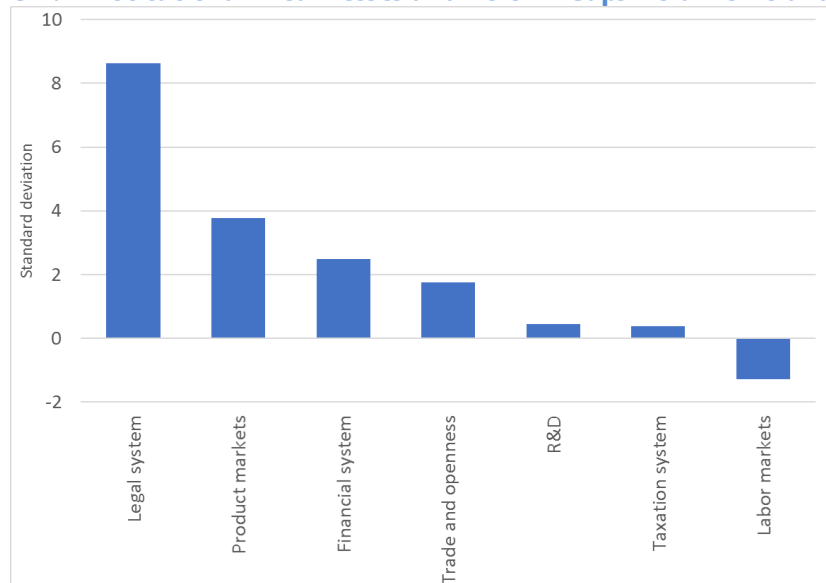
Source: IMF staff calculations based on World Bank, OECD, WEF, and Transparency International data. Red and green reflects lower and higher scoring than Poland, respectively. Darker shades indicate larger score differentials with Poland. Each line represents a separate indicator corresponding to a survey question.

⁵ See Table A1 for a list of individual indicators. Based on the factor loadings the composite indicator for the legal system is primarily driven by structural indicators related to corruption, including bribery, and the rule of law. The indicator for the financial system attributes a large weight to access to financial services and credit, while the product markets indicator reflects market power and administrative and regulatory burdens.

(continued...)

Based on the composite indicators, the macrostructural area where Ukraine is furthest behind Poland is the legal system. In particular, the structural gap pertaining to the legal system is twice as large as that of product markets, which have the second largest shortfall (Figure 4). Smaller but still significant structural gaps exist in the areas of the financial system and trade and openness, while the shortfalls in R&D and the taxation system are negligible. In the case of labor markets, Ukraine's performance is stronger than Poland.

Figure 4. Institutional Weaknesses and Reform Gaps vis-a-vis Poland 2008-2018



IMF staff calculations based on the Macrostructural database. Bars indicate the size of gaps vis-à-vis Poland for any given composite indicator. The size of a gap is measured in terms of standard deviation specific to the given composite indicator

Large positive correlation coefficients between the composite indices suggest that the various structural reform areas are inter-related and progress in one area has positive spillovers to the others (Table 2). Spillovers are likely to be asymmetric. While causality is not established, it is more likely that the legal system affects product market regulation, financial depth and trade than the other way around. For example, breaking up monopolies and opening up markets would require judicial independence and firm property rights for both foreign and domestic investors to feel safe about their investments. Trade facilitation, among other factors, would require corruption and bribes to be reduced at customs. To improve financial intermediation, the balance sheet of banks would need to be cleared from persistently high non-performing loans, which requires stronger enforceability of creditors' claims and legal safeguards against corrupt lending practices, including to related parties. When we construct the policy reform scenarios, we apply the principal component analysis at an even

Regulations on redundancy have a large influence on the labor markets indicator. The indicator for trade and openness assigns a approximately equal importance to the costs of importing and exporting, while the indicator for the taxation system is driven by both direct and indirect burdens imposed on firms. Finally, the R&D indicator reflects corporate spending on innovation and the collaboration of industry with universities.

more aggregated level, in order to consider potential spillovers among the macrostructural areas that are included in each of the scenarios.

Table 2. Correlation between the various structural reform areas

	Legal system	Financial system	Product markets	Labor markets	Taxation system	Trade and openness	R&D
Legal system	1.00	0.68	0.69	0.04	0.33	0.69	0.63
Financial system	0.68	1.00	0.63	0.05	0.23	0.67	0.65
Product markets	0.69	0.63	1.00	-0.02	0.24	0.69	0.76
Labor markets	0.04	0.05	-0.02	1.00	0.28	0.07	-0.06
Taxation system	0.33	0.23	0.24	0.28	1.00	0.32	0.14
Trade and openness	0.69	0.67	0.69	0.07	0.32	1.00	0.59
R&D	0.63	0.65	0.76	-0.06	0.14	0.59	1.00

IMF staff calculations based on the Macrostructural database. Correlations among composite indicators. Red reflects low / negative correlation. Green reflects high / positive correlation.

II. LONG-RUN TFP IMPACT OF STRUCTURAL REFORMS

A. Policy Scenarios

To assess the long-run economic impact of structural reforms, three scenarios are considered:

- *Full reform scenario*: This is the most optimistic scenario with far-reaching structural reforms that allow Ukraine to catch-up with Poland in the four macrostructural areas with the largest structural gaps (the legal system, product markets, the financial system, and trade and openness). This scenario assumes a full liberalization of the land market, without any restrictions on non-resident buyers, and with the ability to pledge land as collateral for bank financing.
- *Partial reform scenario*: In this scenario, Ukraine catches-up with Poland in the macrostructural areas of product markets, financial system and trade and openness, but the structural gap in the legal system, which is by the far largest, is not addressed and remains constant. Land reform is assumed to be partial, with access to land restricted to Ukrainian nationals only. While land may still be pledged as collateral, lower land prices due to restrictions on foreigners also impact its valuation as collateral.
- *Backsliding scenario*: The reform impetus comes to an end in this scenario, resulting in a deterioration in the structural gap in the legal system at the same pace as in 2010-2015, with negative spillover effects on other macrostructural areas. No land reform is assumed.

Composite structural reform indicators are constructed for each policy scenario to account for spillover effects between different macrostructural areas. The composite indicators are constructed by taking the principal component of all structural indicators in macrostructural areas covered by the relevant reform scenario. For the full reform scenario, this includes all indicators associated with the legal system, product markets, the financial system, and trade and openness. For the partial reform scenario, this is a composite of

indicators related to product markets, the financial system and trade and openness. The composite indicator for the legal system is used for the backsliding scenario. The economic impact of land reform is calculated separately from the cross-country estimation exercise (see Section C below).

B. Impact of Structural Reforms on Total Factor Productivity

The impact of structural reforms on Total Factor Productivity (TFP) is estimated using cross-country regressions. Data on TFP and structural indicators are available for 67 countries over 2000-2015. A separate structural reform elasticity for each reform scenario is estimated using the following regression specification

$$\ln(TFP_c) = a_r + \beta_r S_{c,r} + \gamma_r x_{c,r} + \varepsilon_{c,r}$$

where c and r index countries and reform scenarios, a is an intercept, $S_{c,r}$ and β_r denote the composite structural indicator and the long-run reform elasticity for a given reform scenario and ε_c is the residual. In the partial reform scenario, the structural gap in the legal system is held constant by introducing the composite indicator for the legal system as a control variable $x_{c,r}$.

The impact on TFP under each reform scenario is the product of estimated elasticities with structural gaps against Poland in the relevant composite indicators. According to our estimates TFP growth would increase by 5 and 6 percent in the long-run under the partial and full reform scenario, respectively, as a result of a one-standard deviation improvement in institutional quality⁶. Similarly, TFP would decline by 7 percent under the backsliding scenario. Assuming a catching up to Poland, the full reform scenario leads to an increase in TFP by 58.78%, while the partial reform scenario, which does not address the structural gap in the legal system, raises TFP by 22.30 percent over a period of 20 years. Under the backsliding scenario, TFP declines by 17.52% (Table 3).

⁶ Due to limitations of the database our TFP estimates may suffer from an omitted variable bias, since they cannot control for country fixed effects. That said, our results do not differ significantly from Egert and Gal (2016) and Egert (2017) in particular if we take into account that our coefficients refer to the combined long-term TFP impact of various reform initiatives. Comparison with IMF (2019) is complicated by the very different definition of the initial shock (reform episode).

Table 3. TFP impact of policy scenarios (until 2040 cumulative)

	Elasticity	Structural gap against Poland	TFP Impact
Reform scenario	% change in TFP for rise in category by 1 std. dev	Change in std. deviation	% change in TFP
Full reform agenda	0.06	9.1	58.8%
Partial reform agenda	0.05	4.3	22.3%
Backsliding	0.07	-2.5	-17.5%

IMF staff calculations based on the Macrostructural database. The TFP impact is calculated as the product of elasticity and gap.

Model-based estimates from local experts are used to capture the economic impact of land reform⁷. The estimated impact of lifting the moratorium on land sales, while restricting market access to Ukrainian individuals and legal entities, is a cumulative increase in GDP by 6.07% over 10 years. This is incorporated into the partial reform scenario. Removing restrictions on both Ukrainian nationals and foreigners, which constitutes a part of the full reform scenario, raises GDP by 12.6 percent over 10 years. The moratorium on land sales remains in place under the backsliding scenario.

Table 4. Economic Impact of Land Reform (impact over 10 years, in annualized terms)

	Price increase	GDP impact (non-financial channels)	GDP impact (collateral channel)	Total GDP impact	
Closed Market	6.70%	0.00%	0.00%	0.00%	<i>Backsliding scenario</i>
Closed for Foreigners	15.05%	0.40%	0.20%	0.60%	<i>Partial reform scenario</i>
Open to Foreigners	19.43%	0.77%	0.49%	1.26%	<i>Full reform scenario</i>

IMF staff calculations based on estimates of price increase and non-financial GDP impact from EasyBusiness (2019). The collateral channel is based on simulations from a macroeconomic model with financial accelerator effects (see

⁷ EasyBusiness (2019) used a broad cross-country database to calculate possible price increases for both land sales and leases under three distinct scenarios: full market opening, open market with price and quantitative restrictions, and semi-open market with no access of foreigners. According to their calculations, a fully open land market could bring up to 0.77 percentage point additional GDP growth per annum and the additional GDP growth under a scenario with no access to foreigners is estimated at 0.40 percentage points. However, these estimates do not include financial effects arising from the ability to pledge land as collateral. Inputting price increases estimated by EasyBusiness into a macroeconomic model with a financial accelerator channel, IMF staff have estimated that such collateral effects, which work by relaxing financial constraints, could raise an annual GDP growth by a further 0.49 percentage points in a scenario with a fully open land market, and 0.20 percentage points when there are restrictions on foreigners.

section C), where land price increases are assumed to relax financial constraints by reducing monitoring costs in case of a default on bank loans.

IV. SIMULATED MACRO-ECONOMIC IMPACTS OF STRUCTURAL REFORMS

We use a small open economy New Keynesian DSGE model with financial frictions to simulate macroeconomic outcomes under the various reform scenarios.⁸ The structural model combines the small open economy model of Gali and Monacelli (2005) with a financial accelerator mechanism as per Bernanke, Gertler and Gilchrist (1999). In addition, a liquidity premium is introduced in the uncovered interest parity condition in reflection of the relatively shallow foreign exchange (FX) markets in Ukraine. This creates a role for central bank FX interventions, as the sale of central bank FX reserves temporarily reduces the liquidity premium, leading to an exchange rate appreciation. The central bank is assumed to follow an FX intervention rule aimed at stabilizing the nominal exchange rate. The model's calibration corresponds to the literature on business cycles in emerging market economies as well as recent data on Ukraine. The reform scenarios are simulated as a gradual increase in total factor productivity over 20 years, with a cumulative increase that corresponds to the empirically estimated TFP impact with adjustments for the non-financial effects of land reform (see Section III.B above). The financial effects of land reform are simulated as a relaxation in financial constraints that is proportionate to empirically estimated increases in land prices under reform scenarios (see Tables 3 and 4 and Footnote 5).

The reform scenarios result in largely different growth and FX reserve outcomes. We are focused on two main outcomes: (i) the growth impact of structural reforms and the convergence path to Poland, and (ii) the macroeconomic adjustment and its implications for the accumulation of FX reserves (see Figures 5 and 6, and Table 5).

- Under the *full reform scenario*, average annual GDP growth over 20 years could be as high as 7.1 percent, which could result in catching up with the current level of development of Poland by 2040. This scenario implies capital inflows that finance a rise in consumption and investment in advance of the productivity gains, thereby leading to a decline in net exports, a real appreciation and the emergence of a positive output gap in the initial years of the reform. FX reserves also increase by 3.2 billion USD by 2024, and 11.2 billion by 2040, contributing to a reduction in external vulnerabilities. Nominal interest rates only increase slightly due to the lower profile of inflation brought about by the gradual rise in total factor productivity, which also leads to a steady depreciation in the real exchange rates⁹, and a rebound in net exports over 20 years.

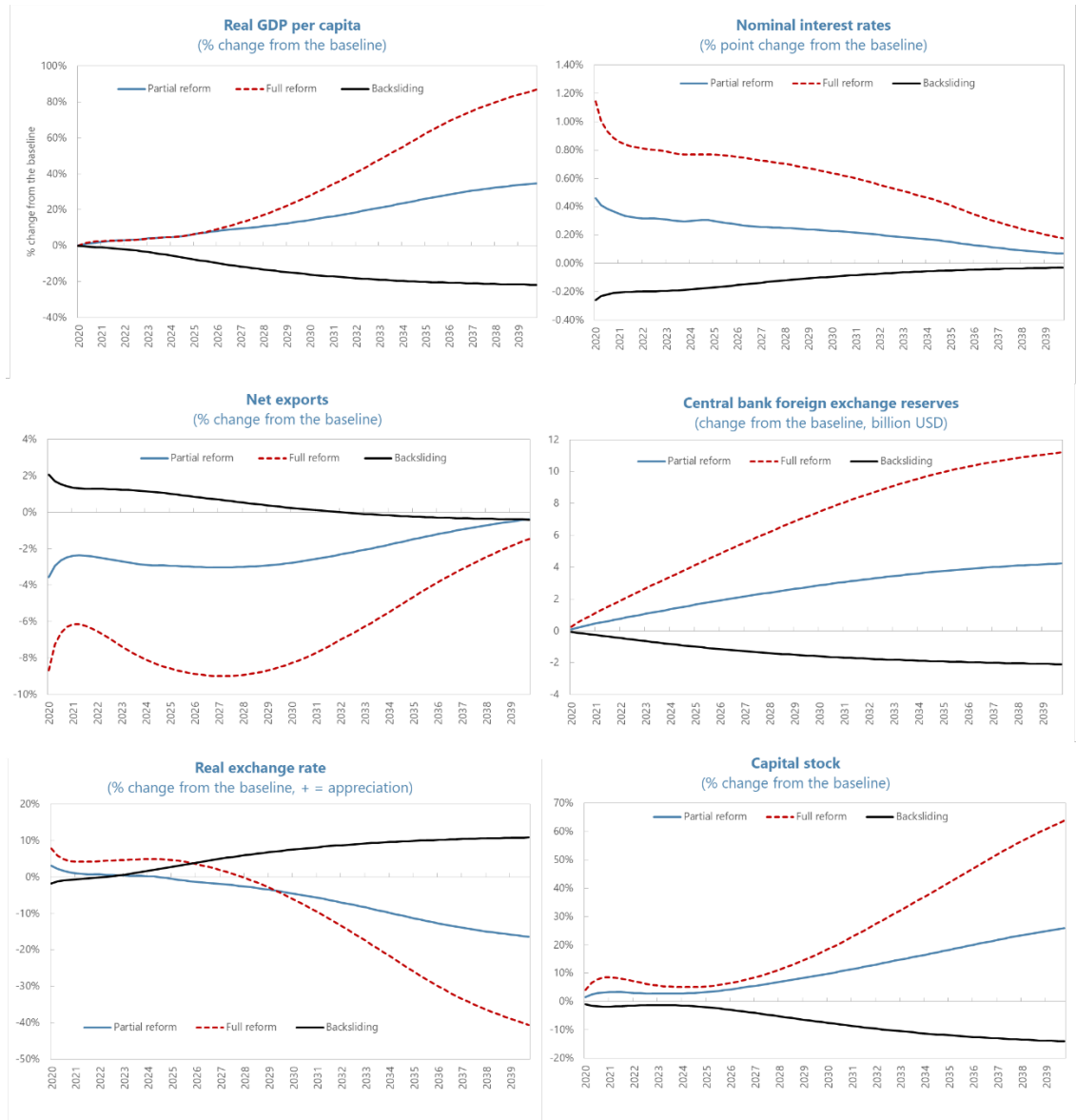
⁸ See Annex II for a fully-fledged description of the model.

⁹ Our model does not capture Balassa-Samuelson effects.

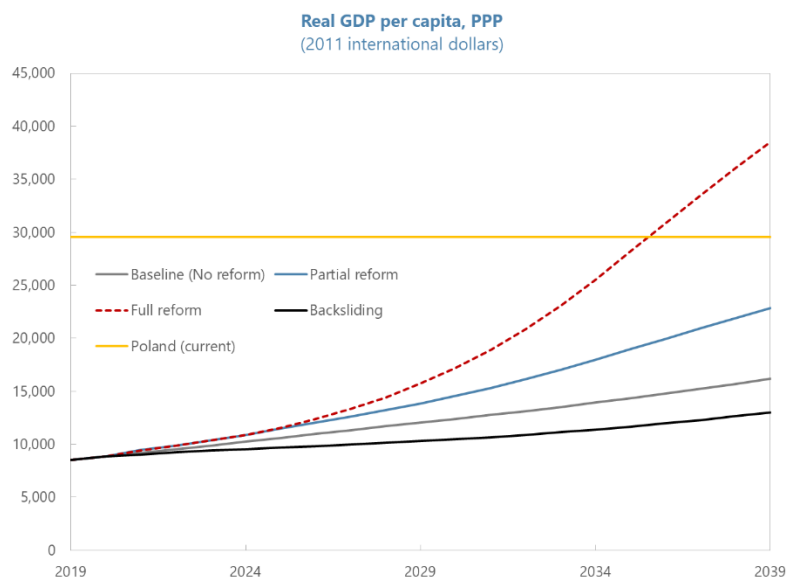
- The *partial reform scenario* entails similar macroeconomic dynamics to the full reform scenario, but at a smaller scale. As the structural gap in the legal system is not addressed, productivity gains from reforms are lower, and average annual GDP growth over 20 years amounts to 4.50 percent, raising GDP per capita to only 77.28 percent of Poland's current level by 2040. Capital inflows and FX reserves also increase by less than in the full reform scenario. Notably, the accumulation of FX reserves amounts to 1.29 billion USD by 2024 and 4.22 billion by 2040.
- Under the *backsliding scenario*, the end in the reform impetus reduces average GDP growth over the next 20 years to 1.67 percent per annum, leading to further divergence from Poland and other regional peers in terms of economic development. In 2040, GDP per capita remains less than half of current Polish GDP per capita. This negative outlook also leads to a decline in capital inflows, which necessitates an adjustment in net exports that is primarily achieved through import compression, since a real appreciation driven by higher inflation leads to an erosion in competitiveness, as well as preventing the central bank from providing monetary stimulus. Consequently, both consumption and gross fixed capital formation decline relative to the baseline. Finally, stabilizing the nominal exchange rate leads to an erosion in FX reserves of 0.84 billion USD by 2024 and 2.30 billion by 2040, thus raising vulnerability to external shocks and adverse shifts in market sentiment.

Successful economic convergence to Poland or other Eastern European peers require long term reform commitment. Structural reforms and institutional changes take a significant amount of time. Even under the optimistic, full reform scenario Ukraine would need to grow at close to 7 percent for 20 years to reach the level of development of Poland today. This would require unaltered reform commitment from the political elite over five parliamentary cycles against strong vested interests and increasing reform fatigue. The Free Trade Agreement with the European Union may provide an institutional umbrella that facilitates the modernization of the economy. At the same time, reform reversals would have significant economic and social costs: under a backtracking scenario, where the quality of legal system deteriorates compared to Poland, GDP growth would drop to below 2 percent per annum.

Figure 5. Macroeconomic impact of structural reform scenarios



Source: Model simulations

Figure 6. Catch-up with Poland under reform scenarios

IMF staff calculations based on model simulations of reform scenarios and baseline forecasts.

Table 5. Reform scenarios: Real GDP growth and catch-up

	Avg. GDP growth rate (annual)	Cumulative growth by 2040	Projected GDP per capita (PPP) relative to current level in Poland
Baseline	2.76%	72.40%	54.63%
Full reform	7.10%	293.07%	130.15%
Partial reform	4.50%	140.95%	77.28%
Backsliding	1.67%	39.25%	43.92%

V. CONCLUSIONS

Ukraine's economic performance has been anemic since the early 1990s. A major impediment to economic growth has been low investment, held back by lack of strong and independent institutions, in particular weak rule of law. Widespread corruption and overregulated markets have severely undermined incentives to accumulate capital, to attract foreign investment, and to diversify exports away from commodities. This analysis quantified the growth impact of structural reforms in Ukraine. The underlying question we analyzed was how much Ukraine's GDP per capita would improve if the country were to catch-up with Poland in terms of the quality of major economic institutions and market development.

Three findings stand out:

First, as regards institutional weaknesses, the areas where Ukraine is furthest behind Poland are the legal system, market competition, openness to trade and financial depth. At the same time, labor market flexibility was found to be even stronger than in Poland and Ukraine performs relatively well in the areas of R&D and taxation.

Second, as regards sequencing, we found that improving the legal system is an important prerequisite for other reforms to work. Notably, tackling corruption and strengthening the rule of law would have significant positive spillover effects to other structural reform areas. In this regard, we simulated a 'full reform scenario', which includes measures to fully close the gap vis-à-vis Poland in all the identified reform areas (the legal system, product market deregulation, trade facilitation and financial market development) as well as a gradual opening up of the agricultural land market, including to foreigners. This optimistic scenario would result in an annual growth rate of close to 7 percent. However, if the authorities fail to reform the legal system, while pushing ahead with reforms on other macrostructural areas, and restrict access to land markets by foreigners, economic growth would be limited to 4–5 percent per annum.

Finally, successful economic convergence to Poland (or other Eastern European peers) requires long term reform commitment. Structural reforms and institutional changes take a significant amount of time to materialize. Even under the optimistic full reform scenario, Ukraine would need a steady reform commitment over 20 years. Reform reversals, on the other hand, would have significant economic and social costs: under a backsliding scenario, where the quality of legal system deteriorates further, GDP growth would drop to below 2 percent per annum.

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Appendix I.

Table A1. List of structural indicators

Individual indicator Name

Legal system	Bribery incidence (% of firms experiencing at least one bribe payment request);
	Bribery index (% of gift or informal payment requests during public transactions);
	Control of Corruption: Percentile Rank;
	Firms expected to give gifts in meetings with tax officials (% of firms);
	Informal payments to public officials (% of firms);
	Percent of firms expected to give gifts to get a construction permit;
	Percent of firms expected to give gifts to get a water connection;
	Percent of firms expected to give gifts to get an electrical connection;
	Percent of firms expected to give gifts to get an import license;
	Percent of firms expected to give gifts to get an operating license;
	Percent of firms expected to give gifts to public officials "to get things done";
	Percent of firms expected to give gifts to secure government contract;
	Percent of firms identifying corruption as a major constraint;
	Value of gift expected to secure a government contract (% of contract value);

Business costs of crime and violence, 1-7 (best);
 If the establishment pays for security, average security costs (% of annual sales);
 If there were losses, average losses due to theft and vandalism (% of annual sales);
 Losses due to theft, robbery, vandalism, and arson (% sales);
 Percent of firms identifying crime, theft and disorder as a major constraint;
 Percent of firms paying for security;
 Voice and Accountability: Percentile Rank;
 Government Effectiveness: Percentile Rank;
 Intellectual property protection, 1-7 (best);
 Property rights, 1-7 (best);
 Efficiency of legal framework in challenging regs., 1-7 (best);
 Efficiency of legal framework in settling disputes, 1-7 (best);
 Percent of firms identifying the courts system as a major constraint;
 Rule of Law: Percentile Rank

**Product
markets**

Burden of government regulation, 1-7 (best);
 Cost of business start-up procedures (% of GNI per capita);
 Percent of firms identifying business licensing and permits as a major constraint;
 Procedures to register property (number);
 Regulatory Quality: Percentile Rank;
 Time required to get electricity (days);
 Time required to obtain an operating license (days);
 Time required to start a business (days);
 Time spent dealing with the requirements of government regulations (% of senior management time);
 Effectiveness of anti-monopoly policy, 1-7 (best);
 Extent of market dominance, 1-7 (best);
 Intensity of local competition, 1-7 (best);
 Firms competing against unregistered firms (% of firms);
 Firms formally registered when operations started (% of firms)
 Account at a financial institution (% age 15+) [w2];
 Borrowed from a financial institution (% age 15+) [w2];
 Debit card (% age 15+) [w2];
 Depth of credit information index (0=low to 8=high);
 Domestic credit to private sector (% of GDP);
 Outstanding mortgage (% age 15+) [w2];
 Percent of firms identifying access to finance as a major constraint;
 Percent of firms not needing a loan;

**Financial
system**

Percent of firms using banks to finance investments;
 Percent of firms using banks to finance working capital;
 Percent of firms with a bank loan/line of credit;
 Percent of firms with a checking or savings account; Private credit bureau coverage (% of adults);
 Proportion of investment financed by banks (%);
 Proportion of investment financed internally (%);
 Proportion of loans requiring collateral (%);
 Proportion of working capital financed by banks (%);
 Saved at a financial institution (% age 15+) [w2];

	Borrowed to start, operate, or expand a farm or business (% age 15+) [w2];
	Debit card in own name (% age 15+) [w2];
	Geographical Outreach: Key Indicators, Number of ATMs per 100,000 adults, Number;
	Geographical Outreach: Key Indicators, Number of commercial bank branches per 100,000 adults, Number;
	Time to resolve insolvency (years)
	Average time to clear exports through customs (days);
	Burden of customs procedure, WEF (1=extremely inefficient to 7=extremely efficient);
Trade and openness	Cost to export (US\$ per container);
	Cost to import (US\$ per container);
	Tariff rate, applied, simple mean, all products (%);
	Tariff rate, applied, weighted mean, all products (%)
	Capacity for innovation, 1-7 (best);
	Company spending on R&D, 1-7 (best);
R&D	PCT patents, applications/million pop.;
	Percent of firms having their own Web site;
	Quality of scientific research institutions, 1-7 (best);
	University-industry collaboration in R&D, 1-7 (best)
	Corporate income tax rate, statutory top central;
Taxation system	Percent of firms identifying tax rates as a major constraint;
	Labor tax and contributions (% of commercial profits);
	Percent of firms identifying tax administration as a major constraint;
	Percent of firms identifying labor regulations as a major constraint;
	Paid annual leave for a worker with 1 year of tenure (in working days);
	Paid annual leave for a worker with 5 years of tenure (in working days);
	Fixed-term contracts prohibited for permanent tasks;
	Notice period for redundancy dismissal (for a worker with 1 year of tenure, in salary weeks);
	Notice period for redundancy dismissal (for a worker with 10 years of tenure, in salary weeks);
	Notice period for redundancy dismissal (for a worker with 5 years of tenure, in salary weeks);
	Notice period for redundancy dismissal (weeks of salary);
Labor markets	Paid annual leave for a worker with 10 years of tenure (in working days);
	Priority rules for redundancies;
	Redundancy costs, weeks of salary;
	Severance pay for redundancy dismissal (for a worker with 1 year of tenure, in salary weeks);
	Third-party notification if one worker is dismissed;
	Maximum working days per week;
	Premium for work on weekly rest day (% of hourly pay);
	Restrictions on weekly holiday work; Flexibility of wage determination, 1-7 (best);
	Minimum wage for a full-time worker (US\$/month);
	Ratio of minimum wage to value added per worker;
	Priority rules for reemployment

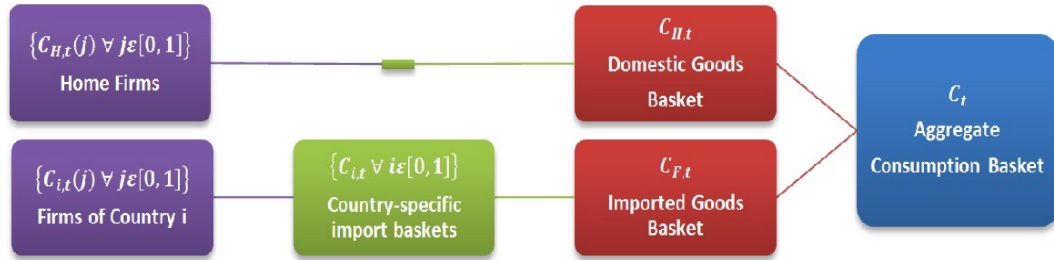
Appendix II.

Description of the small open economy New Keynesian DSGE model with financial frictions

II.1 Small open economy setting and CES aggregation

The world economy consists of a continuum of small open economies $i \in [0,1]$ with identical preferences, technology and market structure. In each economy i , a continuum $j \in [0,1]$ of final good firms produce differentiated goods which are then aggregated into consumption baskets with constant elasticity of substitution (CES) aggregation.¹⁰

Figure A.1: Levels of Aggregation



From the perspective of households in the home country, the aggregation can be broken down into three levels. First, goods produced by domestic firms are aggregated into a basket of domestic goods $C_{H,t}$ with a corresponding price index $P_{H,t}$ such that

$$C_{H,t} \equiv \left(\int_0^1 C_{H,t}(j)^{\frac{\varepsilon_\rho - 1}{\varepsilon_\rho}} dj \right)^{\frac{\varepsilon_\rho}{\varepsilon_\rho - 1}} \quad (1)$$

$$P_{H,t} \equiv \left(\int_0^1 P_{H,t}(j)^{1 - \varepsilon_\rho} dj \right)^{\frac{1}{1 - \varepsilon_\rho}} \quad (2)$$

where $\varepsilon_\rho > 1$ is the elasticity of substitution between domestically produced goods. The same manner of aggregation is also carried out for goods purchased from foreign firms yielding country-specific import baskets $C_{i,t}$ and import price indices $P_{i,t}$ for each foreign country $i \in [0,1]$. Second, these baskets are aggregated across foreign countries to form a basket of

¹⁰ We borrow from Galí and Monacelli (2005) in our exposition of the small open economy framework.

imported goods $C_{F,t}$ with an import price index $P_{F,t}$.¹¹ Finally, the aggregation of imports and domestic products yields the aggregate consumption basket C_t and the consumer price index (CPI) P_t such that

$$C_t = \left[(1 - \alpha)^{\frac{1}{\varepsilon_H}} (C_{H,t})^{\frac{\varepsilon_H - 1}{\varepsilon_H}} + \alpha^{\frac{1}{\varepsilon_H}} (C_{F,t})^{\frac{\varepsilon_H - 1}{\varepsilon_H}} \right]^{\frac{\varepsilon_H}{\varepsilon_H - 1}} \quad (3)$$

$$P_t = \left[(1 - \alpha)(P_{H,t})^{1 - \varepsilon_H} + \alpha(C_{F,t})^{1 - \varepsilon_H} \right]^{\frac{1}{1 - \varepsilon_H}} \quad (4)$$

where $\alpha \in [0,1]$ is the degree of openness of the economy and $\varepsilon_H > 0$ is the trade elasticity term which measures the extent of substitutability between domestic and imported goods. The cost minimization problems solved during the aggregation process also yield the following demand relationships which show that the optimal share of a good within a consumption basket depends negatively on its price relative to the corresponding price index.

$$C_{H,t}(j) = C_{H,t} \left(\frac{P_{H,t}(j)}{P_{H,t}} \right)^{-\varepsilon_H} \quad (5)$$

$$C_{i,t}(j) = C_{i,t} \left(\frac{P_{i,t}(j)}{P_{i,t}} \right)^{-\varepsilon_F} \quad (6)$$

$$C_{i,t}(j) = C_{F,t} \left(\frac{P_{i,t}}{P_{F,t}} \right)^{-\varepsilon_F} \quad (7)$$

$$C_{H,t} = (1 - \alpha) \left(\frac{P_{H,t}}{P_t} \right)^{-\varepsilon_H} C_t \quad (8)$$

$$C_{F,t} = \alpha \left(\frac{P_{F,t}}{P_t} \right)^{-\varepsilon_H} C_t \quad (9)$$

The home country's effective terms of trade, real exchange rate and nominal exchange rate are respectively described by the following expressions:¹²

¹¹ These baskets and price indices are respectively defined as $C_{i,t} \equiv \left(\int_0^1 C_{i,t}(j)^{\frac{\varepsilon_F - 1}{\varepsilon_F}} dj \right)^{\frac{\varepsilon_F}{\varepsilon_F - 1}}$, $P_{i,t} \equiv \left(\int_0^1 P_{i,t}(j)^{1 - \varepsilon_F} dj \right)^{\frac{1}{1 - \varepsilon_F}}$, $C_{F,t} \equiv \left(\int_0^1 C_{i,t}^{\frac{\varepsilon_F - 1}{\varepsilon_F}} di \right)^{\frac{\varepsilon_F}{\varepsilon_F - 1}}$, $P_{H,t} \equiv \left(\int_0^1 P_{i,t}^{1 - \varepsilon_H} di \right)^{\frac{1}{1 - \varepsilon_H}}$ where ε_F measures the extent of substitutability between imports from different foreign countries.

¹² In order to derive the expression for the nominal exchange rate, we assume that the law of one price holds for individual goods and that foreign economies are symmetric.

$$S_t = \frac{P_{F,t}}{P_{H,t}} \quad (10)$$

$$\theta_t = S_t \frac{P_{H,t}}{P_t} = \frac{P_{F,t}}{P_t} \quad (11)$$

$$\varepsilon_t = \frac{P_{F,t}}{P_t^*} \quad (12)$$

where P_t is the world price level. Combining (11) with (4) shows that the gross CPI inflation rate $\Pi_{t-1,t} \equiv \frac{P_t}{P_{t-1}}$ has a non-linear relation with the change in terms of trade and domestic product inflation $\Pi_{H,t-1,t} \equiv \frac{P_{H,t}}{P_{H,t-1}}$.

$$\Pi_{t-1,t} = \Pi_{H,t-1,t} \left[\frac{1 - \alpha + \alpha S_t^{1-\varepsilon_H}}{1 - \alpha + \alpha S_{t-1}^{1-\varepsilon_H}} \right]^{\frac{1}{1-\varepsilon_H}} \quad (13)$$

This reflects the impact of import prices on the CPI. Moreover, it is also possible to show that the real exchange rate and the terms of trade always move together by combining (10) and (11) such that

$$\theta_t = [(1 - \alpha)S^{\varepsilon_H-1} + \alpha]^{\frac{1}{\varepsilon_H-1}} \quad (14)$$

and using (10)-(12) yields a dynamic expression

$$\frac{\theta_t}{\theta_{t-1}} = \frac{\varepsilon_t}{\varepsilon_{t-1}} \frac{\Pi^*}{\Pi_{t-1,t}} \quad (15)$$

which suggests that the real exchange rate depreciates due to a nominal exchange rate depreciation or when the world CPI inflation rate Π^* exceeds the CPI inflation rate at the home country.

II.2 Households

The home economy is populated by a measure one continuum of identical, infinitely lived households. The representative household's expected lifetime utility is

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t u(C_t) \right\} \quad (16)$$

where $\beta \in (0,1)$ is the time preference discount factor, C_t is the aggregate consumption basket defined by (3) and $u(C_t)$ is a standard CRRA utility function with the elasticity of intertemporal substitution given by $1/\sigma$. Financial markets are incomplete and the asset space is limited to three types of one-period nominal bonds: Private bonds B_t issued by domestic

financial intermediaries, domestic government bonds B_t^G and foreign bonds B_t^F . The first two assets have a unit price and pay non-state contingent gross nominal returns of R_t and R_t^G respectively. B_t^F is denominated in foreign currency such that it has a price ε_t and return $\varepsilon_{t+1}R_t^F$ in the home currency. The representative household's period budget constraint can thus be described as

$$P_t C_t + B_t + B_t^G + \varepsilon_t B_t^F \leq P_t \int_0^1 H_t(j) w_t(j) dj + R_{t-1} B_{t-1} + R_{t-1}^G B_{t-1}^G + R_{t-1}^G B_{t-1}^G + \varepsilon_{t-1} \Lambda_{t-1} R_{t-1}^F B_{t-1}^F + T_t^{lump} \quad \text{for } t = 0, 1, 2 \dots \quad (17)$$

where $H_t(j)$ denotes labour hours provided to firm j in exchange of real wage $w_t(j)$ and T_t^{lump} captures all lump sum taxes and transfers to the household including dividends from firms, fees from financial intermediaries and transfers to entrepreneurs. The total labour hours provided by the household is defined as $H_t \equiv \int_0^1 H_t(j) dj$ and assumed to be inelastic such that $H_t = H > 0$. Finally, shallow domestic currency markets lead to a liquidity premium

$$\Lambda_t = \left(\frac{\mathcal{R}_t}{\mathcal{R}_{t-1}} \right)^{\varepsilon_{\mathcal{R}}} \quad \varepsilon_{\mathcal{R}} > 0 \quad (18)$$

on foreign currency-denominated bonds B_t^F which decreases in the sale of foreign exchange reserves \mathcal{R}_t by the central bank.¹³

The representative household chooses its optimal plan $\{C_t, B_t, B_t^G, B_t^F\}_{t=0}^{\infty}$ by taking wages and prices as given and maximizing its utility (16) subject to the budget constraint (17) and its intertemporal solvency constraint. Under the optimal plan, (17) holds with equality and the following first order conditions must be fulfilled

$$1 = \beta E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \frac{1}{\Pi_{t,t+1}} \right] R_t \quad (19)$$

$$1 = \beta E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \frac{1}{\Pi_{t,t+1}} \right] R_t^G \quad (20)$$

$$1 = \beta E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \frac{\varepsilon_{t+1}}{\varepsilon_t} \frac{1}{\Pi_{t,t+1}} \right] \Lambda_t R_t^F \quad (21)$$

which are respectively the Euler conditions conditions for domestic private, domestic government and foreign bonds. Finally, the household must also satisfy a transversality condition for each asset which ensures that the intertemporal solvency constraint is not violated.

¹³ There is a growing literature which provides micro-foundations for deviations from uncovered interest parity and analyzes the impact and optimality of foreign exchange reserve interventions (see e.g. Gabaix and Maggioni, 2015; Cavallino, 2018; Fanelli and Straub, 2019).

II.3 Investment and Capital Producers

The investment goods are a Dixit-Stiglitz composite of domestic and imported consumption goods with an openness parameter $\alpha_I \in [0,1]$ and trade elasticity $\varepsilon_I > 0$ such that

$$I_t = \left[(1 - \alpha_I)^{\frac{1}{\varepsilon_I}} (I_{H,t})^{\frac{\varepsilon_I - 1}{\varepsilon_I}} + \alpha_I^{\frac{1}{\varepsilon_I}} (I_{F,t})^{\frac{\varepsilon_I - 1}{\varepsilon_I}} \right]^{\frac{\varepsilon_I}{\varepsilon_I - 1}} \quad (22)$$

$$I_{H,t} = (1 - \alpha_I) \left(\frac{P_{H,t}}{P_t^I} \right)^{-\varepsilon_I} I_t \quad (23)$$

$$I_{F,t} = \alpha_I \left(\frac{P_{F,t}}{P_t^I} \right)^{-\varepsilon_I} I_t \quad (24)$$

where $I_{H,t}$ and $I_{F,t}$ are the baskets of domestic and imported consumption goods used in the composite for I_t . A cost minimization process similar to the one described in Section II.1 results in an investment price index $P_t^I = \left[(1 - \alpha_I) P_{H,t}^{1-\varepsilon_I} + \alpha_I P_{F,t}^{1-\varepsilon_I} \right]^{\frac{1}{1-\varepsilon_I}}$. Allowing for $\alpha_I > 0$ captures the negative supply-side effects of a rise in import prices $P_{F,t}$ (and hence a depreciation) through a rise in the cost of investment. By combining this expression with (11), we derive an expression for the real price of investment goods

$$p_t^I \equiv \frac{P_t^I}{P_t} = \left[(1 - \alpha_I) \left(\frac{\Theta_t}{S_t} \right)^{1-\varepsilon_I} + \alpha_I \Theta_t^{1-\varepsilon_I} \right]^{\frac{1}{1-\varepsilon_I}} \quad (25)$$

Each period, the representative capital producer purchases effective capital K_t' from entrepreneurs at a real price q_t' after production occurs. This is then combined with investment goods I_t in order to produce new capital K_t with the following linear homogenous technology

$$K_t = (1 - \delta)K_t' + I_t - \frac{\sigma_I}{2} \left(\frac{I_t}{K_t'} - \delta \right)^2 K_t' \quad (26)$$

where δ is the depreciation rate and the last term reflects capital adjustment costs with a sensitivity parameter $\sigma_I > 0$. Finally, the new capital goods K_t are sold back to the entrepreneurs at a real price q_t . As the capital producers are perfectly competitive, they take prices (q_t', q_t, p_t^I) as given and choose a schedule for (K_t, I_t) to maximize lifetime profits. This yields the first order conditions

$$q_t = p_t^I \left[1 - \sigma_I \left(\frac{I_t}{K_t'} - \delta \right) \right]^{-1} \quad (27)$$

$$q'_t = \left[1 - \delta + \sigma_I \frac{I_t}{K'_t} \left(\frac{I_t}{K'_t} - \delta \right) \right] q_t \quad (28)$$

which respectively define q_t and q'_t .

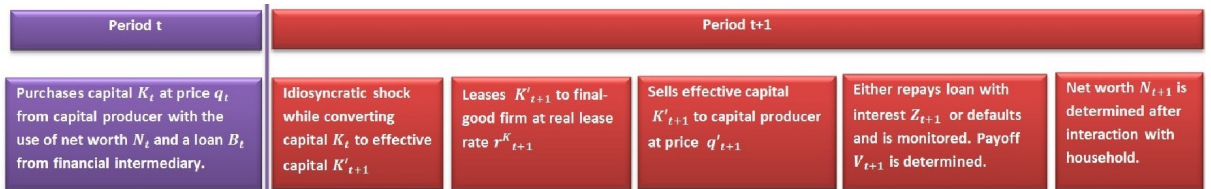
II.4 Entrepreneurs and Financial Intermediaries

There is a measure one continuum $e \in [0,1]$ of risk-neutral entrepreneurs. Before the end of every period t , each entrepreneur purchases new capital $K_t(e)$ from capital producers using net worth $N_t(e)$ as well as a loan $B_t(e)$ from financial intermediaries which yields the financing constraint $P_t q_t K_t(e) = N_t(e) + B_t(e)$. At the beginning of the next period $t + 1$ (after the aggregate state is realized), the entrepreneur is subject to a unit mean idiosyncratic shock $\omega_{t+1}(e) \in [0, \infty]$ while converting $K_t(e)$ into effective capital $K'_t(e)$ such that $K'_t(e) = \omega_{t+1}(e) K_t(e)$. As the idiosyncratic shock is independent across time and entrepreneurs, this relationship becomes $K'_t = K_t$ at the aggregate level.

Following the shock, effective capital is leased to firms for use in production at the real lease rate r_{t+1}^k and then sold back to capital producers at real price q'_{t+1} . As such, the gross nominal payoff to the entrepreneur is $R_{t+1}^K P_t q_t \omega_{t+1}(e) K_t(e)$ where $R_{t+1}^K \equiv \Pi_{t,t+1} \frac{r_{t+1}^k + q'_{t+1}}{q_t}$ is the average rate of return. Finally, the entrepreneur may either pay the lenders the amount stipulated by their contract or default. The lending environment follows the costly state verification framework of Townsend (1979). There is asymmetric information between the entrepreneur and financial intermediaries such that the latter may only observe the idiosyncratic shock $\omega_{t+1}(e)$ after paying a monitoring cost $\mu_t R_{t+1}^K P_t q_t \omega_{t+1}(e) K_t(e)$ which depends on a time-varying shock such that

$$\log(\mu_t) = \log(\mu) + \varepsilon_t^\mu \quad \mu \in [0,1] \quad (29)$$

Figure A.2: A period from the entrepreneur's perspective



We follow Bernanke et al. (1999) in assuming that the contract's terms may be contingent on the aggregate state in period $t + 1$. Under these conditions, the optimal contract takes the form of standard debt with state-contingent nominal interest rates $Z_{t+1}(e)$. In case of default, the lender always monitors the entrepreneur and confiscates the maximum amount possible. Consequently, the entrepreneur's choice regarding default is guided by a cut-off rule based on the idiosyncratic shock realization whereby the entrepreneur repays the loan if $\omega_{t+1}(e) \geq \bar{\omega}_{t+1}(e)$ and defaults otherwise. The cut-off level $\bar{\omega}_{t+1}(e)$ is equivalent to the shock realization at which the entrepreneur is indifferent between the two choices such that

$R_{t+1}^K P_t q_t \bar{\omega}_{t+1}(e) K_t(e) = Z_{t+1}(e) B_t(e)$. This implies that $\omega_{t+1}(e)$ may also be contingent on the aggregate state.

Prior to the idiosyncratic shock realization, entrepreneurs are only distinguished by their net worth and it is expositionally convenient to group them according to it. The financing constraint can then be written as

$$P_t q_t K_t^N = N + B_t^N \quad (30)$$

$$R_{t+1}^K P_t q_t \bar{\omega}_{t+1}^N K_t^N = Z_t^N B_t^N \quad (31)$$

where superscript N indicates net worth.

The representative financial intermediary raises its funding by selling nominal bonds B_t to households. As the financial intermediaries are perfectly competitive, they are subject to a zero profit condition (henceforth ZPC) which requires that they do not make any losses or supernormal profits. We follow the literature in assuming that financial intermediaries do not have access to state-contingent securities such that the ZPC must hold exactly in each aggregate state in period $t + 1$. It also holds separately for each net worth group as the intermediaries have no incentive to cross-subsidize lending across net worth groups. This leads to the set of conditions

$$[\Gamma(\bar{\omega}_{t+1}^N) - \mu_t G(\bar{\omega}_{t+1}^N)] \frac{R_{t+1}^K}{R_t} = \frac{k_t^N - 1}{k_t^N} \quad \forall N \quad (32)$$

where $k_t^N \equiv \frac{P_t q_t K_t^N}{N}$ is the type- N entrepreneurs' leverage, $\Gamma(\bar{\omega}_{t+1}^N) \equiv [1 - F(\bar{\omega}_{t+1}^N)] \bar{\omega}_{t+1}^N + G(\bar{\omega}_{t+1}^N) \in [0, 1]$ is the gross rate of return to the financial intermediary (where 'gross' indicates that monitoring costs have not been deducted) from lending to net worth group N , $G(\bar{\omega}_{t+1}^N) = \int_0^{\bar{\omega}_{t+1}^N} \omega df(\omega) \in [0, \mu_t]$ is the amount recovered from type- N entrepreneurs in default and $F(\omega)$ is the cdf of the idiosyncratic shock.

The 'interim' expected payoff of type- N entrepreneurs can be written as $V_{t+1}^N = [1 - \Gamma(\bar{\omega}_{t+1}^N)] R_{t+1}^K k_t^N N$ such that expectations are taken over the idiosyncratic shock realization after the aggregate state in period $t + 1$ is realized. The optimal contracting problem then consists of choosing a leverage k_t^N and a state-contingent schedule of cut-off levels $\bar{\omega}_{t+1}^N$ to maximize the ex-ante expected rate of return of the entrepreneur $\frac{E_t\{V_{t+1}^N\}}{R_t N}$ (after it has been scaled by R_t which represents the opportunity cost of investing in capital for the entrepreneur) subject to the ZPC (32) holding exactly at each aggregate state of period $t + 1$.

Bernanke et al. (1999) show that, under plausible parameterizations, the solution takes the form of a non-rationing equilibrium such that the first order conditions hold with equality. Consequently, the first order conditions may be simplified into the ZPC (32) which determines the state-contingent schedule for $\bar{\omega}_{t+1}^N$ and the below condition which determines the optimal leverage k_t^N .

$$E_t \left\{ [1 - \Gamma(\bar{\omega}_{t+1}^N)] \frac{R_{t+1}^K}{R_t} + \frac{\Gamma'(\bar{\omega}_{t+1}^N)}{\Gamma'(\bar{\omega}_{t+1}^N) - \mu_t G'(\bar{\omega}_{t+1}^N)} \left[[\Gamma(\bar{\omega}_{t+1}^N) - \mu_t G(\bar{\omega}_{t+1}^N)] \frac{R_{t+1}^K}{R_t} - 1 \right] \right\} = 0 \quad (33)$$

where $\Gamma'(\bar{\omega}_{t+1}^N)$ and $G'(\bar{\omega}_{t+1}^N)$ are respectively the first derivatives of $\Gamma(\bar{\omega}_{t+1}^N)$ and $G(\bar{\omega}_{t+1}^N)$. Since the only net worth specific variables are the choice variables $\{k_t^N, \bar{\omega}_{t+1}^N\}$, the optimal contract is the same for all entrepreneurs regardless of their net worth and the above relations may be written in aggregate terms by integrating over net worth groups and letting $N_t \equiv \int_0^\infty N f_t(N) dN$ be the aggregate net worth where $f_t(N)$ denotes the density of entrepreneurs with net worth N at time t . This yields the following relationships:

$$B_t = N_t(k_t - 1) \quad (34)$$

$$Z_{t+1} = \frac{R_{t+1}^K P_t q_t \bar{\omega}_{t+1} K_t}{B_t} \quad (35)$$

$$k_t = \frac{P_t q_t K_t}{N_t} \quad (36)$$

$$[\Gamma(\bar{\omega}_{t+1}^N) - \mu_t G(\bar{\omega}_{t+1}^N)] \frac{R_{t+1}^K}{R_t} = \frac{k_t - 1}{k_t} \quad (37)$$

$$E_t \left\{ [1 - \Gamma(\bar{\omega}_{t+1})] \frac{R_{t+1}^K}{R_t} + \frac{\Gamma'(\bar{\omega}_{t+1})}{\Gamma'(\bar{\omega}_{t+1}) - \mu_t G'(\bar{\omega}_{t+1})} \left[[\Gamma(\bar{\omega}_{t+1}) - \mu_t G(\bar{\omega}_{t+1})] \frac{R_{t+1}^K}{R_t} - 1 \right] \right\} = 0 \quad (38)$$

$$V_{t+1} = [1 - \Gamma(\bar{\omega}_{t+1})] R_{t+1}^K k_t N_t \quad (39)$$

which are respectively the aggregated forms of the financing constraint, the cutoff rule, the definition for leverage, the lender's ZPC, the FOC for k_t and the entrepreneur's payoff. Using these relations, the effective capital supplied by the entrepreneurs can be written as

$$K'_{t+1} = \frac{N_t}{P_t q_t \left[1 - \frac{R_{t+1}^K}{R_t} \Gamma(\bar{\omega}_{t+1}) - \mu_t G(\bar{\omega}_{t+1}) \right]} \quad (40)$$

We follow Christiano, Motto and Rostagno (2014) in using the large family setting to incorporate the entrepreneurial block into the broader model. This setting has similar implications for the aggregate economy as the entrepreneurial consumption and mortality risk

assumptions of Bernanke et al. (1999) but allows for a considerably simpler exposition. Under this setting, each household contains a large number of entrepreneurs which are instructed to maximize their payoff and receive a transfer $P_t T^{h,e}$ each period to ensure that they have sufficient funds for investment even after default. In return, they transfer a portion $(1 - \gamma)$ of their payoff to their household which prevents them from accumulating enough assets to rely solely on their net worth for investment. Consequently, the evolution of aggregate net worth is given by

$$N_t = P_t T^{h,e} + \gamma V_{t-1} \quad (41)$$

Finally, monitoring undertaken by financial intermediaries has a nominal cost $\mu_{t-1} G(\bar{\omega}_t) R_t^K P_{t-1} q_{t-1} K_{t-1}$ which is paid in period t as the monitoring takes place after the idiosyncratic shock realization. We assume that the monitoring costs are in terms of the same allocation of differentiated goods as consumption C_t and hence take a price P_t . The real resource cost of monitoring may then be defined as

$$M_t \equiv \frac{\mu_t G(\bar{\omega}_t) R_t^K q_{t-1} K_{t-1}}{\Pi_{t-1,t}} \quad (42)$$

II.5 Final Good Firms

In the home economy, there is a continuum of monopolistically competitive final good firms $j \in [0,1]$. Each firm produces a differentiated final good $Y_{H,t}(j)$ by hiring labour $H_t(j)$ at a real wage w_t and leasing effective capital $K'_t(j)$ at a real lease rate r_t^k according to a standard Cobb-Douglas production function

$$Y_{H,t}(j) = A_t K'_t(j)^a H_t(j)^{1-a} \quad (43)$$

where a is the share of capital income and A_t represents total factor productivity and follows a time-varying shock process $\log(A_t) = \log(A) + \varepsilon_t^A$. As there are no frictions in the factor markets, firms determine the optimal allocation of labour and capital by solving a period-by-period cost minimization problem which yields the first order conditions

$$MC_t^n(j) = \frac{P_t w_t}{1-a} \left(\frac{Y_{H,t}(j)}{H_t(j)} \right)^{-1} \quad (44)$$

$$\frac{K'_t(j)}{H_t(j)} = \frac{a}{1-a} \frac{w_t}{r_t^k} \quad (45)$$

The first condition determines the nominal marginal cost $MC_t^n(j)$ and the second condition determines the optimal capital labour-ratio. It is evident from (45) that all firms have the same optimal capital-labour ratio. which implies that $MC_t^n(j)$ is the same for all firms as well. Consequently, real marginal costs may be defined in aggregate terms as

$$MC_t \equiv \frac{MC_t^n(j)}{P_{H,t}} = \frac{S_t}{\theta_t} \frac{w_t}{1-a} \left(\frac{Y_t}{H}\right)^{-1} \quad (46)$$

Firms then sell their product at a price $P_{H,t}(j)$, making profits $[P_{H,t}(j) - MC_t^n(j)]Y_{H,t}(j)$ which are distributed lump-sum to households. Although firms have market power over their product, they are subject to price-setting frictions as per Calvo (1983). In each period, a fraction $\theta \in (0,1)$ of firms are unable to re-optimize their prices and update it by steady-state inflation $\bar{\Pi}$. Consequently, when a firm may update its price, it chooses its optimal price $P_{H,t}^{opt}(j)$ in a forward-looking manner to maximize the expected discounted value of the profit stream generated until it may re-optimize. The representative firm's optimization problem may then be described as

$$P_{H,t}^{opt}(j) \max_{\{Y_{H,t+k}(j)\}_{k=0}^{\infty}} \sum_{k=0}^{\infty} \theta^k E_t [Q_{t,t+k} Y_{H,t+k}(j) (P_{H,t}^{opt}(j) \bar{\Pi}^k - MC_{t+k}^n)] \quad (47)$$

s.t.

$$Y_{H,t+k}(j) \leq \left(\frac{P_{H,t}^{opt}(j) \bar{\Pi}^k}{P_{H,t+k}}\right)^{-\varepsilon\rho} Y_{H,t+k} \quad \forall k \in [0, \infty] \quad (48)$$

where $Q_{t,t+k} \equiv \beta^k E_t \left[\left(\frac{C_{t+k}}{C_t}\right)^{-\sigma} \frac{1}{\Pi_{t,t+k}} \right]$ is the discount factor used by the firm reflecting its ownership by households and (48) is the firm's demand constraint which describes the demand for the firm's differentiated good as a share of the total demand for domestic goods $Y_{H,t+k}$ and holds with equality under market clearing. By substituting (48) into (47), the representative firm's problem can be simplified into one where it chooses the optimal price $P_{H,t}^{opt}(j)$ and commits to hiring sufficient factor inputs to meet the consequent demand $Y_{H,t+k}(j)$ at each period until it can re-optimize its price. The first order condition for the optimal price can then be written recursively as follows

$$p_{H,t}^{opt}(j) = \frac{\Omega_t}{F_t} \quad (49)$$

$$\Omega_t = \frac{\varepsilon\rho}{\varepsilon\rho - 1} MC_t Y_t + \theta \bar{\Pi}^{-\varepsilon\rho} E_t \left[Q_{t,t+1} \Pi_{H,t,t+1}^{1+\varepsilon\rho} \Omega_{t+1} \right] \quad (50)$$

$$F_t = Y_t + \theta \bar{\Pi}^{-\varepsilon\rho} E_t \left[Q_{t,t+1} \Pi_{H,t,t+1}^{\varepsilon\rho} F_{t+1} \right] \quad (51)$$

where $p_{H,t}^{opt}(j) \equiv \frac{P_{H,t}^{opt}(j)}{P_{H,t}}$ is the optimal price in real terms. Under this first order condition, the optimal price $p_{H,t}^{opt}(j)$ may be interpreted as the price that achieves a desired mark-up of $\frac{\varepsilon\rho}{\varepsilon\rho - 1}$ over a weighted average of current and future marginal costs. Note that the only firm-specific variable in the condition is $p_{H,t}^{opt}(j)$, suggesting that firms that re-optimize their price in the

same period will choose the same optimal price. The evolution of domestic product inflation can then be described by the relationship

$$(1 - \theta)p_{H,t}^{opt 1-\varepsilon\rho} = 1 - \theta \left[\frac{\bar{\Pi}}{\Pi_{H,t-1,t}} \right]^{1-\varepsilon\rho} \quad (52)$$

II.6 Aggregate Demand and Aggregate Supply

Goods market clearing in the home economy requires that each domestic final good firm produces just enough goods to meet the demand for its products. Consequently, the goods market clearing condition can be written as

$$Y_{H,t}(j) = C_{H,t}(j) + I_{H,t}(j) + M_{H,t}(j) + G_{H,t}(j) + \int_0^1 [C_{H,t}^i(j) + I_{H,t}^i(j) + M_{H,t}^i(j) + G_{H,t}^i(j)] di \quad (53)$$

where the first four terms are respectively the demand arising from consumption, investment, monitoring costs and government spending in the home country. Together, they make up the domestic demand for the firm's products. The terms with superscript i represent demand from country i such that the integrated term is the export demand for the firm's product. After extensive algebraic manipulation using (5)-(12), (22), (23) and their foreign counterparts, aggregate demand can be described with the following expressions

$$Y_t = (1 - \alpha) \left(\frac{S_t}{\theta_t} \right)^{\varepsilon_H} (C_t + G_t + M_t) + (1 - \alpha_I) \left(\frac{S_t}{\theta_t} \right)^{\varepsilon_I} (p_t^I)^{\varepsilon_I} + S_t^{\varepsilon_F} W_t^* \quad (54)$$

where $W_t^* = \alpha(C^* + G^* + M^*) + \alpha_I I^*$ is the world demand for domestic products.

Aggregate domestic output may also be defined through the supply side by aggregating the production function (43) across firms. This yields

$$Y_t = \frac{AK_t'^a H^{1-a}}{\Delta_t} \quad (55)$$

where the price dispersion term Δ_t reflects the allocative inefficiency caused by price-setting frictions. Using the Calvo pricing structure, this can be described by the recursive expression

$$\Delta_t = (1 - \theta)p_{H,t}^{opt -\varepsilon\rho} + \theta \left(\frac{\Pi_{H,t-1,t}}{\bar{\Pi}} \right)^{\varepsilon\rho} \Delta_{t-1} \quad (56)$$

II.7 Trade Balance

Net exports are defined as the difference between the value of domestic output and domestic spending on consumption, monitoring costs, government spending and investment such that

$$P_{H,t}NX_t = P_{H,t}Y_t - P_t(C_t + M_t + G_t) - P_t^I I_t \quad (57)$$

Using (10) and (11), this expression can be written in real terms as

$$NX_t = Y_t - \frac{S_t}{\Theta_t} (C_t + M_t + G_t - p_t^I I_t) \quad (58)$$

Balance of payments requires that changes in the net foreign assets of the home country mirror the value of net exports, leading to the accounting identity $P_{H,t}NX_t = \varepsilon_t(B_t^F + P_t^* \mathcal{R}_t - R_{t-1}^F(B_{t-1}^F + P_{t-1}^* \mathcal{R}_{t-1}))$ which can be written in real terms as

$$NX_t = S_t \left(b_t^F + \mathcal{R}_t - \frac{R_{t-1}^F}{\Pi^*} (b_{t-1}^F + \mathcal{R}_{t-1}) \right) \quad (59)$$

where $b_t^F \equiv \frac{B_t^F}{P_t^*}$ is the real value of foreign currency denominated bonds and Π^* is exogenous world inflation. Finally, we adopt a debt-elastic interest rate specification (Schmitt-Grohe and Uribe, 2003) such that the spread between R_t^F and the world interest rate R^* is increasing in the domestic currency value of the foreign debt stock relative to the value of annual domestic output. This yields the expression

$$R_t^F - R^* = -\chi \left(\frac{\varepsilon B_t^F}{4P_{H,t}Y_t} \right) \quad (60)$$

where the debt elasticity parameter $\chi > 0$ is small enough to have negligible effects on the short-run dynamics of the model. Nevertheless, this is sufficient to close the model by ensuring that B_t^F always reverts to its steady state value of zero.

II.8 Monetary Policy

Policy interest rates are determined according to a Taylor rule with interest rate smoothing such that

$$\log(R_t) = \log(\bar{R}) + \phi_i \log\left(\frac{R_{t-1}}{\bar{R}}\right) + (1 - \phi_i) \left[\phi_\pi \log\left(\frac{\Pi_{t-1,t}}{\bar{\Pi}}\right) + \phi_y \log\left(\frac{Y_t}{\bar{Y}}\right) \right] \quad (61)$$

where $\phi_i \in [0,1]$ is the interest rate smoothing parameter and $\phi_\pi > 1$ and $\phi_y \geq 0$ respectively determine the responsiveness of the central bank to deviations from steady-state inflation and output.

Exchange rates are flexible but the central bank engages in foreign exchange interventions to reduce the volatility of the exchange rate around its steady-state level. The reserve policy rule is given by

$$\log\left(\frac{\mathcal{R}_t}{\mathcal{R}_{t-1}}\right) = v_{\mathcal{R}} \log\left(\frac{\bar{\mathcal{R}}}{\mathcal{R}_{t-1}}\right) + v_{\varepsilon} \log\left(\frac{\bar{\varepsilon}}{\varepsilon_t}\right) \quad (62)$$

where the first term stabilizes reserves towards a target level $\bar{\mathcal{R}}$ and the second term responds to deviations from the steady-state exchange rate $\bar{\varepsilon}$. Accordingly, $v_{\mathcal{R}} > 0$ and $v_{\varepsilon} > 0$ indicate that the central bank accumulates reserves when they are below the target level, and/or in response to an exchange rate appreciation.

II.9 Fiscal Policy

We assume real government spending G is constant over time, has the same allocation across final goods as the aggregate consumption basket C_t and has no direct impact on production or household utility. The government finances its spending $P_t G$ and debt service costs by levying a lump sum tax $P_t T_t$ on households and issuing one-period nominal bonds B_t^G denominated in domestic currency. Consequently, the consolidated period budget constraint of the government may be written in real terms as

$$b_t^G = G + \frac{R_{t-1}^G}{\Pi_{t-1,t}} b_{t-1}^G - T_t \quad \forall t \quad (63)$$

where $b_t^G \equiv \frac{B_t^G}{P_t}$ is real public debt. The government is also subject to an intertemporal solvency constraint which prevents it from financing its spending through a Ponzi scheme. The following fiscal rule ensures that this constraint is satisfied by having the real lump-sum tax T_t rise in response to increases in public debt.

$$T_t = \bar{\tau} + \tau_y (Y_t - \bar{Y}) + \tau_b (b_{t-1}^G - \bar{b}^g) \quad (64)$$

where $\bar{\tau}$ is the steady-state real tax rate, \bar{b}^g is the steady-state real debt level and the debt-stabilization parameter $\tau_b > 0$ is assumed to be sufficiently high to ensure that the intertemporal solvency constraint is satisfied. Lastly, the second term reflects the procyclicality of tax revenues such that $\tau_y \in [0,1]$.

II.10 Rational Expectations Equilibrium

The rational expectations equilibrium is defined as a collection of endogenous processes for the variables

$$\left\{ \begin{array}{l} C_{H,t}, C_{F,t}, C_t, S_t, \Theta_t, \varepsilon_t, \Pi_{t-1,t}, \Pi_{H,t-1,t}, \omega_t, R_t, R_t^G, R_t^F, b_t, b_t^G, b_t^F, \\ Q_{t,t+1}, I_t, I_{H,t}, I_{F,t}, p_t^I, K_t, K_t', q_t, q_t', N_t, \mu_t, r_t^k, R_t^K, \bar{\omega}_t, k_t, G(\bar{\omega}_t), \\ G'(\bar{\omega}_t), \Gamma(\bar{\omega}_t), \Gamma'(\bar{\omega}_t), M_t, Y_t, MC_t, p_{H,t}^{opt}, \Omega_t, F_t, \Delta_t, NX_t, T_t, \mathcal{R}_t \end{array} \right\} \quad (65)$$

that satisfies the equilibrium conditions described above given exogenous values for variables $\{G, H, \Pi^*, C^*, G^*, M^*, I^*\}$ and exogenous processes for the innovations $\{\varepsilon_t^A, \varepsilon_t^\mu\}$.

II.11 Calibration

We calibrate the parameter values in the model to match the characteristics of Ukraine and emerging market economies, as well as following the standard values in the literature whenever feasible. Each period represents a quarter.

To begin with the household parameters, we set $\sigma = 1$ in order to attain a balanced growth path and calibrate $H = 0.2934$ to match Ukrainian labor hours data. The discount factor is set to $\beta = 0.9975$, bringing about an annualized steady state real (risk-free) interest rate of 1%. Steady state inflation $\bar{\Pi}$ is calibrated to yield an annual inflation rate of 5% consistent with the inflation target of the National Bank of Ukraine and thereby leading to a nominal interest rate of 6% in annual terms. The responsiveness of the liquidity premium on foreign bonds to changes in central bank reserve is set to $\varepsilon_{\mathcal{R}} = 0.83$ in line with the estimates of Adler, Lisack and Rui (2015).

Moving on to the production side, the share of capital income is set to conventional value of $\alpha = 0.3$ while the technology parameter A is calibrated to normalize steady-state output to $\bar{Y} = 1$. We set the price elasticity of demand among domestic goods to $\varepsilon_P = 7.6$ bringing about a mark-up of 15% over marginal costs which is within the range of empirical estimates. The calibration for the Calvo (1983) parameter $\theta = 0.75$ is consistent with an average period of one year between price adjustments as in Galí and Monacelli (2005). Regarding the capital producers, the quarterly depreciation rate is calibrated to $\delta = 0.05$ and the adjustment cost parameter is set to $\sigma_I = 4.602$ according to the estimates of Fernandez and Gulán (2015).

We adopt the same calibration for the open economy parameters for consumption and investment by setting $\varepsilon_F = \varepsilon_H = \varepsilon_I = 1.2$ and $\alpha = \alpha_I = 0.36$. The trade elasticity parameters ($\varepsilon_F, \varepsilon_H, \varepsilon_I$) are calibrated at the lower end of the range of values used in the literature to compensate for the lack of trade flow frictions in the model. Finally, the debt-elasticity parameter is set to a value of $\chi = 10^{-7}$ which has negligible impact over the simulation horizon.

To calibrate the financial accelerator component of the model, the idiosyncratic shock is assumed to be log-normally distributed such that $\ln(\omega) \sim N\left(-\frac{\sigma_{ent}^2}{2}, \sigma_{ent}^2\right)$. Consequently, $\Gamma(\bar{\omega}_{t+1})$, $G(\bar{\omega}_{t+1})$ and their first derivatives can be described by the following analytical expressions:

$$G(\bar{\omega}_{t+1}) = \Phi\left(\frac{\log(\bar{\omega}_{t+1})}{\sigma_{ent}} - \frac{\sigma_{ent}}{2}\right) \quad (66)$$

$$\Gamma(\bar{\omega}_{t+1}) = \Phi\left(\frac{\log(\bar{\omega}_{t+1})}{\sigma_{ent}} - \frac{\sigma_{ent}}{2}\right) + \bar{\omega}_{t+1} \left[1 - \Phi\left(\frac{\log(\bar{\omega}_{t+1})}{\sigma_{ent}} + \frac{\sigma_{ent}}{2}\right)\right] \quad (67)$$

$$\Gamma'(\bar{\omega}_{t+1}) = 1 - \Phi\left(\frac{\log(\bar{\omega}_{t+1})}{\sigma_{ent}} + \frac{\sigma_{ent}}{2}\right) \quad (68)$$

$$G'(\bar{\omega}_{t+1}) = \frac{1}{\sigma_{ent}} \Phi\left(\frac{\log(\bar{\omega}_{t+1})}{\sigma_{ent}} + \frac{\sigma_{ent}}{2}\right) \quad (69)$$

where $\Phi(\cdot)$ and $\phi(\cdot)$ are respectively the standard normal cdf and pdf. $T_{h,e}$ is then set to 1% of steady-state income and the remaining parameters are calibrated to $\gamma = 0.915$, $\mu = 0.324$ and $\sigma_{ent} = 0.125$ according to the estimates of Fernandez and Gulán (2015) for emerging market economies.

The next step is to calibrate the government policy parameters. The monetary policy coefficients are calibrated to $\phi_\pi = 1.5$, $\phi_y = 0.56$ and $\phi_i = 0.99$ where the high smoothing parameter is necessary due to the large shocks associated with structural reforms (see below). For the reserve policy rule, we calibrate the exchange rate responsiveness parameter to $v_\varepsilon = 10$ and the target steady-state level of reserves to $\bar{\mathcal{R}} = 0.18$, which targets USD 20bn under 2019 exchange rates. As with the debt-elasticity parameter, we set the stabilization parameter $v_{\mathcal{R}}$ to an extremely small value which has a negligible impact on reserve policy over the simulation horizon. Regarding fiscal policy, the pro-cyclicality parameter of the tax rule is set to $\tau_y = 0.47$ according to the regional estimates of Girouard and Andre (2005). The steady state lump-sum tax parameter $\bar{\tau}$, on the other hand, is calibrated to sustain a steady state share of government spending in output $\frac{G}{Y} = 0.32$ and a public debt-to-GDP ratio of $\frac{\bar{b}^g}{4Y} = 0.60$, both of which target average values for Ukraine over recent years.

Finally, we calibrate the innovation processes $(\varepsilon_t^A, \varepsilon_t^\mu)$ with gradual but permanent shocks that reflect the estimated impact of structural reforms. Particularly, for each reform scenario, we simulate a transition path $\{\varepsilon_t^A\}_{t=1}^{80}$ which gradually adjusts A_t to a long-term value consistent with the cumulative impact of land reform and other structural reforms as per the corresponding estimates in Table 4 and 5 for the specific reform scenario. Similarly, our simulated transition path for $\{\varepsilon_t^\mu\}_{t=1}^{80}$ gradually reduces monitoring costs (and thereby relaxes financial frictions) proportionate to the collateral impact of the corresponding land reform scenario. Notably, the collateral impact under the full reform scenario is greater than that of the partial reform scenario in line with the differential in land price estimates from EasyBusiness (2019).