Macroeconomic Risk Management - Summer 2020

Solution guide

1 True.

When there is heterogeneity (be this due to a number of reasons) some investors are more levered and invest more on financial assets than others. When a negative shock surprises the economy some of the investors that were most levered see their net worth wiped out and have to liquidate their positions. The lower asset prices due to this fire sale induces other investors to step in, potentially borrowing if they find this an attractive opportunity, and purchase the asset. This will happen regardless of margins (their rise will only imply that new investors cannot lever as much as the initial ones). Most of this reasoning can be found in Geanakoplos (2010).

2 Uncertain.

It is true that persistence, by spreading current shocks onto future generations, is a feature that is present in optimal (or Pareto increasing) intergenerational risk sharing contracts. But this does not imply that politically chosen social security increases welfare. D'Amato and Galasso (2010) show that in this case the social security system is too generous (expected transfers are higher than what a planner giving same weigth to future generations would choose) and provides less insurance than optimal (i.e. the marginal change in transfers to shocks is smaller). Thus, it could be the case that a politically chosen social security reduces welfare relative to laissez faire.

3 True or uncertain.

In the context of Athanasoulis and Shiller (2001), any valuable risk sharing contract would reduce precautionary savings and increase the equilibrium real risk free rate. This is mechanically the case for any innovation in an economy with CARA preferences and heterogeneity such that new contracts allow for risk sharing. In that paper the authors only looked at permanent shocks since they wanted to maximize the demand for risk sharing, but the argument also works with transitory shocks. In other settings, e.g. with CRRA preferences, then it might be the case that there is no mechanical relation between innovation and the real risk free rate, thus the answer could be uncertain.

4 False.

Adrian and Brunnermeier (2016) report the exact opposite when they analyze their CoVaR measure for the subsample of banks (out of the universe of all types of publicly traded financial institutions) for which they have richer balance sheet data. They find that banks with a higher fraction of non-interest bearing deposits have a significantly higher systemic risk contribution, while interest bearing coredeposits and large time deposits are

decreasing the forward estimate of Δ$CoVaR. The reason they give is that non-interest bearing deposits are typically held by nonfinancial corporations and households, and can be quickly reallocated across banks conditional on stress in a particular institution, while interest bearing deposits and large time deposits are more stable sources of funding.

5 False.

We have seen that with incomplete markets and imperfect commitment issues, entrepreneurs tend to overborrow and thus overinvest. They do this to secure funding in the event of a negative shock, as their only source of funding in these economies would be the sale of a fraction of their capital stock. Since the pecuniary externalities of these fire sales are not internalized by individual entrepreneurs, the equilibrium might be inefficient. We have seen this e.g. in Lorenzoni (2008). In this context a coordinated decision to reduce initial investment would increase total welfare. Thus, the statement is false.

6 a) Given the initial endowment (K_0, b_0) and the price q_0, entrepreneurs (Es) solve the following problem

$$\begin{aligned} & \max_{c_0, c_1, K_1, b_1} \; c_0 + c_1 \\ s.t. \quad & c_0 + q_0 K_1 \leq \max[0, q_0 K_0 - b_0] + b_1 \\ & c_1 + b_1 \leq (\xi + a) K_1 \\ & b_1 \leq \xi K_1 \end{aligned}$$

where the first (second) constraint is the period 0 (period 1) budget constraint, and the last constraint is the collateral, or borrowing, constraint. We need $q_0 < \xi + a$, since otherwise Es would choose not to invest, $K_1 = 0$. We need $\xi < q_0$, because otherwise Es would attain infinite utility by choosing $K_1 = \infty$. Note that we also need $b_0/K_0 < \xi$ since otherwise Es would default in period 0.

If $\xi < q_0 < \xi + a$ Es find it profitable to invest an borrow as much as possible to do so. Below we derive this capital demand.

b) Since $\max(\xi, b_0/K_0) < q_0 < \xi + a$, then it can be checked that all the constaints of the problem bind. In particular Es choose $c_0 = 0$ and invest all of their net worth in period 0. This is because investing one unit of net worth has a return of $\frac{\xi + a}{q_0} > 1$, and thus is better than consuming immediately. For this reason Es borrow and invest as much as they can, given their borrowing constraint, i.e. $b_1 = \xi K_1$. Hence, their demand of capital is given by

$$K_1 = \frac{\max[0, q_0 K_0] - b_0}{q_0 - \xi}. \tag{1}$$

c) First we consider $q_0 \leq b_0/K_0$. In this case (1) shows that $K_1 = 0$. Next, if $q_0 > b_0/K_0$. In this case (1) gives

$$K_1 = K_0 + \frac{K_0 \xi - b_0}{q_0 - \xi}$$

This implies the slope of the demand curve, dK_1/dq_0, is negative when $b_0 < K_0 \xi$ (i.e. when $K_1 > K_0$), and positive when $b_0 > K_0 \xi$ (i.e. when $K_1 < K_0$).

In these models the price of capital has two effects on capital demand. First, there is a direct price effect tha depresses Es demand. Second, there is a net worth effect that works by increasing Es net worth and thus their ability to borrow. This effect increases capital demand and if it sufficiently strong it can overturn the usual law of demand and generate an increasing demand curve.

In our model the first effect dominates when Es are net buyers of capital, but the second effect dominates when they are net sellers of capital. This happens since K_0 controls the strength of the net worth channel while K_1 drives the price effect

d) Given their endowments (e_0 and e_1 of goods, $\tilde{K}_0$ of capital), households (Hs) solve

$$\begin{aligned} & \max_{\tilde{c}_0, \tilde{c}_1, \tilde{K}_1 \geq 0} \tilde{c}_0 + \tilde{c}_1 \\ s.t. \quad & \tilde{c}_0 + q_0 \tilde{K}_1 \leq \tilde{K}_0 - \frac{1}{2}(\tilde{K}_0)^2 + q_0 \tilde{K}_0 + e_0 \\ & c_1 \leq \tilde{K}_1 - \frac{1}{2}(\tilde{K}_1)^2 + \xi \tilde{K}_1 + e_1 \end{aligned}$$

Since Hs are unconstrained their capital demand solves

$$\max_{\tilde{K}_1 \geq 0} \tilde{K}_1 - \frac{1}{2}(\tilde{K}_1)^2 + \xi \tilde{K}_1$$

The FOC implies that

$$\tilde{K}_1 = \max[0, 1 + \xi - q_0].$$

Market clearing implies

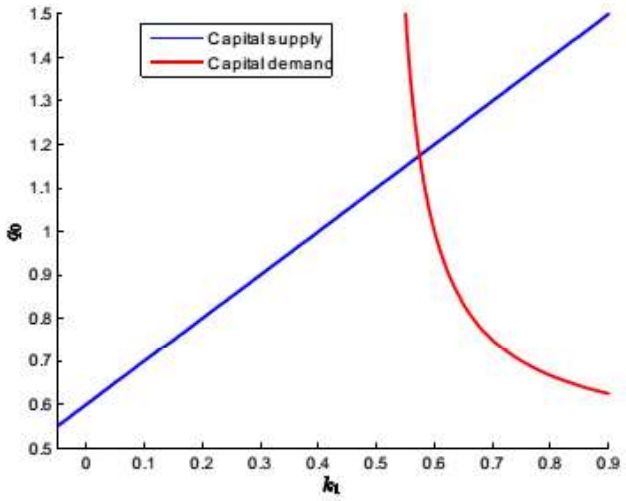
$$\bar{K} = K_1 + \tilde{K}_1 = K_1 + \max[0, 1 + \xi - q_0].$$

This gives us a residual supply curve

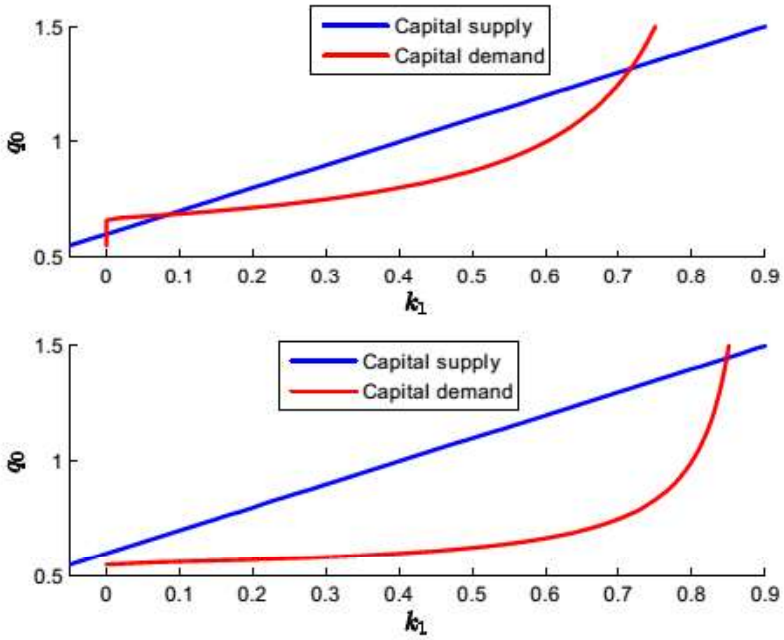
$$K_1 = \min[\bar{K}, \bar{K} + q_0 - 1 - \xi]. \tag{2}$$

This states that as q_0 increases, Hs demand for capital decreases, increasing the supply available for Es.

e) When $b_0 < \xi K_0$, Es are net buyers of capital. From b) Es capital demand is decreasing in q_0. Equilibrium is the unique solution from the intersection of a decreasing demand (1) and an increasing supply (2). The following figure illustrates this equilibrium.



f) When $b_0 > \xi K_0$, Es are net sellers of capital. From b) Es capital demand is increasing in q_0. We can have multiple equilibria since these are characterized by the intersection(s) of two increasing curves, (1) and (2). The following figure illustrates both the case of a unique equilibrium (bottom panel), and when there are three of them.



We have multiple equilibria since (1) is upward sloping revealing the presence of complementarities between capital price and capital demand. If the price of capital is low Es

have low net worth and have low demand of the asset. But if capital is high, their net worth is high and so is their demand of the asset.

g) The case of these parameters is illustrated in the first panel of the graph above. There is a bad equilibrium with $q_0 = 0.6$, and $K_1 = 0$ (Note: there was a typo in the exam since the question said $q_0 = 0$. For $q_0 = 0$ Hs demand would have been higher than supply and we can assume that rationing would imply $\tilde{K}_1 = 0.9$. So in reality any price between 0 and 0.6 would lead to this low equilibrium). At this equilibrium, Es default, since their net worth is zero ($b_0 = 0.6 < q_0 K_0 = 0.54$), and thus do not invest. The lack of demand from Es implies the price should be sufficiently low to induce Hs to purchase capital.

The good equilibrium features $q_0 = 1.32$ and $K_1 = 0.72$. Finally, there is an intermediate equilibrium with $q_0 = 0.68$ and $K_1 = 0.08$. This one is unstable since a small increase in the price leads to an increase in demand, which further increases the price towards the good equilibrium. Similarly a small initial decrease in price decreases demand and price until we arrive at the bad equilibrium.

h) Inspecting (1) shows that reducing b_0 increases Es demand for capital. Intuitively, a reduction in b_0 increases Es net worth which increases investment demand. If b_0 is reduced sufficiently then only the good equilibrium remains (as illustrated in the second panel in the second figure). Hence, an appropriate transfer of resources to distressed Es removes the bad (and also the unstable) equilibrium. Note that further reductions in b_0 would make $b_0 < q_0 \xi$ and (1) would become downward sloping.

i) First, we note that this is a free policy. It requires the government to credibly announces that it will buy capital at any price in the interval $(0.68, 1.32)$, i.e. between the prices of the unstable and good equilibrium. Once this announcement is made, the bad and unstable equilibrium are eliminated since now Es coordinate in the good equilibrium. Once the economy is in the good equilibrium, the capital market clears with no need of government intervention (that is why we say the policy is for free).

Of course to implement this policy it might be required that the government buys some capital. This would increase the price of capital. When this price is above the unstable equilibrium price, the previous logic indicates it will tend to converge to the good equilibrium price. The government can then sell whatever capital it bought.

j) Clearly according to our model policy i) dominates over policy h) since it is "free" while h) requires the use of resources to transfer to distressed Es. (Note that h) also increases the level of capital in the good equilibrium, but this is not the point of the question, we are focusing on fiscal costs).

If we assume that there is adverse selection in the capital market, it could be that h) dominates over i). This is because if the government has less information about assets than maket participants, then it might end up holding the worst types of capital increasing the fiscal cost of the policy. In this case, transfers to Es might be less costly on average.

Another element missing in the model is moral hazard. But it is not clear which of the two policies would make moral hazard more severe.

Another argument might be that if there is uncertainty about underlying fundamentals (parameters of the model), then the government might not be able to identify the "fair" price to announce for purchasing capital. Thus, if this is too low (lower than unstable

equilibrium), the plan would not work. If it is too high the government will purchases assets at price above the good equilibrium wasting fiscal resources.

Finally, it could be that if there is a crisis that there are no multiple equilibria, but a deterioration of fundamentals. In this case purchasing capital would not work, while transfering resources to Es will boost investment, making it a preferred policy.

7 The essay is about two global risks to which individuals, and countries, might be differently exposed to. First, there is the risk of deglobalization that affects trade, and then there is the risk of automation that displaces manual labor. There are several ways in which the essay can be written, the importance for grading is how much the student understands the nature and effects of these risks, how they could in principle be managed through macro markets (and how these can be designed as perpetual fuutres), and what can governments do either to help the development of these markets or reducing the negative effects of the global shocks.

Deglobalization affects mostly tradable activities, as the rupture of supply chains increases production costs for tradable goods. Uncertainty might lead firms to diversify their supply chains with some intermediate goods produced in more than one location to hedge the risk of a trade war disrupting production in one country. In a world with only four occupations the high-skill tradable (HST) and low-skill tradable (LST) would me more exposed to these risks than the high-skill non-tradable (HSN) and low-risk non-tradable. Whether HST or LST is more exposed would depend on technology and whether offshored production would be brought back to the home country or not.

Robotization affects mostly low skill activities. Although there has been some progress reported on automation threatening high skill activities, the risk is smaller. For example, recently a new language model, GPT-3, showed ability to mimic writing, but it yet falls short on common sense (this is good news for the ability of using essays to grade students performance). Thus, LST and LSN are more exposed to this risk than HST and HSN. Whether LST or LSN are more exposed again depends on technology, but it is more likely that the former is more at risk as productivity (and thus the value of robotization) is higher in tradables than non-tradables.

In summary, and considering both risks, the riskiest occupation is LST while the safest one is HSN. To determine which countries are most exposed to the risks it helps to think of what is their exposure to the sources of these risks. For example, clearly more open economies, such as Denmark, are more exposed to deglobalization than more closed economies, like the United States (which due to its size has less trade with the rest of the world). Also countries that while open produce their exports at home are less exposed than equally open countries that rely on import of intermediate goods. Thus, countries that export mostly commodities (agriculture, mining, oil, etc.) are less exposed than countries that export manufactures. Regarding the risk of robotization those countries where more workers are exposed to automation are mostly at risk. But importantly, what matters for this exposure is the relation between wages and the cost of robots. Thus, among countries of similar income, those that are most exposed are the ones that have a larger share of unskilled workers. Also, among countries of similar income, those that, like Japan, have a low ratio of workers to retirees are more exposed (relative to younger

countries like the United States) since they have higher wages.

Heterogeneity in risk exposure across occupations, and countries, implies that there are gains from creating risk sharing contracts. To create these contracts we need indexes that quantify the evolution of these risks. Several indicators can be used for this purpose. For trade risk the volume of goods traded is a natural candidate (note that we are treating the global nature of these risks, thus changes in an individual country's trade balance is not a useful indicator), and perhaps two indexes can be used to differentiate trade according to exposure to deglobalization (as mentioned commodities are less exposed than manufactures) or even exposure to robotization if we are considering the interaction effects between both global risks. Another possibility is the stock market price of Maersk, a large Danish shipping company, that can be used as an index that tracks the risk to trade in manufacturing. Indexes relating to robotization can be constructed using data on installations and stock of operating robots. One source of this data is provided by the International Federation of Robotics (and has been used in academic research). A portfolio of stock market valuation of main robot manufacturers (e.g. ABB, Epson Robots, Yaskawa Electric Corporation, etc.), can also be used as the underlying index.

Who would take a long or a short position in the contracts depends on how these are written. If the contract pays when a risk materializes then those exposed to the shock would be long on the contract. If the contract is correlated with the income that is at risk then those exposed to this risk would short the asset. I assume the latter for the description of individuals and firms' choices. Those that are mostly exposed to the global risks, which go short on the assets and pay a premium for being insured against these risks. On the other hand those that are less exposed will go long on the assets and are insuring the shorts (taking part of their risk) in exchange of the risk premium that they receive when writting these contracts. Based on the description above we expect that LST would go short on both contracts while HSN would go long on both. HST and LSN would go short on the corresponding asset correlated with their income, and it is not clear a priori whether they might take a position on the other asset or not (and if this would be a long or a short). Importantly, contracts are designed on indexes that would in general only be partially correlated with each workers' income. Thus we expect these to only partially hedge their income flows. Finally, firms would demand these contracts if they allow them to hedge (at least partially) their production costs. For example, a manufacturer that has supply chains abroad might want to hedge the risk that trade disruptions increase her production costs.

If we wanted to set up markets as perpetual futures then contracts would be written when a short and a long meet (this need of a pairwise match is alleviated with a parimutuel auction mechanism, as we saw in class). There would be no immediate transaction when the contract is written, but afterwards, and on a daily basis, there would be a cash settlement paid from the shorts to the longs. The integrity of the market would be guaranteed by exchanges that use margin accounts to reduce the risk of default. Margin accounts are debited or credited on a daily basis such that if the balance falls below some threshold shorts are required to put up more margin (or have their position closed). The

daily settlement with perpetual futures, s_t is given by

$$s_t = (f_t - f_{t-1}) + (d_t - r_{t-1}f_{t-1}), \tag{3}$$

where f_t is the price of the perpetual future in period t, d_t is the corresponding income index or dividend, and r_{t-1} is the return on an alternative (liquid) asset (which is used to keep futures price aligned with perpetual). Thus, the first term in (3) is the capital gains from $t-1$ to t, while the second term is the "final" cash settlement. Note that depending on which index we use there is a dividend paid daily (if based on traded stocks), or infrequently based on the publication of the corresponding data used (monthly for trade, yearly for robots).

For these markets to succeed we need that there is sufficient volatility in perpetual futures such that traders have an interest in participating, and that there is enough uncertainty to attract hedgers. Thus, it is more likely that the market on deglobalization succeeds as trade disruptions are today more likely to happen, but might be reversed in the future, and they might affect differently workers in different countries (e.g. European workers might be more interested today, but East Asian workers in a decade). On the other hand, robots tend to displace workers on a regular basis. If this were a lineal process then there would be no volatility in perpetual prices. Thus, for this market to succeed we need sufficient non-linear progress in robotization and in the displacement of manual labor (i.e. some years few workers are replaced, others millions).

Governments can help foster macro markets by educating ordinary citizens in Finance such that they become aware to the long run risks they are exposed to; reducing the stigma associated with seeking insurance on one's income; and nudging workers into participation. They can also try to remove legal and regulatory barriers, and give incentives (subsidies to financial innovators) to overcome initial frictions that prevent markets from gaining sufficient liquidity to be viable. But governments can also help through policy. Regarding trade risk, a policy stance could be to write new free trade agreements with other countries. This is something that the European Union has been exploring in the past few years as the United States made an inward turn to protecionism, and started a trade war with China. Regarding robotization, a policy that has been suggested is to tax robots and use the tax proceeds to complement unemployment insurance for displaced workers, or to fund training programs such that they might find employment elsewhere. A policy that would address concerns that these risks would increase inequality in a given society is to redesign tax systems such that they target a given after-tax Lorenz curve. Each individual would face a specific tax (based on her income and that of the next person) such that even though deglobalization and robotization shift the before-tax distribution of income, the automatic adjustment in taxes leaves the after-tax distribution unaffected. Of course there are important practical issues to solve were a country decide to implement this tax system, but these are beyond this course.